

Abstracts

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Symposia held at the WCM 2001

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Organised by Frank WESSELINGH (Leiden, The Netherlands) and Ellinor MICHEL (Amsterdam, The Netherlands) (sponsored by UM).

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Molluscan Conservation & Biodiversity

Organised by Ian KILLEEN (Felixtowe, UK) and Mary SEDDON (Cardiff, UK) (sponsored by UM).

New Frontiers in Functional Morphology of Molluscs - A Tribute to Vera Fretter and Ruth Turner

Organised by Shirley BAKER (Gainesville, USA) and Diana PADILLA (Stony Brook, USA) (sponsored by AMS and NSF).

Short chronicle of UM-Congresses

WELCOME ADDRESS

Ladies and Gentlemen, it is a great honour and pleasure to welcome you all here in Wien/Vienna in the name of the Unitas Malacologica, of the American Malacological Society and of the Friedrich Held-Gesellschaft. I hope your participation in this World Congress of Malacology will meet your scientific expectations and will enlarge personal contacts of interest. May the lectures, the posters, the discussions and not at least the individual conversations contribute to a stimulating meeting. In this sense I wish you all a successful Congress and a pleasant stay in Wien/Vienna.

L. SALVINI-PLAWEN
President of UM

CONTENTS

This book contains the abstracts of all contributions (lectures within symposia, free lectures, posters) presented on 20-25 August 2001 at the World Congress of Malacology in Wien/Vienna. All abstracts are arranged alphabetically according to the name of the (first) author.

The Editors

Special announcement:

The organising Institut für Zoologie houses its own scientific, in part historical collection (dry and wet) through all the animal kingdom, as well as glass and wax models. Interested persons are asked to contact the curator Dr.H.-L. Nemeschkal (or any person of the committee, with yellow badges) for a guide through the collection.

UNITAS MALACOLOGICA was born on 21 September, 1962 at the final plenary meeting of the first European Malacological Congress in London. Though the idea of an European malacological organisation dates back to 1935, it was not until 1959, at the 25th Anniversary of the Malacological Society in Amsterdam, that a group of distinguished malacologists from various European countries formulated the idea that there should be a common European malacological meeting. On the 8th November in the following year (1960), a committee of six British scientists began to organise and prepared the first European Malacological Congress, to be held in London at the British Museum, 17-21 September 1962. Even before the start of that Congress (which had 125 participants from 20 countries), the suggestion for the formation of an European Malacological Union was being discussed. The idea took more concrete form by the formation of a small committee convened to draw up a set of proposals and an outline constitution. Although this draft constitution was only in English (and not also in French and German, the two other official languages of Congress), this draft was accepted by an overwhelming majority of the plenum in the final meeting and the UNITAS MALACOLOGICA EUROPAEA had been born.

Acceptance of the Constitution of the Union was followed by the election of a council comprising a President, Vice-President, Secretary, Treasurer, an additional member and two auditors) and the more precise elaboration of rules. These included rules concerning membership, the significance of General Assemblies, the election and duties of the Council, etc. It was proposed that Congresses should be organised, if possible, every three years and that UNITAS matters (rules and congresses) could be issued in the three official languages English, French and German. Switzerland was made the legal domicile of the Union (later to be restricted to Basel/Bâle/Basle; until 2000).

At subsequent General Assemblies, several rule changes were approved. In 1977 (Amsterdam) the Union was renamed UNITAS MALACOLOGICA (losing "Europaea"). The number of council members was fixed at nine members (President, Vice-President, Secretary, Treasurer; two retained councilors and two newly elected councilors; and the retiring President as ex-officio member); in 2001 (Vienna) it is proposed to restrict the number to eight members (the Vice-President to be the retiring President).

In 1989 (Tübingen), the official language of UNITAS MALACOLOGICA was restricted to English (abandoning French and German) following the vote of non-English speaking members of 63 against 17. Following earlier discussions in 1993 (Siena), in 1995 (Vigo) it was decided to hold the subsequent congress (in 1998) outside Europe for the first time. Held in connection with the 64th annual meeting of the American Malacological Union (AMU) and the 31st annual meeting of the Western Society of Malacologists (USA), this 13th Congress of UM in Washington thus became the first "World" Congress of Malacology.

The UM Congresses:

- 1st **London** (GB), 17-21 September 1962; Chairman of Committee: L.R. Cox; separate Proceedings, London (Conchol.Soc. GB & Ireland and Malacol.Soc. London; L.R.Cox & J.F.Peake eds.), 1965.
- 2nd **København/Copenhagen** (DK), 10-14 August 1965; President: Henning Lemche; Proceedings in *Malacologia* **5**(1), 1966.
- 3rd **Wien/Vienna** (A), 2-6 September 1968; President: Oliver Paget; Proceedings in *Malacologia* **9**(1), 1969.
- 4th **Genève/Geneva** (CH), 7-11 September 1971; President: Eugène Binder; Proceedings in *Malacologia* **14**(1-2), 1973.
- 5th **Milano/Milan** (I), 3-7 September 1974; President: Ferdinando Toffoletto; Proceedings in *Malacologia* **16**(1), 1977.
- 6th **Amsterdam** (NL), 15-20 August 1977; President: A.C. van Bruggen; Proceedings in *Malacologia* **18**(1-2), 1979.
- 7th **Perpignan-Banyuls** (F), 31 August - 7 September 1980; President: Jean M. Gaillard; Abstracts in *Haliotis* **10**(2), 1980; Proceedings in *Malacologia* **22**(1-2), 1982 (Symposium on Evolution in *Malacologia* **21**(1-2), 1981).
- 8th **Budapest** (H), 28 August - 4 September 1983; President: László Pintér; separate Proceedings (*Hungar.Nat.Hist.Mus.*, Budapest; L.Pintér ed.), 1986.
- 9th **Edinburgh** (GB), 31 August - 6 September 1986; President: David Heppell; Proceedings in *Malacologia* **32**(2), 1991, and in separate Proceedings of UM, Leiden (E.Gittenberger & J.Goud eds), 1992 (Symposium on the Bivalvia, Hong Kong Univ. Press (B.Morton ed.), 1990; Symposium on Endangered species, Occasional Papers IUCN Species Survival Comm. **9** (E.A.Kay ed.), 1995).
- 10th **Tübingen** (D), 27 August - 2 September 1989; President: Claus Meier-Brook; separate Proceedings of UM, Tübingen (C.Meier-Brook ed.), 1992 (Symposium on Biology and Evolution of toxoglossan Gastropods in *Malacologia* **32**, 1990).
- 11th **Siena** (I), 30 August - 5 September 1992; President: Folco Giusti di Massa; Abstract volume (Symposium on Systematics and Ecology of Opisthobranchs in *Bolletino Malacologico* **29**, 1993).
- 12th **Vigo** (E), 3-8 September 1995; President: Angel Guerra; Abstract volume (Symposium on Molluscan Phylogeny in *Journal of Molluscan Studies* **63**, 1997).
- 13th **Washington** (USA), 25-30 July 1998; President: Rüdiger Bieler; Abstract volume.
- 14th **Wien/Vienna** (A), 19-26 August 2001; President: Luitfried Salvini-Plawen; Abstract volume.
- 15th The forthcoming congress in 2004 is proposed to be held in **Perth** (AUS); President: Fred Wells.

L.Salvini-Plawen/Peter Mordan

Effect of heavy metal interaction on the freshwater gastropod *Lanistes carinatus*

AbdAllah Tharwat ABDALLAH

Department of Zoology, Faculty of Science, Al-Azhar University, Assiut, 71524, Egypt.

This work concerned with investigating the nature of lead and copper interaction effect relative to the freshwater prosobranch *Lanistes carinatus* (when mixed together in a ratio of 36:1 lead and copper respectively, matching that recorded in the snail's aquatic habitat). Acute toxicity levels of lead nitrate and copper sulphate after twenty four hours of single and combined exposure to the studied freshwater snail were determined. Long-term exposure to sublethal levels of both metals; singly (100µM Pb and 10 µM Cu) and mixture of them (0.002X) was examined for 21 days period. Comparison of uptake of both metals as a result of combined exposure revealed higher lead storage even in presence of low copper concentrations. Significant correlation was statistically found between lead and copper concentrations in the digestive gland of snails exposed to metal mixture. Also, significant negative regression relationship was shown between metal content and organ weight in all examined groups. Histopathological studies showed more damage in the digestive tubules of snails exposed to sublethal levels of combined metals relative to those exposed to the single metals. Short term exposure experiment demonstrated a lower LC50 for lead or copper in their mixture, if compared with that for each single metal. In conclusion, results of the present investigation indicate that both lead and copper have a synergistic toxic effect on the studied freshwater snail.

Conservation of Land snails in Porto Santo Island – Madeira Archipelago

Cristina M. C. ABREU¹ and António D. ABREU²

CICA- University of Madeira; Edifício da Penteada, P-9050-399 Funchal;
cristina@uma.pt

Marine Biological Station of Funchal – Promenade da Orla Marítima do Funchal; P-9000 Funchal; antonio.d.abreu@mail.cm-funchal.pt

Within the archipelago of Madeira, Porto Santo Island is outstanding in terms of diversity and abundance of land snails. Isolation, small size, together with distinct topographical and geological conditions, when compared to Madeira Island, are some of the possible explanations for the high diversity and endemism.

Under a LIFE-Nature Project, and during a period of 3 years, the molluscan fauna of the islets around Porto Santo and the mountain Pico Branco was studied. The aims of this project were to make an inventory of species living in those places which are proposed for integration in the Natura 2000 Network of Protected Areas and also to determine their conservation status in order to define a proposal for managing and monitoring the habitats and species on a long-term basis.

The results of this project are presented in the poster.

The populations of *Lymnaea truncatula* (Gastropoda, Lymnaeidae) having a low degree of amphibiosis, and their relationships with *Fasciola hepatica* (Digenea, Fasciolidae)

Mouna ABROUS¹, Loïc FAVENNEC², Daniel RONDELAUD¹ and Gilles DREYFUSS¹

¹UPRES-EA n° 3174, Facultés de Pharmacie et de Médecine, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud.pharma.unilim.fr

²UPRES-EA n° 3234, Faculté de Médecine-Pharmacie, 22 boulevard Gambetta, 76183 Rouen, France

Lymnaea truncatula is known to be an amphibian species. However, this ability is not the same in all snail populations and several of them have a low degree of amphibiosis. As the breeding of amphibian snails under laboratory conditions was enough difficult, it was of interest to determine if these more aquatic populations might be successfully used for the production of digenean metacercariae. A comparative study was carried out using a Peruvian and two French populations of *L. truncatula* to analyze the characteristics of experimental infections with *Fasciola hepatica* and the outcome of their susceptibility to experimental infections when their progeny was reared under constant conditions (20° C, steeped lettuce as food). Bimiracidial infections of 4-mm high snails were thus performed during three successive generations for each snail population and the characteristics of infections were studied. High numbers of surviving snails at day 30 post-exposure (>70%), long survivals of numerous infected snails (more than 90 days), and prolonged productions of cercariae (a mean of 40-45 days for the shedding period) were observed in the 3 populations, whatever snail generation. In contrast, several differences were noted in relation to the origin of the *L. truncatula* used. When French strains of miracidia were used for infections, the mean number of *F. hepatica* cercariae in the Peruvian snails decreased from the first to the third generation (from 251 to 124 cercariae per snail), whereas it was similar in the two French populations, whatever snail generation (94-147 per snail). The results obtained for the Peruvian snails might be explained by a progressive adaptation of these *L. truncatula* to French miracidia. The populations of *L. truncatula* having a low degree of amphibiosis could be used for the commercial production of *F. hepatica* metacercariae, as the emergence of snails from water was scarcer and, consequently, the daily time spent to watch snail breeding boxes was shorter.

Pelagic larvae of benthic gastropods from shallow Antarctic waters of Admiralty Bay, King George Island

Theresinha Monteiro ABSHER¹, Guisla BOEHS², Angela RITZMANN FEIJÓ¹
and Andrea CANCELA DA CRUZ¹

¹ Centro de Estudos do Mar, Universidade Federal do Paraná, C.P. 02, 83255-000,
Pontal do Sul, PR, Brasil, tmabsher@aica.cem.ufpr.br

² UFSC/CCB/BEG/LAMEX, C.P. 476, 80040-900 Florianópolis, SC, Brasil.

Many marine gastropods display indirect development and their embryos hatch as a free swimming planktonic larva, whereas in others, the sex cells are discharged directly into the sea where fertilisation takes place. In both cases a veliger larva develops and may be collected in plankton samples. Data on larvae abundance and distribution in Antarctic waters are very scarce (Schreeve & Peck 1995). In order to assess the abundance, distribution and summer variation of pelagic larvae of benthic gastropods in the shallow coastal area of Admiralty Bay, 180 plankton samples were collected. During three summers (1993/1994, 1994/1995 and 1996/1997) a plankton net of 150 µm mesh size was towed obliquely for 10 minutes at 2 knots, at 15 to 30 m depth in 12 stations. Twenty six percent of the samples did not contain any gastropod larva, in the remaining 74% a total of 18,519 larvae were counted. Larvae were present in all summers and stations, from the end of January to February, with significant differences among years and months. Primary production and phytoplankton peaks at the end of January and February (Ligowski & Kopczyńska 1993), may be associated with the survival success of larvae in this period. Multivariate analysis (PCA) combining larval data with environmental variables (temperature, salinity, transparency, tidal phase, wind speed and its direction), indicated the influence of tidal movements, wind speed and direction on larvae abundance. High densities of larvae recorded in February, most probably are due to reproductive pattern of gastropod species that includes planktonic larvae in its life cycle, but our results suggest that distribution and abundance in Admiralty Bay most probably depends on tidal phase, wind speed and direction.

References

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Shreeve RS & Peck LS. 1995. Distribution of pelagic larvae of benthic marine invertebrates in the Bellingshausen Sea. *Polar Biology* 15:369-374.

Depth distribution of benthic bivalve molluscs from Admiralty Bay, King George Island, Antarctica

Theresinha Monteiro ABSHER¹, Guisla BOEHS², Angela RITZMANN FEIJÓ¹,
Sibelle Trevisan DISARÓ¹ and Orlei Antonio Negrello FILHO¹

¹ Centro de Estudos do Mar, Universidade Federal do Paraná, C.P. 02, 83255-000,
Pontal do Sul, PR, Brasil, tmabsher@aica.cem.ufpr.br

² UFSC/CCB/BEG/LAMEX, C.P. 476, 80040-900 Florianópolis, SC, Brasil.

Bivalve molluscs are a dominant group in benthic macrofauna assemblages of Admiralty Bay. Jazdzewski *et al.* (1986) recorded bivalves species as the dominant component of the benthic fauna (86%) in shallow depth (15 m) of Admiralty Bay. In Potter Cove, Maxwell Bay, Sahade *et al.* (1998) recorded the dominance of *Laternula elliptica* at 15 m depth. The occurrence and distribution of bivalve species in relation to a bathymetric gradient were assessed in 12 transects at Admiralty Bay (15, 30, 60, 80 m depths), with a Van Veen grab in the summers of 1994/1995 and 1996/1997. Twenty two bivalve species were recorded. There was no significant difference in bivalve abundance between years. Mean total density in 1994/1995 and 1996/1997 was 15,37 ind.m⁻² and 14.79 ind.m⁻², respectively. The 5 more abundant species were *Mysella charcoti*, *Yoldia eightsi*, *Yoldiella sabrina*, *Adacnarca nitens*, and *Thyasira falklandica*. The highest bivalve densities were observed at 15 m depth, due to *M. charcoti* (average of 516 ind.m⁻²) and *Y. eightsi* (average 156 ind.m⁻²), both were almost absent at 60 and 80 m. *A. nitens* showed low densities at 15 m, dominated at 30 m (131 ind.m⁻²), and diminished at 60 and 80 m. *Y. sabrina* occurred in very low densities at 15 m, increased at 30 m and dominated at 60 and 80 m (71 ind.m⁻² and 68 ind.m⁻²). Even though *L. elliptica* occurred at all depths in low densities, its biomass at 15 and 30 m surplus the biomass of the dominants species. Antarctic marine shallow bottoms are known to be affected by ice impact (Sahade *et al.* 1998; Nonato *et al.* 2000). Recolonisation of impacted sites will most probably depends on r-strategy species. The high density of *M. charcoti* at 15 m suggests that it probably is such high resilient species.

References

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Nonato EF, Brito TAAS, Paiva PC, Petti MAAV & Corbisier TN. 2000. Benthic megafauna of the nearshore zone of Martel Inlet (King George Island, South Shetland Islands, Antarctica): depth zonation and underwater observations. *Polar Biology* 23: 580-588.

Hox domains in a heterodont bivalve

S. Laura ADAMKEWICZ, Matthew K. ARTERBURN and David F. BAILEY

Department of Biology, George Mason University, Fairfax, VA 22030, USA,
ladamkew@gmu.edu

With the goal of determining the number of hox-like homeoboxes in a bivalve, we used highly redundant primers specific for such sequences to amplify genomic DNA from the heterodont bivalve *Donax texianus* Phillipi, 1847. This produced a single PCR product of approximately 300 base pairs which was cloned into a Ti plasmid and cultured in *E. coli*. In 57 randomly selected clones, we found nine different DNA sequences, each coding for 27 amino acids and present in very different frequencies, from one to 23 times. The cause of such unequal representation is unknown.

These nine domains were compared by BLAST to the contents of GenBank, both as nucleotide sequences and as predicted protein sequences. Except for the most divergent sequence, itself a homeobox domain most similar to *unplugged*, all of these domains appear related to the original hox genes discovered in *Drosophila* and one of them is identical in predicted amino acid sequence to the hox domain of *proboscipedia*. Parsimony and distance analyses of the nucleotide sequences group the eight into two clusters.

The commonest sequence (23 isolates), similar to *proboscipedia* (*pb*) and *sex combs reversed* (*scr*) in *Drosophila* and to the hox sequence found in the gastropod *Haliotis*, was actually comprised of two variant nucleotide sequences that differed from each other at two positions. Both of these substitutions are silent in the predicted amino acid sequence and it is possible that the clam used in these experiments was heterozygous for this gene. These results support the conjecture that bivalves have a single hox cluster similar to those found in other invertebrate phyla although further identification of these genes and determination of their homologies will require longer sequences.

Conservation of unionid mussels in Britain

David C. ALDRIDGE

Aquatic Ecology Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK, d.aldridge@zoo.cam.ac.uk

Freshwater mussels are declining throughout the world and Britain is no exception. For example, while Britain holds an internationally important population of the depressed river mussel, *Pseudanodonta complanata*, we have recorded a 30% reduction in the distribution of this species over the last century. The most significant threats to unionids in Britain come from (i) pollution; (ii) invasive species; and (iii) poor river management. For example, pollution from sewage outfalls results in reduced mussel densities and lowered growth rates; infestation by zebra mussels leads to reduced condition of unionid mussels, especially in the case of *Anodonta anatina* which is most heavily infested; a single dredging event can extirpate an entire population of mussels.

This paper reviews these major threats to Britain's unionids and goes on to discuss some of the current conservation efforts that are being undertaken.

The family Buccinidae in Icelandic waters

Gry Koldberg AMUNDSEN and Jon-Arne SNELI

NTNU (Norwegian University of Science and Technology), Trondhjem Biological Station, N-7491 Trondheim, Norway, gryam@stud.ntnu.no, jon.sneli@vm.ntnu.no

The family Buccinidae is a rather large prosobranch family represented in North-Atlantic/Arctic waters with approximately 25 species in 5 genera. The genera present are *Beringius*, *Buccinum*, *Colus*, *Liomesus*, *Neptunea*, *Turrisipho* and *Volutopsius*.

The buccinid species show great variation in shell form and structure and many subspecies, variations and forms have been described. Few workers have studied the causes for such variations, like, *e.g.* is there a geographical cause, or do the differences depend on physical factors such as depth, temperature, salinity, etc.?

As an example of such variation we have studied one of the buccinid species occurring in Icelandic waters and how the species vary in shape and structure. The species was first described by H.P.C. Møller in 1842 as *Fusus holboelli*. *Fusus tortuosus* Reeve, 1855 was synonymized with *F. holboelli* in 1985 by Bouchet & Warén. G. O. Sars (1878) described the two "forms" as *Sipho tortuosus* forma *typica* and *Sipho tortuosus* var. *attenuata*.

Since 1990, Icelandic scientists together with Nordic colleagues, have sampled a huge material of marine invertebrates in the economic zone of Iceland through the BIOICE-project. Material from this project together with a large material of specimens which originate from the Mollusca collection at the Zoological Museum in Copenhagen, has been examined trying to unveil the reasons for the variation of the species. The material in the Zoological Museum in Copenhagen shows a columella length correlated to depth. The specimens collected in deep water have a much longer columella than those from shallow water. Comparing them with the drawings of G. O. Sars, they resembles *Sipho tortuosus* forma *typica*. The specimens collected in shallow water with the shorter columella is comparable with the species that Bouchet & Warén describes. Unfortunately such a correlation is hard to find in the material at hand from the BIOICE-project. The material shows columella length differences but in regard to depth there is a rather uniform variation. Neither can the columella length variation be correlated to temperature or sediment variations. We have so far thus concluded that there are only one species, *Colus holboelli* (Møller, 1842).

Burying behaviour and possible angling in the sepiolid squid *Rossia pacifica*

Roland C. ANDERSON, Jennifer A. MATHER and Craig W. STEELE

The Seattle Aquarium, 1483 Alaskan Way, Seattle WA 98101 USA,
roland.anderson@ci.seattle.wa.us

Although sepiolid squids are known for burying in the sand during daylight hours, little is known of their burying behavior. The burying activity of the stubby squid, *Rossia pacifica*, was examined to determine how it buries, how it breathes while buried, how it sees, and how it behaves under threats while buried. The squid buried themselves using a strict behavioral sequence with few deviations, perhaps using a modal action pattern. This burying behavior is compared to that of other cephalopods. The squid formed a breathing hole while buried and probably formed a breathing chamber by consolidating substrate grains with mucus. Under threat, it used water jets to emit water jets and ink "blobs". Under repeated threats, it emerged from the substrate, inked, and jetted into the water column. There is strong evidence presented here that *Rossia pacifica* may use an angling behavior while partially buried. Because many live on subtidal deltas at the mouths of urban rivers, there is the possibility their burying there may disturb polluted sediments.

Once again on faunal exchange between Indo-Pacific and Paratethys in Middle Miocene

Olga Yu. ANISTRATENKO and Vitalij V. ANISTRATENKO

Department of Cenozoic deposits, Institute of Geological Sciences of NAS of Ukraine, O. Gontchara Str., 55-b, Kiev 01601 Ukraine, dovgal@dovgal.kiev.ua

Some conchological characters of endemic genera *Sinzowia* Kolesnikov, 1935 and *Kishinewia* Kolesnikov, 1935 suggested that they are closely related to one another and belong to the subfamily Phasianellinae Swainson, 1840, which is differently classified into families Trochidae Rafinesque, 1815 or Calliostomatidae Thiele, 1924. The true Phasianellinae have arisen in the Miocene of the Indo-Pacific area. In the Recent Atlantic and Mediterranean regions this taxon is absent. In contrast the representatives of the subfamily Tricoliinae Woodring, 1928 (Phasianellinae *s. l.*) evolved earlier, inhabiting the Mediterranean as well as the Indo-Pacific.

Close relationship between *Sinzowia* and *Kishinewia* on the one side and those two genera with the rest of the Phasianellinae on the other side suggests that in Sarmatian (or in time close before Sarmatian) the Eastern Paratethys established the Mediterranean independent connection to the Indo-Pacific region reflected in faunal exchange. We consider that the representatives of relatively young Indo-Pacific subfamily Phasianellinae penetrated in the Middle Miocene into the area of the Eastern Paratethys where *Sinzowia* and *Kishinewia* were generated. Those Indo-Pacific elements could not penetrate in addition the Mediterranean because of a missing connection to that region. In the Early Sarmatian all marine gastropods become extinct in the Eastern Paratethys. Furthermore in consequence of established permanent land barrier, the next "injections" of Indo-Pacific fauna into the Paratethys and Mediterranean became impossible.

Beside formerly discussed taxa, apparently, there are also other proofs of essential role of the Indo-Pacific influence on generation of the Eastern Paratethys fauna. Indeed a number of other Sarmatian gastropods are also closely related to species inhabiting the Pacific Ocean. They can be interpreted as pairs of geographically homologous species and genera one of which lived in the Eastern Paratethys Sarmatian whereas another do inhabit the Recent Pacific (e.g. *Pondorbis-Squamatisolariella*, *Aglaja-Paleaglaja*).

All those data, representing results of the faunistic revision of Sarmatian Archaeogastropods from Ukraine leads us to conclusion that a short but rather intensive faunal exchange between Indo-Pacific and Paratethys existed in the Middle Miocene.

Strange homologies in the shell sculpture of some Miocene Rissoids

Vitalij V. ANISTRATENKO

Department of Invertebrate Zoology, Institute of Zoology of NAS of Ukraine, Bogdan Khmel'nitski Str. 15, Kiev 01601 Ukraine, dovgal@dovgal.kiev.ua, vestnik@iz.freenet.kiev.ua

In the Eastern Paratethyan region, during Tertiary, species with very similar shell morphologies originated iteratively in heterochronous basins and strata. This holds true for bivalve (Cardiidae, Mactridae, Dreissenidae) likely as for the gastropod representatives (Trochidae, Hydrobiidae, Cerithiidae, Pyrgulidae). An extreme conchological similarity (homeomorphy) of some Rissoidae *s. l.* is especially striking.

Hence the species of *Archaschenia* Zhgenti, 1981 lived during the Eastern Paratethys regional stage Karaghanian, whereas the species of *Coelacanthia* Andrussov, 1890 are known only from the Lower Maeotian deposits. Beside exterior resemblance they demonstrate an amazing similarity of specific sculpture elements, which are undoubtedly homologous, but were generated irrespective of each other. Their morphological similarity is so brightly expressed, that some contributors regards them as species of one genus or even as one species.

Although *Archaschenia* and *Coelacanthia* are not directly phylogenetically connected, their relationship is doubtless. These groups were generated from different species of *Mohrensternia* Stoliczka, 1868, which in a different time penetrated from Mediterranean into the area of the Eastern Paratethys. In Karaghanian, *Archaschenia* developed from *Mohrensternia barboti* or/and some other related species. In Maeotian, *Coelacanthia quadrispinosa* was separated from *Mohrensternia subinflata*. The main features of their striking likenesses should be explained through comparison of morphologies in ancestor forms, pointing out the convergence in development of homologous structures reaching up to homeomorphy. The existence of Vavilov's homologous series of variability can be recognized. In a biological sense, the character of mentioned likenesses can be at best explained as a manifestation of the law of the genetic homology.

Supercooling ability variation in a hibernating population of the land snail *Helix aspersa* (Gastropoda: Pulmonata)

Armelle ANSART¹, Philippe VERNON² and Jacques DAGUZAN¹

¹ Université de Rennes 1, UMR 6553 Ecobio, bat.13, 263 Av. Gal Leclerc, CS 74205, 35042 Rennes Cedex, France, armelle.ansart@univ-rennes1.fr

² Université de Rennes 1, UMR 6553 Ecobio, Station Biologique, 35380 Paimpont, France.

The land snail *Helix aspersa* hibernates in Brittany (North-Western France) from October through April. During this period, it forms an epiphragm covering the shell aperture and aggregates in old stonewall crevices. Snails from a littoral population were studied through one hibernation period. Individuals were monthly collected (n=100), weighed and sized. Their maturity state (adult or youth) and the presence of the epiphragm were noted. Their supercooling ability (*i.e.* the ability of a fluid to remain liquid below its melting point) was determined by measurement of the temperature of crystallization T_c (temperature at which the body fluids spontaneously freeze). A previous work on this population (Ansart *et al.* in press) showed that this partially freezing tolerant ectotherm may also survive winter cold by supercooling. Present data reveal that the supercooling ability evolves significantly from October to April. T_c is of $-3.58 \pm 1.56^{\circ}\text{C}$ (n=30) in October, decreases to a minimum of $-4.94 \pm 1.96^{\circ}\text{C}$ (n=35) in February, and then increases to reach a maximum of $-2.88 \pm 1.93^{\circ}\text{C}$ (n=30) in April when snails are awoken. The percent-age of epiphragmed individuals increases from 0% in October to a maximum of 87% at the end of January. T_c measurements allowed to establish that dormant (epiphragmed) individuals have a significantly higher supercooling ability ($-4.77 \pm 2.09^{\circ}\text{C}$, n=115) than non-epiphragmed ones ($-4.19 \pm 1.89^{\circ}\text{C}$, n=154). Age is important in the realization of an individual T_c. Junveniles have a significantly lower mean T_c than adult snails: $-4.63 \pm 1.86^{\circ}\text{C}$ (n=227) *vs.* $-3.79 \pm 1.97^{\circ}\text{C}$ (n=52). A significant correlation can also be established between size and T_c (p<0.001, n=269), *i.e.* smaller individuals have a higher supercooling ability. *H. aspersa* can be submitted in the field to temperatures below -3°C . In the course of winter, the supercooling ability of this snail is enhanced, in relation with the entry into the dormant state. The fact that smaller snails have a higher ability to supercool may be a part of an avoiding mortality strategy in younger snails. However, T_c has not be considered as a reliable indicator of cold tolerance, and its measure ought to be coupled, as far as possible, with the ecological study of winter mortality at subzero temperatures.

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Evolution of left-right asymmetry: why isn't the snail mirror flat?

Takahiro ASAMI

Department of Biology, Shinshu University, Matsumoto 390-8621, Japan,
asami99@gipac.shinshu-u.ac.jp

The coiling structure of gastropods generally allows us to know the reversal of entire left-right asymmetry, which is not detectable without dissection in other animals. The reversal of whole body asymmetry results from mutation at a single nuclear locus at least in pulmonates. It has repeatedly evolved within and between gastropod species. However, chirally dimorphic species are rare. Sinistral species are only as minor as 10% of entire gastropods. Therefore, sinistrals or chiral variants in populations must have been selected against, while provided by recurrent mutation.

Why are sinistrals disadvantageous? The hypothesis of developmental (phylogenetical) constraint proposes the following; The reversal of left-right polarity causes anomalous morphogenesis including distorted shell growth, regardless of genomic composition which may differ between individuals and/or populations. This hypothesis predicts that either chiral morph is distorted in shell shape consistently between populations and suffers indigenous reduction of fitness due to abnormal ontogeny.

To test this hypothesis, I compared shell shapes between sinistrals and dextrals collected from the same localities, in chirally dimorphic or ordinarily monomorphic species. The chirally dimorphic Hawai'ian tree snail *Achatinella mustelina* exhibited statistically significant differences in shell size and/or shape between morphs and between populations. The chiral morphs differed even in reversed patterns between populations. The sinistral variants of ordinarily dextral species *Bradybaena similaris* also differed in shell shape but not in indigenous components of fitness from dextrals. Thus, the sinistrals are not anomalous but simply differ in shape from the dextrals. These results are against the above predictions and rather suggest that chiral morphs do not grow in mirror images because of genetic interactions between chiral determinants and shell-shape determinants differentiated between populations. Chiral morphs perform courtship and copulation in mirror images exposing genitalia in opposite body sides. Thus, the hypothesis of frequency-dependent selection proposes that the chiral minority suffers positive frequency-dependent selection due to physical mating difficulties with the chiral majority. Mating experiments with *B. similaris* have demonstrated that the interchiral copulation is nearly impossible in the face-to-face mating of *B. similaris*.

From the Tropics to Antarctica: a comparison of chemical defensive strategies in opisthobranch molluscs

Conxita AVILA

Centre d'Estudis Avançats de Blanes, C.S.I.C., Camí de Sta. Bàrbara s/n, 17300
Blanes, Catalonia, Spain, conxita@ceab.csic.es

Opisthobranch molluscs are known to present a wide array of defenses to protect themselves against potential predators. In many cases their defenses include the use of chemicals obtained from their prey, the transformation of these chemicals, or even de novo biosynthesis by the molluscs (Avila, 1995). Over the last 14 years, we studied the chemical defensive strategies of opisthobranch molluscs from different latitudes: Tropics, Mediterranean and Antarctica. This was achieved by a multidisciplinary approach in collaboration with German, American, and Italian researchers. Here, we compare the chemicals used, their proportions in the different body parts, their origin and activity, and their use against sympatric predators, for a selected group of opisthobranch species. Amazingly, the chemical defensive strategies of opisthobranchs are not so different in the distinct geographic areas even if the chemicals are used to avoid very different kinds of predators. Effective protection from potential predators of opisthobranchs, thus, is achieved by similar patterns of chemical defensive strategies in very different ecosystems.

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Marine mollusks from "Banco D. João de Castro", a shallow hydrothermal vent in the Azores: comparison between adjacent ecosystems

Sérgio P. ÁVILA^{1,2}, Frederico CARDIGOS³ and Ricardo S. SANTOS³

¹ Secção de Biologia Marinha, Departamento de Biologia, Universidade dos Açores, PT 9500 Ponta Delgada – Açores, avila@alf.uac.pt

² CIRN (Centro de Investigação de Recursos Naturais), Departamento de Biologia, Universidade dos Açores, PT 9500 Ponta Delgada – Açores

³ Departamento de Oceanografia e Pescas, Universidade dos Açores, PT 9901 862 Horta – Açores

D. João de Castro (Latitude: 38°13.3'N; Longitude: 26°36.2'W) is an isolated seamount with hydrothermal activity at shallow depths. It is located between the islands of Terceira and S. Miguel, Azores. The shallow part of the bank may be the result of submarine eruptions in 1720.

Bacteria in shallow-water hydrothermal vents are an important food source compared to typical coastal ecosystems but the trophic structure differs from that of deep-sea hydrothermal vents (Tarasov & Zhirmunskaya 1989, Kharlamenko *et al.* 1995). This study aims to determine the characteristics for D. João de Castro and possible adaptations of mollusc species.

After a preliminary study of the mollusc community (Ávila 1997), more data from shallow-water areas of S. Miguel Island and from Princesa Alice, another isolated bank located south of Faial Island, now increase the ecological understanding of the marine communities in the waters around the Azores archipelago.

The small number of molluscs (44 taxa) and a different community assemblage, point to an impoverished environment compared to nearby shore environments. Several reasons for this impoverishment are discussed: degree of isolation (inshore vs. offshore), geological age, type of substrate and presence/absence of hydrothermal vents.

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An area-analytical zoogeographical classification of gastropod family Neritidae

Karoly BÁBA

6. Vár u., 6720 Szeged, Hungary

The author executed the area-analytical classification of Neritidae by help De Lattin's faunacircles classification and he used 44 references. *Theodoxus subtermalis* (Issel, 1758) is a element of the Pre Azsian Iranian Refungial areas. Ponto-Caspian elements: *Th. pallasii* (Lindholm, 1924) and *Th. schulterii* (Grimm, 1877). Holo-Mediterranean element: *Th. fluvialitis* (Linné, 1758). Atlanto-Mediterranean element: *Th. bourguignati* (Recluz, 1852). The elements of the subareas of the Ponto-Mediterranean and Ponto-Pannonian: *Th. danubialis* (Pfeiffer, 1828), *Th. transversalis* (Pfeiffer, 1828), *Th. prevostianus* (Pfeiffer, 1828), *Th. pilidei pilidei* (Turnouer, 1879), *Th. varius* (Menke, 1828) (without subarea). The South-Italian element is *Th. meridionalis* (Philippi, 1836). The Euxin elements: *Th. holdreichi* (Martens, 1828), *Th. altenai* (Shütt 1965) and *Th. anatolicus* (Recluz, 1841).

Genetic and phylogenetic data in Molluscan conservation

Thierry BACKELJAU

Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels,
Belgium, Thierry.Backeljau@naturalsciences.be

The global pool of genetic diversity encompasses all the information and "blueprints" governing the dynamics and evolution of biological processes on the planet. Biodiversity at species and higher organizational levels is hence a manifestation of the underlying dynamics of genetic variation, which in turn constitutes the sole basis of evolutionary change. This "project style" wording aims at stressing that conserving biodiversity is not only a matter of protecting species and ecosystems, but also a matter of managing the biological information that underpins these biological systems and their evolutionary potential. Hence genetics and phylogenetics (should) play an important role in modern conservation biology, since these two research disciplines focus on the structure, transmission and historical change of hereditary biological information. Indeed, genetic diversity exists at four fundamental levels: within individuals (heterozygosity), among individuals within populations, between different populations that belong to the same "evolutionary units" (e.g. species), and among different 'evolutionary units' (e.g. interspecific differentiation). All these levels of genetic diversity are relevant to conservation issues and therefore need to be considered.

Against this background, the present contribution aims at providing a rationale and illustration of the (potential) role of genetic and phylogenetic data in Molluscan conservation, with particular focus on the use of such data in assessing (and monitoring) spatiotemporal patterns of genetic variation related with inbreeding, bottlenecks, habitat fragmentation, anthropogenic stress (pollution, overharvesting, etc.), invasive populations, marginal populations, introgression, etc. Evidently, genetic data are also highly important for helping to resolve taxonomic questions, while phylogenetic data may provide a basis to optimize conservation efforts by distinguishing "Evolutionarily Significant Units" (ESUs) and "Management Units" (Mus), even if these concepts are definitely not free from criticism. In spite of all these (and several more) possible applications, (phylo)genetic data are still relatively rarely used in Molluscan conservation. Therefore the present contribution will also try to provide a brief methodological background on a number of common and useful (molecular) techniques (including non-invasive sampling and the potential role of museum collections), thereby stressing that in the future more attention should be paid to quantitative genetic approaches.

Use of digital imaging software for mollusc collections

Martin BAKER

National Museums and Galleries of Wales, Cathays Park, Cardiff CF10 3NP.

Mollusc shells may be particularly difficult to photograph due to complex features such as protoconch microsculpture, apertural folds, and periostracal "hairs". An ordinary image created using a camera will not usually give the whole specimen in focus at the same time, and this is particularly true of spherical shaped gastropods.

Using a microscope system with a high quality digital camera linked to a computer allows series of images with differing focal points to be taken using an Image Grabber program. These images can then be combined by the Automontage program merging the focused parts of these photographs, thus producing a final composite image comprising of the best parts of many images.

Digital images produced in such a way are a useful alternative to photographs created using an electron microscope as no preparation of the specimen is required, and the image may be displayed in colour. Scale bars can be added and the image may be saved in a number of electronic formats suitable for publication. Disadvantages include lower resolution and positioning difficulties with relation to light.

This poster will display some recent results from NMGW projects including the Molluscan Biodiversity of East African Forests described in other posters at this meeting.

Particle capture, transport and sorting – the role of endoscopy in examining the form and function of bivalve feeding organs

Shirley M. BAKER¹, J. Evan WARD² and Jeffrey S. LEVINTON³

1 Dept. of Fisheries & Aquatic Sciences, University of Florida, Gainesville, FL 32653, USA, smbaker@mail.ifas.ufl.edu

2 Department of Marine Sciences, University of Connecticut, Groton, CT 06340, USA, jeward@uconnvm.uconn.edu

3 Dept. of Ecology & Evolution, State University of New York, Stony Brook, NY 11794, USA, levinton@life.bio.sunysb.edu

The structure and function of bivalve feeding organs have been of interest to malacologists for well over a century. Until recently, studies of bivalve feeding organs were limited to preserved, dissected, transparent, or otherwise altered specimens. While these methods contributed greatly to the understanding of bivalve feeding processes, each method has associated shortcomings. Video endoscopy, which allows for the direct *in vivo* observation of bivalve pallial organs, was introduced in 1991 (Ward *et al.* 1991). The addition of video endoscopy to the toolbox of available observational methods has significantly expanded the ability to explore the structure and function of bivalve feeding organs. This paper reviews recent advances in the understanding of bivalve feeding processes that have been facilitated by the use of video endoscopy. Examples will be drawn from our own work on *Dreissena polymorpha*, *Mercenaria mercenaria*, several unionid bivalve species, *Crassostrea virginica*, *Mytilus edulis*, and others (*e.g.* Baker *et al.* 2000). The link between bivalve functional morphology and ecosystem-level processes will be discussed (*e.g.* Levinton *et al.* 2000). In addition, the potential roles of endoscopic techniques in future studies of molluscan structure and function will be proposed.

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Evolution of the Neritimorpha from the paleontological perspective

Klaus BANDEL

Hamburg-University, Geological-Paleontological Institute and Museum,
Bundesstraße 55, D-20146 Hamburg, Germany, bandel@geowiss.uni-hamburg.de

Neritimorpha are an independent subclass of the Gastropoda with rather characteristic species present in different time slices. Before Mid-Devonian all these species known with protoconch belong to the Cyrtoneritimorpha which are provided with a fish-hook like, openly coiled larval shell. During the Devonian the first cases with helically coiled protoconch appear, and diversity of these early Cycloneritimorpha is rather high when teleoconch shapes are considered. In the Carboniferous and Permian the relation of the Neritopsoidea evolved, and by the end of the Permian the last Cyrtoneritimorpha disappeared with *Orthonychia*. In the Triassic the Neritoidea make their appearance distinguished by smooth, convolute larval shells and dissolved inner whorls in the protoconch and teleoconch as well. Neritopsoidea in contrast have a great diversity of shapes also in regard to protoconch ornament. Unusual groups not surviving beyond the end of the Triassic are present with the *Platyceras*-like *Pseudorhynchia* and the small planispirally coiled Cortinellidae. Neritopsoidea began to decrease in number from the Jurassic onward. The Jurassic modern groups appear, among them such resembling modern Neritinae both in shape and in regard to their living environment in the coastal swamps and brackish to fresh water. But also limpets of the Symmetrocypulidae appear and disappear before begin of the Cretaceous. Parallel to these the ornamented Pileolidae represent limpets with shelf resembling modern Septeria. The Cretaceous Otostoma relation has axial ornament and Nerita-like shape. Neritinae like *Nerita* and *Dontostoma* have first species in the Cretaceous. The estuarine environment housed the characteristic Dejaniridae until the end of the Cretaceous. The Hydrocenidae may appear first with *Schwardtina*. With the begin of the Tertiary *Neritina* as well as *Theodoxus* are present, differing in their ontogeny. A Paleogene group is formed by the large sized Velatinae, and with the end of the Eocene modern groups such as the *Septaria*, *Neritilia* and *Smaragdia* relations appear. Most probably Phenacolepadidae also have evolved only then. From Silurian onwards naticoid groups with limpet-like groups. The original larval shell was openly coiled in the early Paleozoic, changed to normal naticoid more and more convolute coiling in the Late Paleozoic. Dissolution of the internal walls began with the Triassic.

Gundlachia bakeri Pilsbry, 1913: morphology as a contribution to the systematics of Ancyliidae (Gastropoda: Basommatophora)

Sonia BARBOSA DOS SANTOS

Instituto de Biologia Roberto Alcantara Gomes, Universidade do Estado do Rio de Janeiro, Laboratório de Malacologia, Rua São Francisco Xavier 524, 20550-900 Rio de Janeiro, RJ, Brasil, sbsantos@uerj.br

A morphological description of *Gundlachia bakeri* Pilsbry, 1913, described based on specimens from the State of Pará, north Brazil, is given on the basis of shell of type specimens and shell and anatomy of topotypes. Anatomical data is being provided for the first time. The shell has an oval-shaped aperture and rounded apex, projected and inclined to the right, not overhanging the right margin; teleoconch with fine radial lines on the anterior slope; protoconch with shallow punctuations irregularly arranged. Septate specimens are also described. The posterior and the left muscle scar are rounded and have approximately the same size; the right muscle scar is elliptical and somewhat bigger than the others; elongated adhesive area between the anterior muscles scars; right muscle formed by two fascicles with a small gap between them; buccal mass according type I of Demian (1962); short radular sac; rachidian tooth tetracuspid, with the two main cusps asymmetrical and aculeate; lateral teeth tricuspid, with a prominent mesocon; pyloric portion of stomach expanded, with a long caecum; ovotestis with about 20 unbranched diverticula; ovispermiduct with a small seminal vesicle; nidamental gland appendix not elongated; spermathecal body rounded; short vagina; small prostate with three short diverticula; ejaculatory complex with glandular flagellum, without penis or true ultrapenis; ejaculatory duct not projected inside the lumen of prepuce. Shell and animal characteristics show that *G. ticaga* is the most similar congeneric species. Diagnostic features to *G. bakeri* are shown by the morphology of shell, muscles scars, seminal vesicle, nidamental gland, prostate and caecum. Comparisons are made with congeneric species as well as with other South American species.

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Biogeography and ecology of shallow-water chemoautotrophic bivalves

Penelope A.G. BARNES¹ and Carole S. HICKMAN²

¹ Smithsonian Tropical Research Institute, P.O. Box 2072, Balboa, Republic of Panama, barnesp@naos.si.edu

² Department of Integrative Biology, University of California, Berkeley, CA 94720-3140, USA, caroleh@socrates.Berkeley.edu

Chemoautotrophy has evolved as distinctive suites of co-adaptive functional anatomical features in at least five bivalve families: the Vesicomidae, Mytilidae, Solemyidae, Thyasiridae and Lucinidae. The chemoautotrophic members of these families are most conspicuous in habitats with high organic and/or sulfide content, including hydrothermal vents, cold seeps, rotting whale carcasses, and seagrass and mangrove sediments. However, they may also occur in what appear to be clean, well-oxygenated sediments. Chemoautotrophic bivalves are globally distributed from tropical to cold temperate latitudes and from the intertidal zone to depths >1000 m. All five families include genus-level taxa that are restricted to bathyal depths (>200 m), and the shells of deep-water taxa often are larger than those of shallow-water sister taxa.

Taxonomic diversity, anatomical diversity, and diversity of shell form are greatest in the Lucinidae, which also has the longest fossil record, first appearing in Upper Ordovician rocks. Lucinid patterns of biogeography and ecology provide a rich model system for exploring the significance of chemoautotrophy in molluscan evolution. Three contrasting biogeographic patterns include (1) the high within-habitat diversities observed in Caribbean seagrass ecosystems, where as many as 9 lucinid species co-occur within one m² of sediment, (2) the low within-habitat diversity (1 species) but high densities (1050 individuals/m²) in some Australian seagrass ecosystems, and (3) fluctuations in diversity within a single habitat type over relatively short intervals (<1 Ma) of geologic time. We re-examine the alternative hypotheses of the tropics as cradles vs. museums of diversity and find both inadequate to explain the observed diversity patterns. The association of shallow-water lucinids and marine angiosperms, particularly in the Caribbean, where both species diversity and density are high, provides a good system for exploring niche partitioning in terms of ecophysiology, including animal-substrate relationships, and life history and demographic patterns.

Reproductive isolation between two morphs of *Arianta arbustorum* (L.) (Gastropoda, Helicidae)

Gabriele BAUMGARTNER

Institute of Zoology, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria.

The courtship behaviour of two morphologically distinct populations of *Arianta arbustorum* from two separated geographical regions are compared under laboratory conditions. Aim of the study is to test possible precopulative isolation mechanisms. Individuals from the Danube lowlands at Klosterneuburg, near Vienna - *A. a. arbustorum* - are characterized by globular and not umbilicated shells. Individuals from the Gesäuse mountains, Styria, Austria - *A. a. styriaca sensu* Baminger (1997) - are characterized by flat and open umbilicated shells. A total of 252 pairs were observed. The courtship behaviour was divided into five phases. Phase 3 was always observed when pairs were successful in copulation and it was the longest phase. Evidently phase 3 has a key position in courtship behaviour. Group comparisons using discriminant analyses (regression analyses, randomisation, 1000 permutation) revealed the existence of significant differences in phase 3 with regard to duration. Precopulative isolation tendencies between *A. a. arbustorum* and *A. a. styriaca* are, therefore, evident and point towards a possible species separation processes. Additionally, it became clear that repeated tests of individuals in trials had significant influence on copulation success (path analyses, randomisation, 1000 permutation).

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Neighbouring populations of two forms of *Arianta arbustorum* (L.) (Gastropoda, Helicidae)

Gabriele BAUMGARTNER¹, Doris KLEWEIN², Elisabeth SINGER¹ and Helmut SATTMANN³

¹ Institute of Zoology, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria.

² Gentzgasse 17/1/7, A-1180 Vienna, Austria.

³ Natural History Museum, Vienna; Burgring 7, A-1014 Vienna, Austria, helmut.sattmann@nhm-wien.ac.at

Arianta arbustorum is a European landsnail which is highly variable in the shape, size, colour and patterns and also remarkably tolerant in its habitat demands. Numerous different "forms", "races" and other subspecific taxa have been named, particularly in the 19th century. One of these forms, "*A. a. styriaca*", is distinguished from *A. a. arbustorum* by flatter and open umbilicated shells. Flat-shelled populations were studied mainly in the Gesäuse mountains, Styria, Austria. Recently, the first neighbouring populations of *Arianta arbustorum* and *A. a. styriaca sensu* Baminger (1997) were discovered. Over the course of one summer, individuals were marked and shell characters, injuries, position of finding places, site preferences and activities recorded repeatedly. Adults of *A. a. arbustorum* and *A. a. styriaca sensu* Baminger (1997) are clearly distinguishable by shell characters. The two groups prefer different habitats. The more rocky and steep habitat of *A. a. styriaca* is accompanied by an increased rate of shell injuries.

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First investigations on the habitats of *Lymnaea truncatula* and *Physa acuta* (Gastropoda) in the irrigated area of Doukkala, western Morocco

Malika BELFAIZA¹, Mohammed MONCEF¹ and Daniel RONDELAUD²

¹ Laboratory of Hydrobiology, Department of Biology, Faculty of Sciences, Chouaïb Doukkali University, B.P. 20, 24 000 El Jadida, Morocco, moncefmd@ucd.ac.ma / mdmoncef@yahoo.fr

² UPRES-EA n° 3174, Faculty of Medicine, 2 rue du Docteur-Marcland, 87025 Limoges Cedex, France.

Natural infections of cattle (prevalences, 15%) and sheep (36%) with the trematode *Fasciola hepatica* were regularly detected in the livestock grazing in the irrigated district of Doukkala (western Morocco) and field investigations on the local populations of *Lymnaea truncatula* were necessary to control fasciolosis. As studies on snail habitats in irrigated areas under a Mediterranean climate were few in number and damages caused by fasciolosis were important (rate of livers distrained, 13.3% for cattle and 9.7% for sheep), the aims of this report were to determine the principal characteristics of lymnaeid habitats in the district of Doukkala, to measure the values of several physico-chemical parameters in running water, and to specify the prevalences of natural infections in snails. A total of 13 lymnaeid populations were found in the areas between El Jadida and Sidi Bennour while passing by Ouled Frej, Laarba Laounat and Jemaat Benihlal. The surfaces of these habitats and the total numbers of *L. truncatula* inhabiting them ranged from 0.3 to 3 m² and from 1.2 to 730 snails, respectively. An other freshwater species, *Physa acuta*, was also identified in 33 habitats with surfaces ranging from 0.3 to 30 m² but its populations were more abundant (6 to 11733 snails). These two species formed monospecific populations. The values of physico-chemical parameters were only measured in the habitats of *L. truncatula*. In all sites, the calcium contents in running water ranged from 70 to 134 mg/L, the electric conductivity from 88 to 205 µS/cm, whereas the pH ranged from 7.7 to 8.9. Snails naturally infected with *F. hepatica* were only found in a single habitat of *L. truncatula* (prevalence, 0.85%). Despite the low number of *L. truncatula* habitats found in the district of Doukkala, the snail was living in sites of small size and formed monospecific populations. Further studies are necessary to follow up the dynamics of snail populations throughout the year and determine the number of parasitic cycles which occurred in snails.

Do snails obey Red Queens?

Frida BEN AMI

Department of Evolution, Systematics and Ecology, The Hebrew University,
Jerusalem 91904, Israel, Frida@vms.huji.ac.il

The adaptive significance of sexual reproduction is still unclear. On the one hand sex is so very widespread that it seems advantageous, but on the other it has many disadvantages: fewer offspring per sexual parent, the female propagates only half her genome, the energy and risk involved in finding a mate and the risk of not finding one. Of the many theories offered to explain sexual reproduction, a major one is that of the Red Queen: sex can generate variability; therefore, in cases of very closely interacting species (such as hosts and their parasites), it enables an ongoing process of reciprocal coadaptation. This theory predicts that sex should be more common in populations heavily infested with parasites, than in those without.

The aquatic snail *Melanoides tuberculata* provides a model to test the Red Queen theory, because both sexual and parthenogenetic individuals exist in its natural populations; and some populations are heavily infested by trematodes. If parasite frequency in *M. tuberculata* could predict the extent of sexual reproduction, as expressed in terms of male frequencies, this would support the Red Queen theory. Here, I examine whether infestation frequencies do indeed predict male frequencies, in two dimensions: space and time.

Space (throughout Israel and throughout one summer): A survey of 22 *M. tuberculata* populations (all collected in one summer; in each population 100 snails were sex-determined and 40 were examined for trematodes) revealed a weak, negative correlation between male frequency and trematode infection ($r = -0.377$, $P = 0.046$). This does not support the Red Queen theory.

Time (within four populations and throughout three years): In two populations with initial high parasite levels and in two others with low ones, infestation and male frequencies were inspected bi-monthly (for three years). More than 1500 snails were dissected to examine trematode infection and in more than 23500, sex was determined in the field. The findings do not support the Red Queen theory: in one population with high parasite frequencies, male frequencies were low but in another they were high; one population without parasites had males throughout the year but another one had no males at all.

In *M. tuberculata*, the lack of a positive correlation in space along with the lack of consistent correlation in time – suggest that the Red Queen theory cannot explain the very wide occurrence of sex in nature.

Antimicrobial compounds from marine molluscs

Kirsten BENCKENDORFF

Institute for Conservation Biology and Biomolecular Research Institute, University of
Wollongong, NSW, 2522, Australia, kirsten@uow.edu.au

Marine molluscs are a potential source of lead compounds for the development of novel antimicrobial agents. Extracts from the egg masses of 39 molluscs were tested for antimicrobial activity at approximately natural concentrations. Activity was detected in 32 of these species, including molluscs from two classes and 18 families. Both leathery egg capsules and gelatinous egg masses were found to inhibit the growth of human and marine pathogens. Antimicrobial activity was observed in the fresh egg masses but not the well developed egg masses of a subset of species. Antimicrobial activity has also been recorded in the tissues and haemolymph of adult molluscs from 4 classes (Polyplacophora, Cephalopoda, Bivalvia and Gastropoda). In general, activity appears to be ten times higher in extracts of the haemolymph compared to the whole body extracts. The level of activity in the haemolymph of *Turbo torquatus* can be increased 10-fold by pre-treating the snails with a small injection of heat-killed bacteria. This suggests that molluscs produce antibacterial agents as part of their humoral immune response, as well as to protect their fertilized egg masses.

Gill ciliation and mucocyte distribution in *Bathypecten vulcani*: possible and impossible particle processing mechanisms

Peter G. BENINGER¹, Suzanne C. DUFOUR², Priscilla DECOTTIGNIES¹ and Marcel LE PENNEC³

¹ Laboratoire de Biologie Marine, Faculté des Sciences, Université de Nantes, 44322 Nantes Cédex, France, Peter.Beninger@Isomer.univ-nantes.fr

² Marine Biology Research Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0202.

³ Institut Universitaire Européen d'Etudes de la Mer, Université de Bretagne Occidentale, Site Technopôle Brest-Iroise, 29280 Plouzané, France.

To better understand the feeding biology of *Bathypecten vulcani*, a primitive pectinacean associated with hydrothermal vents, seven specimens were sampled from the East Pacific Rise in May 2000 using the Alvin submersible, and the gill ciliation and mucocyte distribution were investigated, using scanning electron microscopy (SEM) and mucocyte mapping, respectively. *Bathypecten vulcani* lacks laterofrontal cilia of any type, and possesses lateral cilia which are extraordinarily long for the gill filament diameter (approx. 20 µm for a filament diameter of 35 - 40 µm). The dense frontal cilia are much smaller (approx. 6 µm). Junctional cilia function to link the filaments to each other and to the mantle. The lack of laterofrontal cilia in this homorhabdic gill indicates that the particle capture mechanism is unlike any of those yet proposed for bivalves. The SEM data also confirm the absence of abfrontal cilia, indicating a loss of the original cleaning function.

The frontal surfaces of the dorsal bends and gill arch presented high densities of acid mucopolysaccharide - secreting (AMPS) mucocytes, whereas the ventral bends possessed high densities of acid-dominant mixed mucopolysaccharide - secreting mucocytes (ADMPS). The two mucocyte types differed in form and staining affinities with alcian blue - periodic acid - Schiff. This highly atypical mucocyte distribution does not correspond to currently known particle transport features of other bivalve gill types. No mucocytes were observed on the abfrontal surfaces, indicating a complete loss of surface function. The relationship of these features to those of the principal known bivalve gill types are discussed.

Pedal glands of some protobranchiate bivalves (Bivalvia, Protobranchia)

Heather BENNETT

Department of Biology and Geology, University of South Carolina-Aiken, Aiken, SC 29803, USA.

Pedal glands have been widely reported in the protobranchiate Bivalvia, but very little detailed information about their structure and function is available, particularly for near-shore examples. I examined adult specimens of seven species of protobranch bivalves to determine 1) if pedal glands are indeed present and 2) if glands are present, what is their structure and probable function? My results show that the structure of the gland is remarkably uniform among those taxa that possess it. Glands are located close to the "heel" of the foot and open onto the surface of the foot via a small pore. At least two of the species, both in the genus *Yoldia*, lack a pedal gland, a surprising result given that a pedal gland was previously reported for *Yoldia limatula* (Drew 1899). These results indicate that the pedal glands of protobranch bivalves merit further study, both to determine the distribution of this character within the Protobranchia and also to clarify what its relationship, if any, is to the byssal apparatus characteristic of many lamellibranch bivalves.

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Status of invasive European terrestrial slugs in North America

Gary BERNON

United States Department of Agriculture, Animal and Plant Health Inspection
Service, Otis Plant Protection Laboratory, Building 1398, Otis Air Force Base, Cape
Cod, Massachusetts 02542, USA, gary.bernon@aphis.usda.gov

Over the last two hundred years a complex of European terrestrial slug species has become naturalized in North America. Although these species may have evolved in forest habitats, they traveled from disturbed areas on various commodities to North America. However, the method of introduction was reversed; invasive species established first in disturbed areas and then species expanded their ranges into forests. Invasive species are continuing to expand their ranges, and aggressive species that are not yet known to be established, such as *Arion lusitanicus*, are potential future introductions.

Taxonomy on the Half-Shell: a "PEET" project investigating marine bivalves

Rüdiger BIELER¹, Paula M. MIKKELSEN², Louise CROWLEY² and Isabella KAPPNER¹

¹ Department of Zoology (Invertebrates), Field Museum of Natural History, 1400 S Lake Shore Drive, Chicago, Illinois 60605-2496, bieler@fieldmuseum.org, ikappner@fieldmuseum.org

² Division of Invertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024-5192, mikkell@amnh.org, crowley@amnh.org

In partnership with academic institutions, botanical gardens, freshwater and marine laboratories, and natural history museums, the U. S. National Science Foundation seeks to enhance taxonomic research and help prepare future generations of experts. Created in response to the world's biodiversity crisis and as a means of reinvigorating taxonomy and systematics, the "*Partnerships for Enhancing Expertise in Taxonomy*" (PEET) program supports projects that target groups of poorly known organisms for modern systematic research. Three major components are included: 1. Monographic products; 2. Training of new systematic biologists, and 3. Computer infrastructure to translate current expertise into electronic databases and other products with broad accessibility to the scientific community. This multi-institutional PEET project has been designed to enhance the field of marine bivalve systematics. Involving students at the graduate and postdoctoral levels, we are using a wide range of approaches and techniques, from field collecting and comparative anatomical studies to molecular sequencing. Our project is emphasizing Veneridae, the most diverse marine bivalve family with more than 500 living species (and nearly 250 genera) many of which form key components in the world's clam fisheries. Existing phylogenetic analyses of Veneridae are taxon-poor, and its monophyly remains questionable; our preliminary analyses using traditional shell characters and published molecular sequences have failed to support most currently accepted subfamilies. A phylogenetic definition of the family and its major subtaxa, based on reanalyzing traditional characters and elucidating new ones (especially from soft anatomy), is one of the goals of this project. A key area of investigation includes two of the largest of the 12 subfamilies, the Pitarinae and the Venerinae. Pitarines, with 72 nominal genera, contribute 29% of all venerid genera, the most of any subfamily. Preliminary data show as many as 135 valid living species in Pitarinae and a similar number of extinct taxa. The Venerinae currently comprise 15 genera with more than 400 extant and fossil species, including the name-bearing genus and several important commercial taxa. For more information about the PEET program, the Marine Bivalve Project, its products and activities (such as workshops), see <http://peet.finnh.org>.

Field Museum's Molluscan Collections

Rüdiger BIELER, Janet R. VOIGHT, Jochen GERBER, Janeen JONES and Marty PRYZDIA

Department of Zoology (Invertebrates), Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, Illinois 60605-2496, USA, bieler@fieldmuseum.org, jvoight@fieldmuseum.org, jgerber@fieldmuseum.org, jjones@fieldmuseum.org, mpryzdia@fieldmuseum.org

The breadth and historic significance of the Field Museum's Invertebrate collections belie their relative late arrival on the international stage (the museum was founded in 1893, its "Lower" Invertebrate Division in 1938). Widely recognized for its land snail collection with an estimated 2.5 million specimens in 165,000 series representing 20,000 taxa, Field Museum's Invertebrates collections include a broad range of molluscan taxa plus a comparatively small representation of other phyla. By 1993, an estimated 62% of recognized molluscan families were represented in the collection. Recent collection-building research activities at deep-sea sites and hydrothermal vents in the North Pacific Ocean and off the Florida coast continue to diversify the marine collections and complement the existing strengths of collections built by past curators Fritz Haas (1938-1958) and Alan Solem (1956-1990). Many formed collections have been integrated in FMNH's holdings and include contributions by individuals such as P. P. Carpenter, E. Hall, W. F. Webb, J. Ferriss, E. E. Hand, J. Zetek, C. D. Nelson, F. F. Laidlaw, C. F. Billups, F. Button, M. de Boe, W. J. Eyerdam, M. Teskey, G. Arnemann, W. Biese, L. Price, A. Wegner, A. L. Goodwin, T. & B. Burch, d'Alte Welch, H. Koto, F. & J. Aslin, A. Riedel, K. Emberton, A. Wiktor, W. Weyrauch, V. Kessner, H. J. Walter, D. Beetle-Pillmore, F. Schilling, A. J. Kohn, as well as "orphaned" holdings from institutions such as the University of Utah and Oberlin College. These collections, in turn, contain much historic material (*e.g.*, by G.K. Gude, F. Stearns, and J.G. Cooper). Support from the U.S. National Science Foundation allowed Leslie Hubricht's 43,000-series collection of North American land snails to be computerized and archivally rehoused; a second NSF-supported project, retrospective data capture and rehousing 100,000 series of land snail holdings, is now complete. The data are searchable at http://www.fieldmuseum.org/research_collections and with more than 140,000 series currently provide access to the largest "virtual" gastropod collection (freshwater and most marine mollusks are yet to be databased). The collections are well complemented by an excellent malacological book and serial library, as well as collections of relevant newsletters and reprints. To facilitate specimen study, FMNH sponsors grants for visiting scientist and will loan specimens to researchers unable to travel. For further information, see our web page at http://www.fieldmuseum.org/research_collections/scholarships/.

Some aspects of the gonadal cycle in the Antarctic bivalva *Laternula elliptica* (King & Broderip, 1831)

G. BIGATTI¹, Pablo E. PENCHASZADEH¹ and G. MERCURI²

¹ Facultad de Ciencias Exactas y Naturales, UBA y Museo de Ciencias Naturales-CONICET, Av. Angel Gallardo 470, Buenos Aires, Argentina, gbigatti@bg.fcen.uba.ar, penchas@bg.fcen.uba.ar

² Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina.

Vitellogenesis and oocyte growth in *Laternula elliptica*, a common hermaphrodite bivalve living in the soft muddy bottoms of the Antarctic continent, is reported. Facts related with the formation of the gelatinous layer surrounding the oocyte, gonadic development, accumulation of mature oocytes and spawning events are studied through histological evidence. Gonad development was observed at a size of 27 mm, reaching maturity at a size of 49 mm. The vitellogenesis has been found to last seven months, and storage of oocytes before spawning has been observed. It has been observed that once sexually mature, the animals remain with sperm cells and oocytes available during the whole year, suggesting that individuals would be prepared to spawn in any moment, probably depending on environmental conditions.

Phylogenetic systematics of the Unionidae (Mollusca, Bivalvia, Unionoida): evidence from COI and 28S DNA sequences

Arthur E. BOGAN¹, Walter R. HOEH² and Xiaoping WU³

¹ North Carolina State Museum of Natural Sciences, Research Laboratory, 4301 Reedy Creek Road, Raleigh, NC 27607, USA, arthur.bogan@ncmail.net

² Dept. of Biological Sciences, Kent State University, Kent, OH 44242, USA.

³ Dept. of Biology, Nanchang University, Jiangxi Province, P.R. China.

We currently perceive the freshwater unionoid fauna of the world as being comprised of five families in two superfamilies. Extant representatives of the order are found on six of the seven continents. Unionoid bivalves, which have an obligate parasitic larval stage on host fish, represent one of the most endangered groups of animals in the world. Our understanding of unionoid evolutionary relationships has been primarily based on non-phylogenetic analyses of a relatively small number of conchological and anatomical characters. However, we have recently presented a hypothesis of evolutionary relationships for the order based on a combined phylogenetic analysis of morphology and mitochondrial DNA sequences. This hypothesis supports the Unionidae+Margaritiferidae as a monophyletic assemblage (= Unionidae *sensu lato*, Davis & Fuller). Here, we address the phylogenetic relationships among the genera of the families Unionidae and Margaritiferidae from North America, Asia, Europe and Africa. We compare multiple exemplar species representing these genera using phylogenetic analyses of both nuclear and mitochondrial DNA sequences. These analyses enable tests of the monophyly of the constituent higher taxa as well as hypotheses regarding the evolution of unionid larval morphology and brooding location.

Sperm storage organs and their impact on sexual selection in stylommatophoran gastropods

Nenad C. BOJAT and Martin HAASE

Conservation Biology Research Group, Department of Integrative Biology, University of Basel, St. Johanns-Vorstadt 10, CH-4056, Switzerland, N.Bojat@unibas.ch, Martin.Haase@unibas.ch

Simultaneous hermaphrodites, which reproduce through both sperm and ova during each breeding season, possess no conceptual difficulties to apply sexual selection theory. Moreover, promiscuity, long-term sperm storage and elaborate mating systems characterizing many hermaphrodites including pulmonate land snails provide an ideal environment for sperm competition through the combat of spermatozoa to fertilize a given set of ova.

Evidence for sperm competition in gastropods is scarce. The variable fertilization patterns in double mated *Arianta arbustorum* may be influenced by the complex morphology of the sperm storage organ, the spermatheca (Baur 1994). Ultrastructural analyses suggest that the complex muscle system surrounding the spermathecal tubules together with the heterogeneous epithelial ciliation would allow for differential storage and use of sperm from different partners, and thus set the stage for cryptic female choice (Bojat *et al.* 2001).

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Development of asymmetry in two caenogastropods

Carin BONDAR

Department of Biology, University of Victoria, Victoria, BC, Canada V8W 3N5,
carinb@uvic.ca

The gastropod body plan is profoundly asymmetrical. Much of this asymmetry has been directly or indirectly attributed to a hypothetical evolutionary event known as torsion. Torsion is described as a 180° rotation of the cephalopodium relative to the visceropallium and it is widely believed that torsional displacement of organs occurs during the development of all gastropods ("ontogenetic torsion"). Although ontogenetic torsion is central to theories of gastropod evolution, surprisingly few studies have documented the actual tissue movements during the development of asymmetry in gastropods. Most literature on this topic involves speculation about the adaptive significance of gastropod torsion and is largely based on descriptions of development in patellogastropods and vetigastropods. Some authors have expressed doubt about the plausibility of the torsion scenario, which implies that alternative hypotheses about the evolution of gastropod asymmetry should be explored. I investigated the development of the mantle cavity and circumesophageal nerve ring in the caenogastropods *Amphissa columbiana* and *Euspira lewisii*. Asymmetries in both these components of the gastropod body are frequently cited as supporting torsion hypothesis. SEM micrographs of histological sections of developmental stages show that the initial inpocketing of the developing mantle cavity occurs on the right side in both species. The cavity subsequently expands over the back of the head to the left side. Labeling of the developing nervous system with antibodies against serotonin or FMRFamide reveals a marked asymmetry of the circumesophageal nerve ring at the earliest stages of antibody detection. The right limb of this connective extends posteriorly from the right cerebral ganglion down the right side of the embryo, whereas the left limb extends obliquely from the left cerebral ganglion to the far right side. Subsequently, the right limb becomes displaced to the left concurrent with expansion of the mantle cavity to the left side. Therefore, an oblique trajectory for the left limb of the circumesophageal connective is apparent before the right limb acquires an oblique trajectory, a phenomenon not predicted by the torsion hypothesis. A right sided-mantle cavity and nerve ring deflection on the left side before deflection is expressed on the right side was also reported in Vetigastropoda and Heterobranchia. This conserved developmental stage may be fundamental for the gastropod body plan. Alternative to the torsion hypothesis, I propose that the gastropod mantle cavity and the pallial innervation targets of the circumesophageal nerve ring arose from the right side only of a bilateral, pre-gastropod mantle cavity which has undergone unilateral enlargement over the dorsal surface during the early evolution of gastropods.

The magnitude of molluscan species richness in the tropical Indo-Pacific: Results from a massive collecting effort at New Caledonia sites

Philippe BOUCHET and the Montrouzier Expedition Party

Muséum national d'Histoire naturelle, 55 rue Buffon, 75005 Paris, France,
bouchet@mnhn.fr, and Institut de Recherche pour le Développement, BP A5,
Nouméa, New Caledonia

The seminal work by Erwin on the diversity of beetle species living in the canopy of rainforest trees has fueled a rich debate on the magnitude of global species diversity. Traditionally, species richness in marine environments has been approached at very small (typically 0.1 m²) or very large (typically 100s or 1,000s km of coastline or 106 km² of sea bottom or sea surface) scales, but the results are not appropriate to estimate the richness of macrofauna species at spatial scales relevant to conservation and management, e.g. a bay, a stretch of coral reef, an island.

A massive collecting effort involving 400 day-persons at 42 discrete stations on a 294 km² site on the west coast of New Caledonia, SW Pacific, revealed 2738 species of marine molluscs actually observed, and extrapolations from the cumulation curve indicate a range of 3137-3971 species potentially present. This is several times the number of species recorded from any area of comparable extension anywhere in the world. "Specialist" families are the most speciose, with the "Turridae" *s.l.* (265 species), Triphoridae (178), Eulimidae (138), Pyramidellidae (125) and Cerithiopsidae (97) together accounting for 37% of gastropod richness. The most speciose bivalve families are the Galeommatidae *s.l.* (60 species), Veneridae (54) and Tellinidae (52). Spatial and habitat heterogeneity is high, with 32% of the species collected at single stations. With 20% of the species represented by single specimens (0.4% of all catches), rare species make up a considerable proportion of the fauna. This justifies the parallel drawn between coral reefs and rain forests in terms of species diversity. Despite the intensity of the collecting effort, 28.5% of the mollusc species present at the study site are represented only by empty shells, suggesting that the real richness of many soft-bodied marine taxa is probably underestimated in many surveys.

The spatial correlates of species richness are poorly understood in the marine environment and it remains conjectural how our results bear on global mollusc species richness in the Indo-Pacific. Data analysis in progress from a second site on the east coast of New Caledonia indicates that only 36% of the species are shared between the two study sites, that differ in facies and general reef structure, but are only 200 kilometers apart.

Possible changes in seasonal distribution of *Ostrea edulis* (Bivalvia) larvae in marine protected area Mali Ston Bay, Southeastern Adriatic Sea

Ana BRATOS¹, Jaks BOLOTIN² and Robert KAKARIGI¹

¹ Collegium Ragusinum, Dubrovnik, Croatia, abratos@vdu.hr

² Institute of Oceanography and Fisheries, Dubrovnik, Croatia.

During the last 15 years, the farmers from Bay of Mali Ston noticed some disturbances in occurrence of oyster larvae. For that reason, the studies of variations in oyster larvae started in May 2000. Oyster larvae were caught by plankton net, at four positions in Mali Ston Bay. The data on temperature and salinity were also collected and related to spatting.

During the first year of the studies, the results show that oyster larvae occur in plankton during the whole year. The number of larvae in the sea reached maximum at the end of July and beginning of August. That is the period when the highest values of the sea temperature were measured. The data are quite different from the last published ones on that subject.

Further studies will indicate if there are changes in distribution of oyster larvae in Mali Ston Bay.

Morphology of feeding organs during postlarval development of the sea scallop, *Placopecten magellanicus*

Monica BRICELJ¹, Anne VENIOT¹ and Peter G. BENINGER²

¹ National Research Council Canada, Institute for Marine Biosciences, Halifax, N.S., Canada, B3H 3Z1.

² Laboratoire de Biologie Marine, Faculté des Sciences, Université de Nantes, 44322 Nantes, France.

The slow postlarval development of cold water pectinid species including the North American sea scallop, *Placopecten magellanicus*, is often associated with high, unexplained mortalities during culture. To assess potential ontogenetic constraints in food acquisition, the development of the gills and associated pallial structures (labial palps and mantle) was studied using scanning electron microscopy. Observations were made on several cohorts of post-settlement animals ranging in shell height (SH) from 0.35 to 14 mm. Key transitional stages were identified in relation to scallop size, as morphogenesis was size-, rather than age-related. The gill was initially homorhabdic with non-reflected inner demibranchs forming a basket-like structure. Their reflection and the formation of the outer demibranchs began at ~1 mm in size, when hatchery-reared seed are usually deployed in the field by commercial growers. It is noteworthy that at this critical size, sea scallops are not yet equipped with a fully developed, adult gill. Both demibranchs were fully formed at 2.6-2.8 mm, and the onset of the heterorhabdic adult form of the gill was not observed until scallops attained 3.5-5.5 mm. Differentiation of principal and ordinary filaments, first evidenced by the appearance of dorsal respiratory expansions on the abfrontal gill surface, continued beyond these sizes. Gill plication, first observed at ~4.7 mm, was fully developed in 7 mm scallops. The number of gill filaments increased linearly with scallop size throughout development. This relationship showed a marked inflection point at ~1mm SH, indicating that filament multiplication increases beyond this size threshold resulting in rapid increase in gill surface, and that 1 mm SH may represent a key transitional stage during development. The labial palps showed slow development: ridges on the inner surface first appeared at ~2 mm SH, and did not become pronounced until scallops attained 5 mm. A well-developed mantle ciliated tract (absent in adults), extending from the oral region to the mantle edge, may play a role in particle rejection during postlarval stages. The potential functional significance of morphological changes to particle retention and sorting in this species is discussed. Gill abnormalities associated with poor growth and survival of sea scallop postlarvae are also described. These data suggest that gill morphology may be a determining factor in postlarval growth and survival.

The systematics and phylogeny of the nudibranch family Dendrodorididae (Opisthobranchia, Doridoidea)

Gilianne D. BRODIE

School of Marine Biology & Aquaculture, James Cook University, Townsville, 4811,
Australia, gilianne.brodie@jcu.edu.au

This project was undertaken to produce systematic descriptions of Indo-Pacific members of the radula-less family Dendrodorididae and investigate relationships both within the family and to other radula-less Doridoidea. Debate exists as to whether radula loss has occurred more than once in the doridoidean nudibranchs and thus whether such taxa should be grouped together as the Porostomata.

In this study fourteen dendrodorids are investigated in detail (10 *Dendrodoris* and 4 *Doriopsilla* species) using both traditional morphological methods and a resin histology technique. This latter technique was used to study microstructure, particularly of glandular tissues. Representative members of the other radula-less doridoidean families (Mandeliidae and Phyllidiidae) and of radula-bearing Doridoidea were also investigated for comparative purposes. A phylogenetic analysis was performed using the computer program PAUP.

To date, results support the monophyly of the radula-less Doridoidea (= Porostomata) and therefore a single occurrence of radula loss. However, a broader investigation of Doridoidea is now required to determine the relationship of the Porostomata to other doridoidean taxa.

The microanatomy of glands associated with the anterior digestive tract shows analogy between some genera. Vestibular glands in the reproductive system and mantle glands in the notum also appear to have developed independently several times. Mantle gland microanatomy in particular, has proven to be of considerable systematic and phylogenetic value. The need for a broader study of Doridoidea is highlighted by my unexpected discovery of mantle dermal formations (MDF's) in the radula-less family Mandeliidae. These highly specialised mantle glands have previously been found only in the radula-bearing doridoidean families Chromodorididae and Triophidae.

Members of *Dendrodoris* are clearly united by a distinctly structured ptyaline gland and a uniquely glandular oesophagus. The little known temperate species *Dendrodoris maugeana* stands alone in possessing a reproductive system quite different to other members of the genus. Previously undescribed complex mantle glands, and an anal papilla that is located to the left of the gill branchia, unite *Doriopsilla*. However, features that unite these two genera together into the family Dendrodorididae are to date unclear.

Lateral asymmetry of eye use in *Octopus vulgaris*

Ruth A. BYRNE, Michael KUBA and Ulrike GRIEBEL

Konrad Lorenz Institute for Evolution & Cognition Research, Adolf-Lorenz-Gasse 2,
A-3422 Altenberg, Austria

Recently the lateralisation of sensory and motor functions has been demonstrated in various groups of vertebrates. In this study we examined lateral asymmetry of eye use in *Octopus vulgaris* by ethological methods. *Octopus vulgaris* uses monocular vision almost exclusively and can move its eyes independently. The amount of binocular vision is very small because the eyes are located on the sides of the head. Eight octopuses were tested in two different situations (one with and one without external stimuli) where the use of the eye for frontal vision could be determined unequivocally. Experimental data were recorded on video tape. All animals showed preference for one eye (5 left-eyed, 3 right-eyed) in a ratio of about one to two. There was no correlation between eye use and direction of movement of the animal. Intensity of pigmentation of the ventral sides of the arms tended to be highest on the side of the preferred eye. The body side of the eye currently in use was pigmented darker than the other side. We found no sex differences for visual lateralisation. Pigmentation of the ventral sides of the arms was lighter in females than in males.

Two sibling nudibranch species with different ecological niches

Gonçalo CALADO^{1,2} and Victoriano URGORRI²

¹ Instituto Português de Malacologia, Apartado N° 52. S. Pedro do Estoril, 2766-501 Estoril, Portugal, bagoncas@mail.telepac.pt

² Laboratorio de Zooloxía Mariña, Departamento de Biología Animal, Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain, bavituco@usc.es

Calma glaucoides (Alder & Hancock, 1854) is an aeolid nudibranch mollusc inhabiting Western and Southern European coasts (Atlantic and Mediterranean). Adults (7 to 16 mm) fed exclusively on spawns of teleost fishes such as *Lepadogaster lepadogaster*, *Lepadogaster candollei*, *Parablennius gattorugine* and *Parablennius pilicornis* which deposit their eggs on the underside of boulders or empty bivalve shells.

By following *C. glaucoides*' life cycle in the field we also found nudibranchs on the eggs of the gobiid fish *Gobius niger*. Initially this observation seemed to be just an update to the species list which are predated by *C. glaucoides*, however, upon closer examination we found that these were two sibling species which had been confused for decades.

They are not easily distinguishable from a morphological point of view, but have very different ecological niches in the adult phase. They only recognise one kind of eggs as food (they were easily observed eating) even if placed in direct contact with the other one. When placed together only individuals of the same species were observed copulating.

In both species, the life cycle is coincident with the fish spawn period of the species which eggs they fed on. Young juveniles having recently metamorphosed from planktonic larvae became mature in less than two weeks which allows them to lay their own eggs before fish spawning ends.

Although male fish actively guard the nest and surrounding territory, they apparently do not detect the presence of the nudibranchs. These are hidden in small depressions underneath the boulders near where the fish spawns during the day when the fish is more active and only crawl over the eggs at night.

Preliminary phylogeny of the genus *Jorunna* Bergh, 1876 (Nudibranchia: Kentrodorididae)

Yolanda E. CAMACHO-GARCÍA

Department of Invertebrate Zoology and Geology, California Academy of Sciences, Golden Gate Park, San Francisco California 94118, U.S.A. / Sub-Programa de Malacologia, Instituto Nacional de Biodiversidad (INBio), Costa Rica, ycamacho-garcia@calacademy.org

The genus *Jorunna* is characterized by having a dorsum covered with caryophyllidia, prostate with two portions, penis occasionally with hooks, a copulatory spine, presence of an accessory gland and labial cuticle smooth or armed with jaw elements. The examination of a number of specimens and a review of the literature show that there are at least 20 valid species of the genus *Jorunna*. Seventeen of them have been previously described by other authors and three are new species. Specimens were dissected, and particularly interesting soft parts were critical point dried for scanning electron microscopy (SEM). Special attention was paid to the morphology of the reproductive system.

The phylogeny obtained from twelve species supports the hypothesis that the genus *Jorunna* is a monophyletic group. Therefore, the genera *Kentrodorid* and *Jorunna* are regarded as synonyms. Maintenance of the genus *Kentrodorid* renders the genus *Jorunna* paraphyletic. The present study presents the first preliminary phylogenetic analysis of this cryptobranch dorid genus in order to better understand the evolution of several characters present in this group.

Constructing species/area curves for continental areas: some British examples

Robert A. D. CAMERON

Department of Animal and Plant Science, University of Sheffield, Sheffield S10 2DL,
U.K., r.cameron@sheffield.ac.uk

Malacologists are familiar with species/area curves for islands, but there are very few published species/area analyses for land molluscs within a continental land mass (Nekola & Smith 1999). The ways of constructing such curves differ from those using island data, and these can present particular difficulties for getting reliable data. The theoretical bases for interpreting them are also distinct (Rosenzweig 1995). This poster gives details on the construction of three curves based on data from Britain, and looks at their predictive power and their limitations. Some evidence is also provided that similar local relationships apply elsewhere. This poster is in part a technical appendix to the talk "From continents to quadrates: species/area relationships in land mollusc faunas".

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From continents to quadrates: species/area relationships in land mollusc faunas

Robert A. D. CAMERON

Department of Animal and Plant Science, University of Sheffield, Sheffield S10 2DL,
U.K., r.cameron@sheffield.ac.uk

The forms of species/area relationships are important for two reasons. Knowing the form in particular cases enables us to make meaningful comparisons of diversity between areas of different sizes, and this knowledge is also heuristic, suggesting explanations or prompting new investigations. Preliminary analyses of species/area relationships within Europe quantify the strong latitudinal gradient in species diversity at large scales, and enable some comparisons with diversity levels in other continents. The European pattern is not universal. Island relationships, and small-scale relationships down to the level of small quadrates, show a different set of patterns. These give us clues about the way that diversity in European faunas has developed, and help us in comparisons with the small, but growing body of data on tropical and humid subtropical faunas.

Phylogeny of the Bivalvia: are morphology and molecules compatible?

David C. CAMPBELL

Biology Department, St. Mary's College of Maryland, 18952 E. Fisher Rd, Saint
Mary's City MD 20686-3001 USA, bivalve@mail.davidson.alumlink.com

Recent work has produced molecular and morphological phylogenies for the Bivalvia. Although the results are in broad agreement, discrepancies remain. The present study used molecular data from Steiner & Hammer (2000) and Campbell (2000) and morphological data from Carter *et al.* (2000) to assess the relative support for various clades. Clades supported by both data sets as monophyletic include Pteriomorpha, Heteroconchia, the crown-group paleoheterodonts, and Ostreoidea plus Pterioidea. The general agreement between the data sets suggests that we are converging on a common phylogeny; however, some details of the early radiation remain poorly elucidated by either approach. The relationships among major pteriomorph clades, the affinities of certain heterodonts, and the relationships of protobranch orders to each other and to the autobranchs remain unclear.

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Shell Variation and Hinge Morphology in *Nucinella adamsi* and *N. serrei* (Bivalvia: Manzanellidae): a population study from the Western Atlantic

Lyle CAMPBELL, Sarah C. CAMPBELL and Mileidy GONZALEZ

Natural Sciences, University of South Carolina at Spartanburg, 800 University Way,
Spartanburg, SC 29303, USA, lcampbell@gw.uscs.edu

Over 100 *Nucinella* valves dredged off the South Carolina coast supported the first population-level analyses of variation in this obscure genus. Most species had been erected from only a few specimens or unique types. Current literature argued for two extant Western Atlantic species, *N. serrei* from North Carolina and Brazil, and *N. adamsi* from southern Florida, Texas, and Venezuela, and possibly two Pliocene species from Florida. Cited species-defining traits included absolute size; number of chevron teeth; width and length of lateral hinge plate; height-width ratio; inflation; ornamentation; size, form and number of cardinal teeth; and presence of a cusp on the cardinal hinge plate. These traits appear to change during ontogeny, and/or vary among adults within a single population so that we recognize only two species, one highly variable and the other quite conservative.

The holotype of *N. adamsi*, a broad shell with large peg teeth, matches the maximum limit for dentition and relative width found in South Carolina populations. Yet most of the population conforms with the fossil *N. woodii* and recent "*N. serrei*" from North Carolina in being narrower and having a mixture of medium peg, blade, and chevron teeth. Thus only one variable species can be supported by the Pliocene and Recent specimens from North Carolina to Florida and Texas, and, now, Bahamas. Despite the extensive variation in *N. adamsi*, South American populations remain distinct and are less varied. They include Venezuelan lots and Brazilian specimens from Bahia, type locality for *N. serrei*, and from Espirito Santo.

The complex *Nucinella* hinge has been interpreted as modified taxodont, heterodont, or even a relict actinodont. In *Nucinella* the chevron teeth form during ontogeny by the fusion of peg-teeth and hinge spurs, and are not homologous with the primary chevron teeth common to other protobranch genera. Pojeta (1988) suggested that the odd hinge features reflected secondary development from edentulous solemyoid ancestry. We suggest that the *Nucinella* hinge development does not fit into any existing category of dentition.

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Phylogenetic and evolutionary implications of Late Paleozoic (Pennsylvanian, Carboniferous) silicified marine Gastropoda from Indiana, central North America

Matthew CAMPBELL

Department of Geological Sciences, Indiana University, 1001 East Tenth Street,
Bloomington, IN 47405-1403 USA, ecphora@indiana.edu

A silicified marine invertebrate fauna from Weller Falls, Warren County, Indiana, USA provides exceptional preservation of gastropods. Few late Paleozoic aragonitic and calcitic mollusks have original shell material preserved to show critical protoconch and adult taxonomic characters (Nutzell et al. 2000, Kues & Batten 2001). The exceptional preservation of this Pennsylvanian fauna enables more accurate assessment of the morphological and taxonomic diversity and patterns of faunal change. Preliminary work has recovered 24 genera from 14 families, with most specimens between 0.35 and 10 mm in length. From this assemblage, I will select the taxa with the most complete data for cladistic analyses, from the species to the subclass level. These analyses will be coupled with revised taxonomic assignments as warranted by the quality of preservation of both individual specimens and the range of variability in populations in this fauna. Protoconch whorl characteristics are critical for assigning gastropods to higher taxonomic levels including order and subclass. Knowledge of higher-level affinities of the fossils is crucial for establishing phylogenetic connections with older and younger faunas. The Weller Falls fauna is dominated by a diverse molluscan fauna, which is a pattern more characteristic of the Mesozoic. Faunas dominated by brachiopods, bryozoans, and echinoderms are more typical of the Paleozoic (Sepkoski 1984). This similarity of a Pennsylvanian fauna with the Mesozoic diversity pattern records the background trends in gastropod evolution during the transition to the Mesozoic shallow marine faunas.

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Toward a simple method for estimation of lipid content in *Crassostrea gigas* oocytes

Rozenn CANNUEL and Peter G. BENINGER

Isomer, Faculté des Sciences, Université de Nantes, 44322 Nantes Cédex 03 France,
Rozenn.Cannuel@isomer.univ-nantes.fr

Oocyte quality is a significant factor in larval development and survival in oysters (Kennedy 1996). The amount of lipids in oocytes is especially important, because these lipovitellines are used as energy reserves during development (Barlett 1979).

A relatively simple, rapid and inexpensive method has been developed for the estimation of oocyte lipid contents in *Crassostrea gigas*, using a modification of the Oil Red O lipid specific staining technique (Gallager & Mann 1986). Spectrophotometric measurements were performed on stained suspensions of oocytes in vivo to quantify the absorption of oocyte suspensions, of known oocyte density. The relation between absorption and numerical densities of oocytes was clearly linear for oocyte suspensions of each female tested (n=3). Some oocytes appeared less stained than others, putatively because of their lower lipid contents.

By correlating the absorption of oocyte suspensions to their extracted lipid contents, this method should allow a rapid and simple estimation of oocyte quality in *Crassostrea gigas*.

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Histological and histochemical aspects of reproduction in the archaeogastropod *Megathura crenulata*

Rozenn CANNUEL, Peter G. BENINGER, Jean-Louis BLIN, Sébastien PIEN and Olivier RICHARD

Isomer, Faculté des Sciences, Université de Nantes, 44322 Nantes Cédex 03 France,
Rozenn.Cannuel@isomer.univ-nantes.fr
Syndicat Mixte pour l'Exploitation du Littoral, Zone conchylicole, 50560 Blainville sur Mer, France.

Megathura crenulata is a Californian archaeogastropod whose haemocyanin is used in the treatment of certain cancers. A histological and histochemical study was performed on individuals sampled in the field, in order to ascertain the fundamental features of its reproductive biology, with a view toward wild population management and ultimately rearing. Basic aspects addressed were gonad and gamete structure, nature of vitelline reserves, and composition of oocyte coat. Stereological counts and oocyte measurements were performed to obtain a quantitative assessment of the reproductive cycle from June 1999 to June 2000.

No simultaneous hermaphrodites were observed. The gonad structure of *M. crenulata* consisted of traversing trabeculae from which gametes developed centrifugally. The gonads of both males and females were homogeneous, allowing reliable data to be obtained from a single histological sample of each individual. Mature gametes greatly dominated the profile throughout the study period; coated oocyte diameters were also very stable. These techniques, routinely applied to the study of reproductive cycles, did not allow the identification of spawning preparedness in this species.

Vitelline reserves were dominated by non-staining (putatively lipid) vacuoles; no appreciable quantities of glycogen were observed. The oocyte coat was chiefly composed of acid mucopolysaccharides, conferring both mechanical and antimicrobial protection, as well as limiting egg and larval dispersal.

Mechanical design of mussel byssus

Emily CARRINGTON

Department of Biological Sciences, University of Rhode Island, Kingston RI, USA,
carrington@uri.edu

One key to the ecological success of mussels is their ability to maintain a secure attachment on wave-swept rocky shores. Mussels tether themselves to a solid substrate with a byssus composed of numerous extracellular, collagenous threads secreted by the foot. This study explores the mechanical design of *Mytilus* spp. byssus, from the materials of which they are made to the ecosystems in which they function. Each byssal thread is composed of two morphologically distinct regions, a corrugated proximal region and a smooth distal region, which also differ in molecular composition and mechanical properties. For example, the distal region is stiffer, stronger, but less extensible than the proximal region. When exposed to repeated subcritical loads, the high initial stiffness of the distal region is lost when loaded beyond its yield stress ($\sim 35 \text{ MN m}^{-2}$), but stiffness is recoverable over time (days/weeks). The overall strength of a byssus is determined not only by the material properties of individual threads, but also by the number of threads present, which in turn can vary temporally and spatially. To explore temporal variation in byssal attachment, the attachment strength of *Mytilus edulis* was measured quasi-monthly for over three years in Narragansett Bay, Rhode Island, USA. A strong seasonal cycle was observed, with a two-fold increase in attachment strength in winter compared to summer. The variation in mussel attachment strength generally mirrored seasonal changes in offshore significant wave height, suggesting that mussels compensate their attachment in response to changes in their flow environment. However, reproductive effort of the same population also varied seasonally, with peaks in gonad development coinciding with troughs in attachment strength. Thus seasonal variation in mussel attachment may not simply be due to a response to prevailing wave conditions, but may also reflect an energetic trade-off between byssal thread production and gonad development. The strength of mussel attachment relative to the force it encounters is an important biological parameter in the prediction of dislodgment rates of mussels by waves. It is therefore important to understand the causes of variable attachment strength in order to make confident predictions of how long-term shifts in wave climates affect mussel populations and ability to control rocky shore community structure.

Bio-remediation of nutrient-enriched ditch systems

Robert L. CATHCART, Anna L. MCIVOR and David C. ALDRIDGE

Aquatic Ecology Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK, rlc32@cam.ac.uk

Ditches the world over represent important habitats for aquatic flora and fauna of conservation importance. However, all too frequently such sites are degraded by cultural eutrophication with a consequent loss of diversity. This study is examining the effects of excessive nutrient enrichment on the ditch communities of the Ouse Washes – an internationally important wetland in eastern England that is designated under the Ramsar Convention. Water chemistry data are being collected to investigate the current extent of nutrient loading in the system and to evaluate its effects on diversity. In addition, a number of potential mitigation techniques for buffering the effects of eutrophication are being assessed. Beds of local mussel species have been introduced to selected ditches and the impact of their filtering on phytoplankton biomass and composition is being investigated. Other treatments, including the use of limestone beds, vegetation filtration systems and food-web manipulation, are also being monitored to evaluate remediation potential.

A new Mediterranean species of *Thordisa* Bergh, 1877 (Mollusca: Nudibranchia: Discodorididae)

Juan Lucas CERVERA¹, Renato CHEMELLO² and Riccardo CATTANEO-VIETTI³

¹ Departamento de Biología Animal, Vegetal y Ecología, Facultad de Ciencias del Mar, Universidad de Cadiz, E-11510 Puerto Real, Spain, lucas.cervera@uca.es

² Dipartimento di Biologia animale dell'Università, Via Archirafi 18, I-90123 Palermo, Italy, chemello@unipa.it

³ Dipartimento per lo Studio del Territorio e delle sue Risorse, Università di Genova, I-16123 Genova, Italy, catta@unige.it

A new species of nudibranch mollusc of *Thordisa* Bergh, 1877 from North Eastern Sardinia (Mediterranean Sea) is described. The colour pattern of this species, as well as its external and internal anatomy is supplied. The brilliant red-orange body color and two lateral and irregular series of large darker patches defining areas with a high density of calcareous spicules; the higher number of gills and the absence of vaginal glands distinguish it from the remaining Mediterranean and Atlantic species belonging to this genus.

Characterization of some intestinal symbionts of edible snails: a first approach of the chemical substances consumed and released by the microflora

Maryvonne CHARRIER¹, Gérard FONTY², Brigitte GAILLARD-MARTINIE²,
Marie-Claire MARTIN¹ and Gérard ANDANT²

¹ Université de Rennes, UMR CNRS EcoBio 6553, Campus de Beaulieu, 35042
Rennes Cedex, France.

² CR INRA de Clermont-Ferrand – Theix, laboratoire de Microbiologie, 63122 St
Genès Champanelle, France.

The nutritional requirements of edible snails are little understood. Studies investigating the gut microflora and their role in host nutrition are most needed, both to manage protected species and to improve intensive rearing. We used culture-based methods on starved and lettuce-fed individuals of *Helix aspersa*, *H. lucorum* and *H. pomatia*. We performed counts of the total viable bacteria and searches for cellulolytic, acetogenic and methanogenic bacteria. Independent of species and nutritional status, viable counts of anaerobic bacteria ranged from 10⁷ to 10¹⁰ g⁻¹ tissue, in the distal intestine, whereas the anaerobic microflora was low in the digestive gland of starved snails, around 10² g⁻¹ tissue, but the counts increased up to 10⁵ g⁻¹ tissue with food and on aerobic media. No cellulolytic or methanogenic bacteria occurred in the gut. The non-stoichiometric ratio of H₂ consumption to acetate production suggested the absence of acetogens. Charrier *et al.* (2000) characterized 14 intestinal strains in the anaerobic gut lumen belonging to 10 genera, among which only one strict anaerobe and 13 facultative anaerobic species are found in *H. aspersa*. According to the 16S rRNA sequences, the strains are closely related to the genera *Buttiauxella*, *Citrobacter*, *Enterobacter*, *Klebsiella*, *Pantoea*, *Enterococcus*, *Lactococcus*, whereas the strict anaerobes was referred to *Desulfotomaculum guttoideum*, a sulfate-reducer. Two strains could not be assigned to a known genus. Starved *H. aspersa* showed the highest bacterial diversity with 5 strains, while in *H. pomatia* *Citrobacter* or *Lactococcus* predominated. In fed *H. pomatia* and *H. lucorum*, the diversity slightly increased. Substrate utilization and H₂ production were reported for all the strains and the main-end products of glucose fermentation were studied on the most interesting ones. Our findings led to classify helicid snails as hindgut fermenters. The importance of intestinal symbionts in the biology of these terrestrial gastropods is discussed.

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Dart shooting influences paternal reproductive success in the garden snail *Helix aspersa* (Gastropoda, Pulmonata)

Ronald CHASE and Michael A. LANDOLFA

Department of Biology, McGill University, 1205 Dr. Penfield Ave., Montreal,
Quebec, H3A 1B1, Canada, ronald.chase@mcgill.ca, landolfa@hotmail.com

In the accompanying paper (Rogers & Chase) we report that dart receipt promotes sperm storage in once-mated snails (*Helix aspersa*). Here we test an additional prediction from the hypothesis that effective dart shooting increases male reproductive success. We mated eventual mother snails sequentially to two potential fathers while observing the depth and duration of dart receipt. Once the mother had produced offspring, we assayed the paternity of each offspring using protein allozymes, which allowed us to calculate the percentage of offspring sired by each potential father. When the two sperm donors shot their darts equally well, either both shooting poorly or both shooting well, their reproductive successes were not significantly different. However, if the first-mated donor shot poorly and the second-mated donor shot well, the second donor fathered 60% of the eggs. This result corresponds well with the finding, reported in the accompanying paper, that once-mated snails stored 116% more sperm from successful shooters than from unsuccessful shooters. On the basis of that result, one would expect a successful shooter to fertilize 68% of the eggs in a competitive mating against an unsuccessful shooter, assuming a random selection of sperm. Therefore, results from the two studies strongly support the hypothesis that the dart is a device used by the sperm donor to increase its reproductive success in contexts where there is competition from other sperm donors. Previous work from this laboratory suggests a mechanism by which the dart can influence the fate of donated sperm (Koene & Chase 1998). The dart penetrates the recipient laden with mucus from a special gland located adjacent to the dart sac. Using an in vitro physiological assay, we demonstrated that the dart's mucus causes certain contractions in the female reproductive tract which likely facilitate the uptake of the spermatophore and protect allosperm from enzymatic digestion.

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Corbulidae (Bivalvia) of the Brazilian coast

Maria Júlia E. CHELINI¹ and Sônia G.B.C. LOPES²

Institute of Bioscience, University of São Paulo, Rua do Matão, tr. 14, n°101, 05508-900, São Paulo, Brasil, ¹jchelini@ib.usp.br, ¹sonialop@uol.com.br.

Corbulidae Lamarck, 1818 is found worldwide in tropical to temperate waters that range from marine to brackish salinities. We consider that, for the Brazilian coast, Corbulidae is represented by one genus, *Corbula* Bruguiere, 1797, distributed in four subgenus, totalling eight species: *C. caribaea* Orbigny, 1846, *C. lyoni* Pilsbry, 1897, *C. patagonica* Orbigny, 1846, *C. tryoni* E.A. Smith, 1880, *C. cymella* Dall, 1880, *C. dietziana* C.B. Adams, 1852, *C. cubaniana* Orbigny, 1846, *C. operculata* Philippi, 1849.

The identification of these species has been made based in characteristics of the shell, which are not always enough to identify small sized specimens.

Anatomical studies of species of this family are restricted to *Corbula gibba* Olivi, 1792, *C. crassa* Reeve, 1843, and *C. caribaea*, the only one occurring in Brazilian waters. The present work has the purpose of redescribing the species of the Brazilian coast, examining the variations presented by the shell in different growth stages and, if necessary, the anatomy of the organs of the pallial cavity. The animals used in this work were collected on the Brazilian coast, having in mind that only specimens of *C. caribaea* and *C. cubaniana* are being analysed alive.

Considering only the characteristics of the shell it had been possible to unmistakably identify *C. lyoni*, *C. cubaniana*, *C. patagonica* and *C. operculata*. Specimens classified as *C. caribaea* can be separated into two groups according to general shape of the shell, the presence or not of pallial sinus and the main differences of the hinge, especially for the left valve. Observations of free mantle margins and siphons confirm the existence of two distinct groups. Analysis of types and an anatomical study of the other Brazilian species are being made to complete the review of the Brazilian species in the genus.

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Factors affecting the feeding choices of *Helix aspersa* (Gastropoda: Pulmonata) and their use for diet optimisation

Laure CHEVALIER and Maryvonne CHARRIER

Equipe Physiologie et Ecophysiologie, UMR 6553 "EcoBio", Université de Rennes I, Avenue du Général Leclerc, 35042 Rennes Cedex, France, Laure.Chevalier@univ-rennes1.fr

Helix aspersa is faced in its natural environment with constraints that limit its locomotion (energetic cost of mucus production) and its periods of activity (climate). Feeding decision has a dramatic importance for this species submitted to several dormant stages during its life. Studying the diet of two populations of *Helix aspersa* by the observation of plant epidermis and grasses phytoliths in the faeces, we tried to explain the feeding choices of this species, focusing on chemical factors that could characterize the plants:

The ICP-MS analysis of 3 appetent and 3 rejected plants highlighted the importance of inorganic nutrients and especially calcium and zinc. The RMN analysis of the same plants pointed out their richness in sugars and especially glucose, fructose and sucrose.

The feeding behaviour of snails and the position of chemoreceptors in contact with the food substrate suggested that the chemicals present on the leaf surface (phylloplane) could influence the snails feeding choices. These chemicals were collected at the leaf surface of *Urtica dioica* and *Picris echioides* by water spraying and tested on the snail during choice trials. We found them to be attractive for this species. Thanks to the GC/MS analysis of the solutions, we isolated the major primary metabolites (amino acids, sugars, alcohols, organic acids) of these plants.

Some secondary metabolites have often been reported as deterrent for terrestrial molluscs. During repeated seven days choice trials in the laboratory, we tested the feeding choices of *Helix aspersa* faced with 3 chemotypes of *Lupinus albus* differing in their quinolizidine alkaloid contents. Snails were repelled by the bitter chemotype. This reaction raised in time, evolving like an aversive ingestive conditioning.

These results revealed that chemical factors, both organic and inorganic, are susceptible to facilitate the feeding decision of *Helix aspersa* in term of reaction delay and security of diagnostic. Moreover, it seems likely that they act synergistically so that feeding choices exerted by snails should lead to the optimisation of the diet available.

Diversity of larval trematodes infecting freshwater gastropods from the Highveld and Lowveld areas of Zimbabwe

Givemore CHINGWENA¹, Samson MUKARATIRWA¹, Thomas K. KRISTENSEN² and Moses CHIMBARI³

¹ University of Zimbabwe, Department of Paraclinical Veterinary Studies, Box MP 167, Harare, Zimbabwe

² Danish Bilharziasis Laboratory, Jaegersborg Allé 1D, 2920 Charlottenlund, Denmark

³ Blair Research Laboratory, Box CY573, Causeway, Harare, Zimbabwe.

Between November 1998 and October 2000 freshwater gastropods were collected every month from the highveld and lowveld areas of Zimbabwe in order to determine the diversity of larval trematode parasites they were harbouring. A total of 13789 gastropods, representing 10 species were collected from 21 sites and 909 (6.6%) were harbouring trematode parasites. Altogether, 8 morphologically distinguishable groups of cercariae were identified. *Bulinus tropicus* had the highest overall prevalence of infection (13%).

Echinostome was the most common type of cercariae recovered contributing 38.5% of all infections recorded. Schistosome cercaria were recovered mainly from the highveld and constituted 8.1% of all infections recorded. Amphistome cercaria contributed 37.8% of all infections recorded in gastropods and was recorded from both the highveld and lowveld regions with peak prevalence during the post-rain period (March-May). Occurrence of vivax cercaria and xiphidiocercaria was erratic. The main intermediate host for amphistome was *Bulinus tropicus*. Infections of *Bulinus globosus*, *Bulinus forskalii* and *Biomphalaria pfeifferi* with amphistome cercaria recorded in this study are new records in Zimbabwe.

The evolution of the Miocene oysters from the Transylvanian Basin and the north-western basins of Romania

Carmen CHIRA¹ and Mirela POPA²

¹ Babes-Bolyai University, Faculty of Biology and Geology, 1 Kogalniceanu Street, 3400 Cluj-Napoca, Romania, mcchira@bioge.ubbcluj.ro

² Babes-Bolyai University, Faculty of Biology and Geology, Palaeontology-Stratigraphy Museum, 1 Kogalniceanu Street, 3400 Cluj-Napoca, Romania, popamir@bioge.ubbcluj.ro

The evolution of the Miocene oysters from the Transylvanian Basin and five basins of the north-western Romania: Baia Mare, Borod, Simleu, Beius and Zarand is presented. All the data concerning the oysters mentioned from these basins and also the data of our research on all the species kept in the collections of the Palaeontology-Stratigraphy Museum from Cluj-Napoca are synthesized.

In the Transylvanian Basin, the Eggenburgian oysters are well represented in the western part of the basin (Alba Iulia area), in Cluj area (Petresti – Borzesti), and Corus (Corus Formation), by species of *Crassostrea* (*C. gryphoides aginensis*, *C. gryphoides crassissima*, *C. gryphoides gryphoides*) and species of *Ostrea*. *Crassostrea gryphoides aginensis* has previously been reported only from Borod basin, belonging to western basins. The *C. gryphoides aginensis* zone in the Upper Egerian formations was also defined. Ottnangian oysters (Hida Formation - Transylvania) are represented by *Crassostrea gryphoides aginensis*, *C. frondosa*, *Cubitostrea digitalina*, in addition to previously reported *Ostrea duvergieri* and *O. granensis*.

Neopycnodonte navicularis is very well represented in the Badenian of the Transylvanian Basin and also in the western basins. One of the richest oyster assemblage was remarked in the Upper Badenian of Zarand Basin (Upper Badenian). *Neopycnodonte* is considered a deep water genus.

In the deposits of Borod Formation (Eggenburgian - Badenian) the oysters are relatively frequent, being represented by *Crassostrea gryphoides gryphoides*, *C. gryphoides aginensis*, *C. frondosa*, *C. frondosa dertocaudata*, *C. fimbriata*, *C. fimbriata crassa*, *Cubitostrea digitalina*, *Neopycnodonte navicularis*. Within the Sarmatian deposits, only *Crassostrea gryphoides sarmatica* is known, from the western Transylvanian Basin and from the southern Simleu Basin. *Crassostrea* is one of the most frequent species noticed in the entire Miocene sequence, being considered the most euryhaline oyster. *Ostrea* is very frequent in Badenian deposits and prefers brackish waters of higher salinities than *Crassostrea*.

A 3D model to estimate shell-tube overlap in coiled gastropods

Roberto CIPRIANI

Departamento de Estudios Ambientales, Universidad Simón Bolívar, Caracas,
Venezuela. Mail: CCS 91392, 4440 NW, 73rd Av., Miami, FL 33166, USA.
rcipri@usb.ve

During the evolution of gastropods, calcareous microstructures high in organic content have become less common (Palmer 1983, 1992). Experimental evidence suggests that the cost of skeletal construction can be so important for the energy budget of gastropods (*e.g.* Palmer 1981) that a trade-off might well exist between shell growth and body growth. However, few studies have attempted to relate the economy of shell construction to its geometry. Heath (1985) designed a two-dimensional model to test the overlap of the shell-tube against an optimal value, defined as the ratio of the area of shell material to the volume (tube lumen) enclosed. He concluded that the actual amount of overlap in a number of British gastropods, was greater than that expected by his optimality criteria. Here, I introduce a three-dimensional model to study the overlap of the shell-tube. In this model, a regularly coiled shell is parametrized into a geometrically simple and scaled three-dimensional shape, constructed by aligning sections of the shell tube transversal to the growth trajectory. Overlapping regions obtained from cross sections of actual shells are mapped on the upper surface of the parametrized shape, by defining their position on the aperture and their arc-length on the aperture's border. Given the properties of this parametrized shape, few regions can be used to estimate the overall amount of shell-tube overlap. The model demonstrates that differences in shell thickness determine the economy of shell material when the shell-tube overlaps during growth. Moreover, the economy of shell construction depends on the trade-off between overall shell thickness and shell overlap, and hence, on the overall geometry of the gastropod shell.

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Type-species of the mollusk collection of Museu Nacional, Rio de Janeiro, Brazil

Arnaldo Campos dos Santos COELHO, Norma Campos SALGADO, Júlio César MONTEIRO and André Favaretto BARBOSA

Malacologia, Museu Nacional/ UFRJ. Quinta da Boa Vista, s/nº, São Cristóvão, cep. 20940-040, Rio de Janeiro, RJ, Brasil, malacomn@mn.ufrj.br

The type-species are presented from the Mollusk Collection of Museu Nacional, the oldest Brazilian scientific research Institution, founded in 1818, entailed to the Universidade Federal do Rio de Janeiro (UFRJ). The Collection, one of the most important and representative of South America, disposes on 23.032 registered lots and about 20,000 more being processed, including shells and specimens with soft parts, from national and international origins. The type-material is constituted by species of Gastropoda (marine: 66; terrestrial: 31 and freshwater: 5), Bivalvia (marine: 7 and freshwater: 2) and Cephalopoda (2), correspondents to studies carried out since the end of the 19th Century by eminent Brazilian and foreigner researchers.

Mechanisms and sites of processing and selection of large particles in *Crassostrea gigas*

Bruno COGNIE, Laurent BARILLÉ and Peter G. BENINGER

Isomer, Faculté des Sciences, Université de Nantes, 44322 Nantes Cédex 03 France,
Peter.Beninger@isomer.univ-nantes.fr

The mechanisms and sites of processing and selection of large natural particles were studied in the oyster *Crassostrea gigas*, using 600 cells ml⁻¹ suspensions of intact (25%) and empty (75%) 150 x 200 µm *Coscinodiscus* sp. Video endoscopy was used to observe processing on the gill and to allow *in vivo* sampling of contents of the dorsal and ventral particle tracts, while individual flow-through chambers were used to sample pseudofaeces. Manual counts of intact *vs.* emptied *Coscinodiscus* sp. were performed on all samplings. The proportions of intact and empty cells in both the dorsal and ventral particle tracts were identical to those initially presented (χ^2 , $P > 0.05$, power=0.9, $\beta=0.1$). In contrast, the pseudofaeces contained over 98% empty cells (χ^2 , $P \leq 0.001$). These results show that (1) large natural particles within the size range naturally encountered are processed and undergo qualitative selection in *C. gigas*, (2) the site of selection is not the gill, but rather the peribuccal organs, probably the labial palps. Selection of such particles on the gill is precluded by their size, which prevents entry into the principal filament troughs and hence directs all particles to the ventral tract. Selection sites and mechanisms in bivalves should therefore be studied over the entire range of particle sizes naturally available.

Parallel losses of structure and function in gastropod development: Is the re-evolution of feeding larvae from direct developers possible?

Rachel COLLIN¹ and Oscar CHAPARRO²

¹ Department of Zoology, The Field Museum, 1400 S. Lake Shore Dr., Chicago, IL 60605, USA, and Committee on Evolutionary Biology, The University of Chicago, 1025 E. 57th St., Chicago, IL 60637, USA, rcollin@midway.uchicago.edu

² Instituto de Biología Marina, Universidad Austral de Chile, Valdivia, Chile, ochaparr@valdivia.uca.uach.cl

In-depth studies of the function of the larval velum of feeding gastropod larvae have shown that two opposed bands of compound cilia act to capture food particles and a ciliated food-groove transfers the food to the mouth. These cilia also act to propel the larvae through the water column. The loss or reduction of the velum along with some other larval structures is generally observed in direct developing species.

Observations on the development of 70 species of calyptraeid gastropods combined with a hypothesis of their phylogenetic relationships demonstrates parallel modifications in direct developing species. Direct developing species lose the structure and function of the opposed band cilia on the velum, the velum itself, and the operculum, in that order. In addition the embryonic kidneys are greatly elaborated in direct developers. The extent of these modifications correlates with the branch lengths between the direct developing species and its nearest planktotrophic relative. In the closely related *Crepidula dilatata* and *C. fecunda* from Chile the direct developing *C. dilatata* embryos show minimal modifications in embryonic structure or function. Phylogenetic analysis demonstrates that planktotropy has re-evolved from direct development in this case.

Learning about mechanisms of mtDNA gene-order change from the caenogastropods: Major gene order change and gene order homoplasy

Timothy M. COLLINS¹, Timothy A. RAWLINGS² and Rüdiger BIELER³

¹ Department of Biological Sciences, Florida International University, University Park, Miami, FL 33199, USA, collinst@fiu.edu

² Department of Palaeontology, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK, T.Rawlings@nhm.ac.uk

³ Department of Zoology, Field Museum of Natural History, 1400 S. Lake Shore Drive, Chicago, IL 60605-2496, USA, bieler@fieldmuseum.org

Animal mitochondrial genomes are typically closed-circular molecules with a complement of 15 major genes (13 proteins, and two ribosomal RNAs) and 22 tRNA genes. These genomes are known to be models of economy, usually with little intergenic sequence. Although nucleotide sequences within animal mitochondrial genomes commonly evolve quite rapidly; changes in the order of mitochondrial genes tend to be rare. As a result, mitochondrial gene order changes, especially those involving major genes, have proven useful for diagnosing groups of organisms at higher taxonomic levels: phyla, classes, orders etc. The rapid rate of nucleotide sequence evolution, however, combined with the tendency to eliminate noncoding regions, means that telltale molecular traces of rearrangement are overwritten or deleted in these ancient comparisons. The molecular palimpsest has become obscured. We have discovered two cases within the caenogastropods that may be illuminating with regard to the mechanisms and frequency of mtDNA gene order rearrangement. In one case, we document a major gene order rearrangement within a genus of vermetid gastropods. We date this rearrangement, based on the fossil record and molecular calibrations, as the most recent well-documented major mtDNA gene order rearrangement in animals. Molecular traces of this rearrangement give clues as to mechanisms. In the second case we document a tRNA gene duplication that has created a rearrangement hot spot, and demonstrate that repeated changes in gene order have occurred within the caenogastropods at this site. We discuss mechanisms and patterns of mtDNA gene order rearrangement in light of these results.

Terrestrial gastropods from southern Nuevo Leon, Mexico

Alfonso CORREA SANDOVAL

Departamento de Biología, Instituto Tecnológico de Cd. Victoria, Tams. A.P. 175, C.P. 87010, Cd. Victoria, Tams, Mexico.

Forty genera, 67 species and 9 subspecies of terrestrial gastropods belonging to 20 families are recorded for the southern region of the state of Nuevo León. Fourteen species are new records. The families with more species are Spiraxidae (12) and Polygyridae (8). The species with greater distribution by localities are *Praticolella berlandieriana*, *Rabdotus alternatus* and *Helicina chrysocheila*.

Terrestrial gastropods from southern Tamaulipas, Mexico

Alfonso CORREA SANDOVAL

Departamento de Biología, Instituto Tecnológico de Cd. Victoria, Tams. A.P. 175,
C.P. 87010, Cd. Victoria, Tams, Mexico.

Forty six genera, 102 species and 12 subspecies of terrestrial gastropods belonging to 24 families are recorded for the southern region of the state of Tamaulipas. Thirty two species are new records. The families with more species are Spiraxidae (18), Polygyridae (11) and Helicinidae (10). The species with greater distribution by localities are *Praticolella berlandieriana* and *Helicina chrysocheila*.

Disappearing snails and alien invasions: the biodiversity/conservation interface in the Pacific

Robert H. COWIE

Center for Conservation Research and Training, University of Hawaii, Gilmore 409,
3050 Maile Way, Honolulu, Hawaii 96822, USA, cowie@hawaii.edu

Conservation of biodiversity requires sound scientific knowledge, appropriate management strategies, and a supportive socio-political environment. In this paper on non-marine snail conservation in the Pacific islands I focus primarily on the underlying science. We need to know: 1) which species occur where now; 2) which species occurred where in the past; 3) what their relationships are and where did they come from; 4) what determines their diversity; and 5) what do they do ecologically. In the islands of the Pacific there are probably around 5000 native land snail species that exhibit high levels of single island or single archipelago endemism. Freshwater species are far fewer and exhibit lower endemism. This diversity is declining rapidly in the face of habitat destruction and the impacts of alien species. There are probably 100-200 alien non-marine snails and slugs in the Pacific. Some of these are extremely widespread tropical "tramps". The rate of introduction of new alien species is not declining and may be increasing. The diverse and geographically structured native fauna is being replaced by a relatively small number of species introduced widely by people - the fauna is becoming homogeneous. The impacts of alien species must be reduced by eradication or control, if possible, and by comprehensive quarantine programs to prevent further introductions. An agenda for non-marine snail conservation in the Pacific, as elsewhere, depends on sound science that includes 1) new surveys of poorly known areas and poorly known taxa; 2) an understanding of phylogeography (native species) and sociobiogeography (alien species); and 3) ecological knowledge. This science must be developed and used in close collaboration with biodiversity managers, and within the constraints of local and global socio-political environments, which may change.

Comparative sperm ultrastructure in Bulimulidae (Gastropoda, Stylommatophora)

María Gabriela CUEZZO

Facultad de Ciencias Naturales-CONICET, Universidad Nacional de Tucumán,
Miguel Lillo 205, 4000 Tucumán, Argentina, mcuezzo@unt.edu.ar

The fine structure of mature spermatozoa from different species of Bulimulidae were studied and described with the aid of electron microscopy. The spermatozoa were obtained from adult specimens of the genera *Drymaeus*, *Bostryx*, *Spixia* and *Plagiodontes*, that are classified in two different subfamilies: Bulimulinae and Odontostominae. The results show that the spermatozoon in this family exhibits the characteristic features of euthyneuran gastropod sperm: 1) acrosome composed of apical vesicle and acrosomal pedestal; 2) nucleus helically keeled with basal invagination containing dense plug/ periodically banded coarse fibres; 3) midpiece formed by axoneme and glycogen helix enclosed by matrix and paracrystalline materials of the mitochondrial derivative (Healy 1988, Healy & Jamieson 1989). Most conspicuous characters of Bulimulidae sperm are: acrosomal pedestal cylindrical, short, with irregular transverse striations and an electron-lucent central zone in longitudinal sections; perinuclear sheath with granulose material of variable density, usually thicker in Odontostominae; acrosomal complex sometimes reflected from the nuclear apex; nuclear apex truncated; nucleus straight or curved; presence of a single glycogen helix in sperm midpiece. Terminal sperm portion without axoneme and glycogen helix which are replaced by glycogen-like granules and membranous deposits. Differences among the species studied are based mainly on measurements of acrosomal complex and nucleus. The results on spermatozoa ultrastructure are compared with previous studies in Bulimulidae (Cuezzo 1995) and with spermatozoa from other stylommatophoran families.

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Analysis of reproductive and ecological aspects of allopatric populations of *Biomphalaria tenagophila*

Conceição Aparecida DA SILVA¹ and Toshie KAWANO²

¹ Departamento de Biologia/Genética, Instituto de Biociências, Universidade de São Paulo, Brasil.

² Laboratório de Parasitologia, Instituto Butantan, São Paulo, SP, Brasil, tkawano@usp.br

Biomphalaria tenagophila is one of the three intermediate host of schistosomiasis in Brazil. This species has a large occurrence in São Paulo state (Brazil). In this project four allopatric populations of *B. tenagophila* from the state of São Paulo were analyzed and aspects of their reproduction and ecology were compared. Crossing experiments were carried out using the recessive factor of albinism as a genetic marker. The albino population was from Taubaté, and the pigmented populations were from Taubaté, Bananal, Itanhaém and Pedro de Toledo. Those localities were separated by a distance of about 100 km. Results from cross-fertilization and self-fertilization experiments were analyzed for various factors, including the diameter of the snails at first egg laying, the average age at first egg laying, the number of egg masses and the number of eggs. These comparative analyses were used to understand evolution, especially to determine if the geographic distance is interfering with the process of cross-fertilization between populations. Some differences in reproductive biology were observed among these populations: the albino population from Taubaté had the largest shell diameter at first egg laying. The pigmented population from Taubaté had the highest reproductive performance.

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Monoclonal and polyclonal origin of the musculature of *Patella* (Gastropoda): implications for studying evolutionary relations

Peter DAMEN and Wim J.A.G. DICTUS

Department of Developmental Biology, University Utrecht, Padualaan 8, 3584 CH, Utrecht, The Netherlands, W.J.A.G.Dictus@bio.uu.nl

Based on descriptive studies, it has been relatively well established that the mesoderm in molluscs is derived from two distinct sources. The first is the endomesoderm, which is formed from one of the third generation macromeres. The second is the ectomesoderm, which is formed from first, second and/or third quartet micromeres. In spite of the wealth of descriptive data, detailed studies exactly describing the origin and fate of the mesodermal precursors are scarce. Therefore, injectable cell-lineage tracers were used to study the cellular origin and fate of the mesodermal precursors in the primitive gastropod *Patella*. To this aim early cleavage stage blastomeres were injected with a fluorescent dye. Muscle differentiation in 48 h old larvae was used as a marker to identify mesoderm. The development of the musculature in the larva of the gastropod *Patella* has been well described in the literature. In 48 h old posttorsional larva several muscles are present, *i.e.* the main larval retractor, the accessory larval retractor, the pedal plexus, the velum muscle ring, and the adult shell muscles. Apart for these previously described muscles an until now undescribed muscle was identified. This newly-described muscle seems to be an antagonist of the main larval retractor, and as such responsible for the extension of the larva out of its shell. Therefore this muscle has been called the larval extensor. The contribution of the injected early cleavage stage blastomeres to all these muscles was determined and the following mesodermal precursors were identified, *viz.* the 2b-, 3a-, 3b-, and 4d-micromeres. Most muscles were found to have a polyclonal origin, *i.e.* they were formed from two or more precursors. However, one muscle was found to have a monoclonal origin. The results are compared to cell-lineage results obtained in other species in order to study phylogenetic relationships.

Distribution of the golden mussel *Limnoperna fortunei* (Dunker, 1857), after 10 years of american invasion

Gustavo DARRIGRAN¹ and Guido PASTORINO²

¹ Facultad Ciencias Naturales y Museo, Paseo del Bosque, 1900 La Plata, Argentina, invasion@way.com.ar ; www.way.com.ar/~invasion

² Museo Argentino de Ciencias Naturales, Av. A. Gallardo 470, 3° piso, lab 57, C1405DJR Buenos Aires, Argentina, rvpastor@criba.edu.ar

The objective of this communication is to provide information on the invasion of the mytilid *Limnoperna fortunei* (Dunker, 1857) in the Americas and to update its distribution in the Neotropical Region. *Limnoperna fortunei* or golden mussel, is native from rivers and creeks of China and Southeastern Asia. It invaded Hong Kong in 1965 and, Japan and Taiwan in the 1990ies. Darrigran & Pastorino (1995) demonstrated the non-intentional introduction of this species into America in 1991, through ballast water of oceanic vessels. The following features point out *L. fortunei* as invasive species: high biotic potential: In 1991, when it was first detected its density was 4-5 indiv. m⁻². Today in the same environment, its density is approximately 150000 indiv. m⁻²; niche exclusivity: It is the only epifaunal bivalve to achieve these high densities in the area; selected problems: caused both to natural and human environments. Most of the problems caused by *L. fortunei* in South America are similar to those described for *Dreissena polymorpha*, the zebra mussel, in the Northern Hemisphere. In 1991 the golden mussel was introduced into the Americas through the Río de la Plata. Eight years later (11/1999) *L. fortunei* was detected in Rio Grande do Sul, Brazil. In February 2001 it was found at four localities along the Uruguay River, in March it was collected at the Itaipu hydroelectric power plant, on the Paraná river. This binational (Brazil-Paraguay) plant is amongst the largest in the world. Considering all the above distribution changes through time, the golden mussel has moved forward over 240 km per year since its introduction. From 1991 to present it has settled over 2000 km along the Río de la Plata Basin.

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New data on Late Miocene viviparids (Gastropoda, Architaenioglossa) from Ukraine

Ludmila N. DATSENKO

Melitopol Pedagogical Institute, Lenin Str., 20, Melitopol, Zaporozhskaja reg.,
Ukraine

The results of revision of the Viviparidae *s. l.* from the Upper Miocene deposits of Southern Ukraine is presented. One subgenus, one species and two subspecies are described as new. Seven species of the superfamily Viviparoidea Gray, 1847 are present in the Sarmatian and Maeotian deposits of the Ukraine. Four of those belong to the family Viviparidae - *Viviparus* (*s. str.*) *ucrainicus* Gozhik in Gozhik & Priszajhnjuk, 1978, *V. (Balcanipaludina) novorossicus* (Sinzow, 1897), *V. (B.) conoideus* (Mangikian, 1931), and a newly described species of the genus *Contectiana*. Three species belong to the family Bellamyidae Rohrbach, 1937 - *Sinotaia barboti* (Sinzow, 1884), *S. bugensis* (Gozhik in Gozhik & Pryszajhnjuk, 1978), and a newly described species of *Sinotaia*. Within the extremely variable and old genus *Sinotaia* Haas, 1939, a new subgenus is established. The phylogenetic relationships of all known species of this new subgenus are analysed. In addition, two new subspecies of the subgenus *Viviparus (Balcanipaludina)* are described. The paleoenvironment of Sarmatian and similar Maeotian deposits is briefly compared and paleogeographic implications are discussed.

Activity of predatory gastropods on the shells of Late-Oligocene (Egerian) molluscs collected from Wind Brickyard, Eger, Hungary

Arpad DAVID

Karoly Eszterhazy College, Department of Geography, Leanyka u. 6. Eger, H-3300,
Hungary, davida@ektf.hu

The clay-pit Wind Brickyard in Eger is well known as the stratotype of the regional Central Paratethys stage Egerian. The lithological sequence of the profile is as follows: (1) glauconitic, tuffaceous sandstone, (2) molluscan clay, (3) marine silty sandstone ("x" layer), (4) marine limonitic sandstone ("k" layer), (5) alternation of coarse sand, carbonaceous clay and a thin gravelly intercalation ("c" layer). These formations contain abundant molluscan fossils. 22065 specimens were examined, belonging to 189 species. Shells of bivalves, gastropods and scaphopods showed signs of the activity of predatory gastropods belonging to the families Naticidae and Muricidae. Mode of life, feeding habits of the prey molluscs, and the distribution of successful, unsuccessful (unfinished) borings were investigated and compared. The molluscs examined came from the following layers: molluscan clay, marine silty sandstone ("x" layer), marine limonitic sandstone ("k" layer), alternation of coarse sand, carbonaceous clay and a thin gravelly intercalation ("c" layer). Naticid boreholes were examined on the shells of molluscs collected from three different layers of Wind Brickyard. Traces of naticid predation occurred on the shells of bivalves, gastropods and scaphopods. Mainly gastropods were attacked by naticids. 998 boreholes were observed on 944 shells, with successful borings the most frequent. The rate of bored specimens is 4.44% in the samples examined with the number of borings low in samples from the Molluscan Clay. An increasing number of naticid borings were observed in molluscs of the "x" and "k" layers. Multiple naticid borings and "cannibalism" were also have been found. Suspension feeders and scavengers are dominant among the prey species of naticids. Occurrence of muricid drillholes on the shells of molluscs collected from four different layers of Wind Brickyard was examined. Traces of muricid predation were found on the shells of bivalves and gastropods. 220 borings were observed on 201 shells with gastropods the most common prey and successful borings were dominant. As with naticids, the number of boreholes was low on the molluscs collected from the Molluscan Clay with higher numbers in the "x" and "k" layers. The only layer where the number of unfinished borings was higher than the two other boring types was the "c" layer. Suspension feeders and scavengers were the main prey items of muricids.

Activity of boring bivalves in Early-Miocene (Carpathian) abrasion pebbles of two localities - a comparison (Nagyvisnyó and Dédestapolcsány, Bükk Mountains, Hungary)

Arpad DAVID¹ and Rozalia FODOR²

Karoly Eszterhazy College, Department of Geography, Leanyka u. 6. Eger, H-3300, Hungary, ¹ davida@ektf.hu, ² neaddfellia@yahoo.com

The *Gastrochaenolites* ichnogenus is formed by boring bivalves in calcareous substrates. Their characteristic club shaped trace fossils are dwelling structures (domichnia). Pebbles of two localities (Nagyvisnyó, abandoned limestone quarry and Dédestapolcsány, gravel pit) have been examined on the basis of the presence, abundance and distribution of *Gastrochaenolites* ichnogenus.

The reworked, black Permian limestone and dolomite pebbles belong to the Early-Miocene (Karpatian) Egyházasgerge Formation. Epoxy casts of the borings have been made in the case of pebbles of both localities. The number of examined pebbles is 32 from Nagyvisnyó and 42 from Dédestapolcsány. While the number of the observed bioerosional traces of boring bivalves is the following: 273 (Nagyvisnyó) and 232 (Dédestapolcsány). The following ichnospecies have been determined: *G. lapidicus*, *G. ampullatus*, *G. cluniformis*, *G. orbicularis*, *G. torpedo*, and *G. turbinatus*. The frequency of *G. lapidicus* and *G. torpedo* is significant in the case of both localities. Their predominance indicates a rocky shore with nips and bended surfaces.

Trail-following: an energy saving device in temperate and tropical gastropods

Mark S. DAVIES¹, Janine BLACKWELL¹, Sanjay NAGARKAR² and Gray A. WILLIAMS³

¹ Ecology Centre, University of Sunderland, Sunderland, SR1 3SD, UK, mark.davies@sunderland.ac.uk, janine.blackwell@sunderland.ac.uk

² Department of Ecology and Biodiversity, The Swire Institute of Marine Science, The University of Hong Kong, Pokfulam Road, Hong Kong, snagarka@hkusua.hku.hk, hrrbwga@hkucc.hku.hk

Proposed functions for mucus trail-following by conspecific gastropods are numerous and diverse. Some, such as homing, mate-finding and food-finding have been realised. But given the expensive cost of mucus production, trail-following per se may bring its own rewards in terms of a saving of energy as snails traverse a ready-laid mucus path. We investigated this by examining the quantity of mucus laid by "marker" and "tracker" snails of two different intertidal grazers: the temperate littorinid, *Littorina littorea* (L.) and the tropical trochid, *Monodonta labio* (L.). Mucus quantity was estimated by measuring the thickness of freshly-laid trails using either an automated confocal microscope or a manual fluorescence microscope, each coupled with a fluorescent stain. For *Littorina littorea*, a single mucus trail was convex in profile, typically ~15 - 20 mm at its edges and ~35 mm at its centre. Double mucus trails were significantly thicker, typically ~25 mm at the edges and ~45 mm at the centre, but not twice as thick as single trails. On smooth surfaces, tracker snails laid ~25 % of the mucus laid by marker snails. Single and double trails were exposed on-shore and decayed at similar rates, such that after 1 week the trails were almost flat with thicknesses of ~8 and ~10 mm, respectively. When tracker snails were allowed to lay trails over single trails that has been exposed on-shore, the resultant trails were convex and had profiles approximating to a freshly-laid single trail. The deposition of mucus by the tracker snails was altered to produce this final profile, despite differences in the profile of the aged single trails. Single trails of *Monodonta labio* varied considerably in thickness, from 12 – 62 mm, and showed no consistent profile. Curiously, double mucus trails were thinner, ranging from 8 – 18 mm. We are unable to account for this by procedural errors and must assume that the tracker is either ingesting the mucus and then laying a thinner trail or none at all, or, more likely, the tracker is 'bulldozing' some of the marker trail away with the leading edge of its shell or foot. The results are discussed in terms of the ability and extent of gastropods to save energy by locomoting over old trails.

Phylogenetic relationships of euthyneuran gastropods: a consensus between morphological and molecular analyses

Benoît DAYRAT and Simon TILLIER

Laboratoire de Biologie des Invertébrés Marins et de Malacologie, Muséum National d'Histoire Naturelle, 55, rue Buffon, F-75005 Paris
Service de Systématique Moléculaire, Muséum National d'Histoire Naturelle, 43, rue Cuvier, F-75005 Paris. dayrat@mnhn.fr, tillier@mnhn.fr

The phylogenetic relationships of the Euthyneura were re-evaluated by morphological and molecular approaches. A morphological data matrix comprised a total of 77 characters and 75 genera (Dayrat & Tillier 2000, Dayrat & Tillier in press). Sequences of the D1 and D2 domains of the 28S rRNA were also analyzed for 31 euthyneuran species. These two data sets were not congruent according to an ILD test and were analyzed by parsimony separately. A Bremer's Combinable Component Consensus was used to obtain a new tree (Dayrat *et al.* 2001). Previous results of relationships (Salvini-Plawen & Steiner 1996) were greatly reduced, new clades were obtained, and new evolutionary histories of characters were proposed. The monophyly of Pulmonata was confirmed but Opisthobranchia remained paraphyletic among the clades Acochlidioidea, Pyramidelloidea, Runcinoidea, Sacoglossa, Umbraculoidea, Pleurobranchioidea, Nudibranchia, Cephalaspidea *sensu stricto*. In addition, one strongly supported new clade included the pelagic pteropods (Thecosomata and Gymnosomata) and the Anaspidea. Within the Pulmonata, the Systellommatophora and Stylommatophora are grouped in a clade called Geophila; the ellobiids and Geophila could constitute a clade called Eupulmonata; and the monophyly of the clade Hygrophila, including Chilina, is well confirmed by molecular data.

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Land snail species diversity among three rainforest sites in southern Cameroon

Anton J. DE WINTER

National Museum of Natural History, P.O. Box 9517, 2300 RA Leiden, The Netherlands, winter@nmm.nl

The land snail faunas of three localities in a rainforest area in SW Cameroon, located within the triangle Bipindi-Lolodorf-Akom II, were compared. These sites are at most 30km apart and differ in altitude (100-800m) and degree of disturbance by agriculture and commercial logging. Each site covers a broadly equal surface (c. 100 ha), and includes a similar range of natural habitats (swamp forest, dry forest, large rock outcrops, etc.). De Winter & Gittenberger (1998) described the fauna of one site in some detail. The other sites include patches of fallow land and young secondary forest following agricultural activities, and a cocoa plantation. Collecting was done in 89 plots (23-36 plots per site) of 20 m x 20 m each by timed-searching and semi-quantitative sampling of leaf-litter and understorey vegetation, resulting in 7741 specimens that belong to at least 134 morphospecies. This probably gives a fairly complete picture of the faunas. Nine species were restricted to strongly disturbed plots, mostly in large numbers. These are considered anthropochorous, not locally native, taxa. Species richness in undisturbed forest is high (up to 45 species per plot), but numbers of individuals are low (De Winter & Gittenberger 1998). Numbers of indigenous species per site ranged from 69 to 98. 42 species (34%) were found in all 3 sites, 43 (34%) were shared by 2 sites, and 40 species (32%) were found in one site only. Because of the large proportion of rare species, the 3 sites were also compared with respect to the 15 most common native species of each site. Of the resulting list of 38 species (present in >35% of plots and/or represented by >1.7% of the individuals in any of the sites), 20 occurred in all 3 sites, 13 in 2 sites, whilst 5 species were restricted to 1 site.

Of 125 native species, 50 (40%) inhabited also strongly disturbed plots (fallow land, cocoa plantation, young secondary forest); the remaining 75 species were collected from the less disturbed forest habitats only. The impact of selective commercial logging (1-2 trees/ha) seemed limited, although the low altitude site, which has been logged repeatedly in the past, had the lowest number of species of the 3 sites studied. The cocoa plantation was inhabited by a substantial number of both anthropochorous and indigenous species (38).

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Intersex and sterility in the periwinkle *Littorina littorea* (Mollusca: Gastropoda) along the western Scheldt estuary, The Netherlands

Hans DE WOLF¹, Wim DE COEN¹ and Thierry BACKELJAU^{1,2}

¹ University of Antwerp (RUCA), Department of Biology, Groenenborgerlaan 171, B-2020 Antwerp Belgium

² Royal Belgian Institute of Natural Sciences, Malacology Section, Vautierstraat 29, B-1000 Brussels, Belgium

In this study we present the results of an intersex survey of *Littorina littorea* along the heavily polluted Western Scheldt estuary (the Netherlands), and record for the first time the intersex phenomenon in *L. littorea* from Dutch waters. *Littorina littorea* was collected at six sites along the estuary. At each site 40 animals were collected in the mid-littoral zone on a rocky surface. Only those specimens were included that had reached sexual maturity (shell height above 12 mm). The animals were sexed based on the presence of the vesicula seminalis. Intersex females were attributed to either one of the four intersex stages and the intersex index (ISI) was calculated according to Bauer *et al.* (1995). Intersex incidence differed significantly between the different sites and was highest in the vicinity of the harbour of Antwerp and Vlissingen, as reflected by the ISI distribution along the estuary. Female sterility did not differ between sites, but nonetheless, followed the ISI distribution as well, ranging from 0 to 33%. In contrast, the mean penial gland distribution did not follow the ISI or sterility distribution, and did not differ from site to site. Despite the current ISI levels are high (maximum=1.26), they are still much lower than the ISI levels reported for *L. littorea* in some German harbour areas.

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Heavy metal levels in the sediments of four Dar-Es-Salaam mangroves: accumulation in and effect on the morphology of the periwinkle *Littoraria scabra* (Mollusca: Gastropoda)

Hans DE WOLF¹, Shadrack ULOMI², Thierry BACKELJAU^{1,3} Harish B. PRATAP² and Ronny BLUST¹

¹ University of Antwerp (RUCA), Department of Biology, Groenenborgerlaan 171, B-2020 Antwerp Belgium

² University of Dar Es Salaam, Department of Zoology and Marine Biology, Dar Es Salaam, Tanzania

³ Royal Belgian Institute of Natural Sciences, Malacology section, Vautierstraat 29, B-1000 Brussels, Belgium

Heavy metals (*i.e.* Ag, Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr, Zn) were determined in the soft tissue and shells of the littorinid *Littoraria scabra* and in the sediments of four mangrove areas (*i.e.* in order of increasing pollution load: Msimbazi, Mtoni, Kunduchi and Mbweni), along the Dar-Es-Salaam coastline where *L. scabra* was collected. Metal levels were compared (1) between the four sites and (2) with sediment metal levels, which were measured a decade ago in the Msimbazi mangrove. Several metals accumulate preferentially in the animals soft body parts (*i.e.* Cr, Cu, Mn, Sr, and Zn), but do not seem to affect the shell morphology of this species. Sediment metal levels, measured in the direct vicinity of Dar-Es-Salaam (*i.e.* Msimbazi) have increased dramatically over the last decade. This increase is most obvious for Al (from 530 to 6375 µg/g dry weight), Fe (from 630 to 3539 µg/g dry weight) and Cr (from 2.7 to 10.1 µg/g dry weight). Nonetheless these levels are still lower compared to metal sediment levels reported in polluted European and American estuaries. Soft tissue metal levels detected in *L. scabra* are, nevertheless, with the exception of Cr and Zn, comparable to metal levels reported in other gastropod species.

Conserved developmental gene regulatory systems expressed in *Haliotis asinina* larvae: insights into spiralian evolution and development

Bernard M. DEGNAN

Department of Zoology and Entomology, University of Queensland, Brisbane,
Queensland 4072, Australia

Developmental gene expression patterns in insects and vertebrates demonstrate that radically different animals use a remarkably similar genetic repertoire. How can the formation of disparate metazoan architectures be controlled by effectively the same genes? Molluscs, along with their spiralian allies (*e.g.* annelids, sipunculans, echiurans), provide a unique comparative system to address this question. Despite having a diverse range of segmented and unsegmented adult body plans, spiralian share a number of embryological and larval characters that appear to have been derived from a common ancestor. These include spiral cleavage with matching cell fate maps, an endomesoderm derived from a single founder cell, the 4d mesentoblast, and a trochophore-like larval stage. As a first step towards understanding the evolving role of conserved gene regulatory systems in molluscan and spiralian development, we are characterising a number of transcription factor gene families that are activated in the trochophore of the gastropod *Haliotis asinina*.

Of the highly conserved genes that are expressed in consistent patterns in bilaterian development, the Hox genes are arguably the most intensely investigated. This group of genes are clustered in the genome and expressed in nested and co-linear patterns along the anteroposterior axis of a range of bilaterians. The five anterior Hox genes in *H. asinina* (named Has-Hox1-5) are first expressed in the trochophore. Has-Hox2-5 are expressed in overlapping and co-linear patterns in the neuroectoderm of trochophore and veliger larvae. Neuroectodermal expression of Has-Hox genes appears to reflect the direct patterning of the adult CNS from lineage-based embryonic processes. Has-Hox1 is expressed in the mantle margin throughout larval development and Has-Hox4 transcripts are detected in this tissue in mature veliger larvae, suggesting parts of the Hox code has been co-opted into gastropod shell formation. Comparison of Hox expression patterns in gastropods and annelids indicate that while the role of these genes in the developing CNS appears to be shared, there are a number of taxon-specific differences that may reflect the phyletic specialisations. Other transcription factor gene families are expressed in the *H. asinina* trochophore, including members of Mox, POU, Pax and brachyury families. Each gene is expressed in restricted morphogenetic fields that reflect both ancestral and novel roles in the formation of the gastropod body plan. Activation of these genes in the trochophore suggests that this is when morphogenetic domains for the adult body plan are first determined and patterned.

Populations of the European freshwater pulmonate *Physa acuta* are not reproductively isolated from American *Physa heterostropha* or *Physa integra*

Robert T. DILLON, Jr.¹, Amy R. WETHINGTON², J. Matthew RHETT¹ and
Thomas P. SMITH¹

¹ Department of Biology, College of Charleston, Charleston, SC 29424, USA,
Dillonr@cofc.edu

² Department of Biological Sciences, Biodiversity, and Systematics, University of
Alabama, Box 870345, Tuscaloosa, AL 35487, USA, amyw65@juno.com

It has long been speculated that the widespread and invasive *Physa acuta* of the old world may have originated in North America. But the identification of a new world cognate has been complicated by the confused systematics and taxonomy of the American Physidae. More than 40 species of physids are currently recognized in the United States, many with variable and overlapping morphology. We have previously established that sexual isolation is negligible among physid snails (Wethington *et al.* 2000). Here we report results from crosses involving populations of the widespread American *P. heterostropha* and *P. integra*, both with each other and with *P. acuta*, using a no-choice design. We tested two populations of each species, comparing interspecific measures of reproductive success to measures between populations within species, and within populations. *Physa acuta* were collected from France and Ireland, *P. heterostropha* from Philadelphia and Charleston, and *P. integra* from southern Indiana and northern Michigan. The six incross controls varied quite significantly in their survivorship, age at first reproduction, parental fecundity, F1 viability, and F1 fertility under our culture conditions. Measures of survivorship and reproduction in the six outcrosses were generally intermediate, but in no case significantly worse than the more poorly-performing control. Thus we report no evidence of reproductive isolation among our six *Physa* populations from two continents. All should be referred to the oldest available nomen, *Physa acuta* (Drap., 1805).

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Imaging gills and pallial organs of freshwater mussels (*Bivalvia*, *Unionoida*) by video endoscopy

Ronald V. DIMOCK, Jr.¹ and Richard A. TANKERSLEY²

¹ Department of Biology, Wake Forest University, Winston-Salem, North Carolina
27109, USA, dimock@wfu.edu

² Department of Biological Science, Florida Institute of Technology, Melbourne,
Florida 32901, USA, rtank@fit.edu

Video endoscopy within the pallial and suprabranchial cavities of bivalve molluscs reveals 3-dimensional morphological detail that cannot adequately be interpreted from histology or dissection. This presentation employs video imaging to document structural and functional differences in the architecture of gills and pallial organs of species in the Order Unionoida. These freshwater mussels are typical eulamellibranch bivalves in respect to the anterior-posterior tissue fusion of gill filaments, and the formation of water tubes within the demibranchs. However species of Hyriidae, Margaritiferidae and Unionidae differ significantly in details of the organization of inter-lamellar structures, and exhibit the 3 larval brooding conditions of unionoid bivalves. Glochidia larvae are held within inner (endobranchous hyriids), all 4 (tetragenous margaritiferids) or the outer demibranchs (ectobranchous unionids). Differential use of gills as marsupia includes variation in the inter-lamellar tissue connections characteristic of eulamellibranch ctenidia. Hyriids and margaritiferids have perforated inter-lamellar septa (or simple tissue bridges), whereas most unionids have numerous complete septa. Among anodontine unionids the marsupial water tubes are capped dorsally, creating sealed brood chambers. These and other anatomical details are readily resolvable with video endoscopy and provide new insight for functional and phylogenetic considerations.

Bacterial endosymbioses in the gills of marine bivalves: Overview and evolutionary perspective

Daniel L. DISTEL

Department of Biochemistry, Microbiology, and Molecular Biology, and School of
Marine Sciences, 5735 Hitchner Hall, The University of Maine, Orono, ME 04469-
5735, USA, distel@maine.edu

Endosymbiotic bacteria have been observed within the gills of a large number of bivalve species. These species are confined to a relatively small but extremely diverse collection of bivalve lineages. These include all examined species within the families, Solemyidae, Vesicomysidae, Lucinidae, Fimbriidae, Teredinidae, all examined members of the subfamilies Xylophaginae (family Pholadidae) and Bathymodiolinae (family Mytilidae) and many Thyasiridae. Symbiont species are also numerous and physiologically diverse, but are confined to only four well-circumscribed lineages within the gamma subdivision of the proteobacteria. I will provide a brief overview of these diverse symbioses and discuss examples in which molecular, phylogenetic, morphological, and physiological evidence may shed light on the evolutionary phenomenon of bivalve-bacteria gill endosymbiosis.

Morphological and anatomical description of some species of Phyllidiidae (Mollusca: Opisthobranchia) from Papua New-Guinea. (I)-The genus *Phyllidia*

Marta DOMÍNGUEZ¹, Jackie L. VAN GOETHEM² and Jesús S. TRONCOSO¹

¹ Departamento de Ecoloxía e Bioloxía Animal, Facultade de Ciencias, Campus de Lagoas Marcosende, Univ. de Vigo, E-36200, Spain, malvarez@uvigo.es, troncoso@uvigo.es

² Malacology Section, Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, Belgium.

The family Phyllidiidae Rafinesque, 1814, belongs to the Order Nudibranchia and the Suborder Doridacea (Gastropoda: Opisthobranchia), and their most important features are the absence of jaws, radula and dorsal gills. The gills are flat and are situated ventrally between the mantle and the foot, and the mantle generally has tubercles (Brunckhorst 1993).

These specimens were collected in Papua New-Guinea (in the tropical Indo-Pacific Ocean), where the coral reefs present the appropriate conditions for their life. Most of them were found for us in the low coral formation of Laing Island, which is located in Hansa Bay (Madang Province) on the northern coast of Papua New-Guinea, and the rest of the specimens (also from Papua New-Guinea) were loaned by the Royal Belgian Institute of Natural Sciences. In this communication we present the features of external morphology and anatomy of the species belonging to genus *Phyllidia* Cuvier, 1797. The species found are the following: *Phyllidia varicosa* Lamarck, 1801, *Phyllidia elegans* Bergh, 1869, *Phyllidia cf. elegans*, *Phyllidia celestis* Bergh, 1905, *Phyllidia cf. multituberculata* Boettger, 1918, *Phyllidia* sp.1 and *Phyllidia* sp.2.

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Molecular phylogeny of the Anomalodesmata (Bivalvia): initial results from 18S rDNA sequences

Hermann DREYER¹, Gerhard STEINER¹ and Elizabeth M. HARPER²

¹ Institute of Zoology, University of Vienna, Althanstr. 14, A-1090 Vienna, Austria, hermann.dreyer@univie.ac.at, gerhard.steiner@univie.ac.at

² Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK, emh21@cus.cam.ac.uk

The position of the Anomalodesmata within the Bivalvia is as enigmatic as the group itself. This taxon unites 14 morphologically highly divergent families with controversial phylogenetic relationships (Harper *et al.* 2000). Proposed sistergroups of the Anomalodesmata are the remaining Autobranchia, the pteriomorph Mytiloidea, the Heterodonta or, within the Heterodonta, the Myoida. We present preliminary results of parsimony and maximum likelihood analyses of a bivalve 18S rDNA dataset containing 13 anomalodesmatan sequences.

The monophylum Anomalodesmata and its origin within the Heterodonta is robustly confirmed. However, there is no support for a sistergroup relationship with the diphyletic Myoida. Instead, they emerge near the base of the heterodont line, between the carditid branch and the Lucinidae. The branching order within the Anomalodesmata is unstable and outgroup-dependent, probably due to their divergent sequences resulting in a long common branch. Monophyly of the Laternulidae and Cuspidariidae is well supported, the latter being robustly joined by the verticordiid *Policordia* and a clade uniting *Myadora* and *Cleidothaerus*. The only other well supported clade within the Anomalodesmata contains *Lyonsia*, *Pandora*, and *Brechites*. We hope that the low resolution will improve by adding more ingroup species. Despite the limited taxon sample, several discrepancies to the morphological tree of Harper *et al.* (2000) are evident and are being discussed. Supported by the Austrian Science Fund project P14356-BIO, and the Royal Society, London.

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The presence of predators modifies the larval development of *Fasciola hepatica* (Digenea, Fasciolidae) in surviving *Lymnaea truncatula* (Gastropoda, Lymnaeidae)

Gilles DREYFUSS, Philippe VIGNOLES and Daniel RONDELAUD

UPRES-EA n° 3174, Facultés de Pharmacie et de Médecine, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud@pharma.unilim.fr

The attack of a predator on *Lymnaea truncatula* often caused the death of the snail and could interrupt the larval development of *Fasciola hepatica*, as this lymnaeid species was known to be the main intermediate host of this trematode. However, the destruction of a snail population by predators was never complete and many snails could survive. As many animal species, such as the larvae of numerous sciomyzid species (Diptera) or the terrestrial snail *Zonitoides nitidus*, feed on *L. truncatula*, it was interesting to study the outcome of parasite larval forms in surviving snails. Bimiracidial infections of *L. truncatula* with *F. hepatica* were thus performed to study the consequences caused by the presence of predators (20 first-instar larvae of *Tetanocera arrogans*, 6 third-instar larvae, or 10 zonitid snails for 100 or 110 *L. truncatula*) on the characteristics of trematode larval development in surviving *L. truncatula*. Controls were constituted by infected snails that were not subjected to predators. Compared to controls, the survival rate at day 30 post-exposure, the duration of cercarial shedding, and the number of cercariae shed by surviving snails were significantly lower when predators were present in snail breeding boxes, whatever the type of predator used. In contrast, the prevalences of *Fasciola* infections in snail, and the lengths of time between exposure and the first cercarial shedding did not show any significant variation. Lower numbers of predators in the snail-breeding boxes inhabited by first-instar larvae or *Z. nitidus* were found at day 30 p.e. According to the authors, the progressive development of a stress reaction in surviving snails against predators during the 30 first days of experiment would have late effects on snail survival during shedding period and, consequently, on the number of cercariae shed by these snails. The decrease found at day 30 p.e. in the number of live sciomyzid larvae might be explained by a competition between these larvae for the same snails. The reduced number of live *Z. nitidus* (one per box) found in the other breeding boxes might be explained by the feeding behaviour of this predator which did not hesitate to attack and feed on the other snails of its own population.

Variations in gill morphology and symbiont presence in the Thyasiridae

Suzanne C. DUFOUR

Marine Biology Research Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0202 USA, sdfour@ucsd.edu

Through recent studies of chemosymbiosis in bivalves, progress was made in understanding relationships between the host and its bacterial symbionts; however, fundamental questions dealing with the evolution of symbiosis remain unanswered. To better understand the dynamics between symbiotic partners, as well as how anatomical features shared by chemosymbiotic bivalves have evolved, comparative approaches must be used. In particular, it is important to study groups in which the symbiotic characters seem less derived, as they may be representative of early symbiotic states. The family Thyasiridae appears to be a good candidate for evolutionary studies of chemosymbiosis: previous studies have independently shown that: 1) the family contains both species with and species without symbionts; and 2) gill structure within the family is highly variable.

Here, semi-thin gill sections and transmission electron microscopy are used to look at the distribution of symbiont presence and gill morphology within the family Thyasiridae. Specimens of 21 species, representing eight of the 11 extant genera, were obtained from the southern California coastal shelf, the Gullmarfjord in Sweden, as well as various museum collections.

The TEM observations have revealed that symbiont presence in this family is not phylogenetically constrained: although some genera have only symbiotic or non-symbiotic representatives, the genera *Thyasira* and *Axinopsida* have both. Furthermore, differences in symbiont abundance were observed among conspecific individuals.

Transverse, semi-thin sections of gill filaments were described and classified into four types based on differences in: 1) the degree of filament elongation along the frontal-abfrontal axis; and 2) symbiont location within bacteriocytes. There is no clear relationship between gill type and current thyasirid taxonomy, but gill type and symbiont presence appear to be linked. Within and between gill types, the amount of tissue available for symbionts varies, suggesting that symbiosis is plastic, and perhaps even facultative, in this family.

The results are discussed in terms of thyasirid phylogeny, and an anatomical sequence in symbiosis evolution is proposed.

Molluscan paleoecology and paleoenvironment of the Börzsöny Mts. (Hungary) at the beginning of the Miocene volcanism

Alfréd DULAI

Hungarian Natural History Museum, Department of Geology and Paleontology,
Budapest, P. O. Box 137, H-1431, Hungary, dulai@paleo.nhmus.hu

The Börzsöny Mts. are among the westernmost and oldest members of the Carpathian Volcanic Chain. The deposits directly underlying the volcanics belong to the Karpatian - Early Badenian. Prior to the volcanism and during the early phase, a littoral-sublittoral bay to the N, a swamp environment to the S, and a delta front to the E have been distinguished in the earlier literature. However, on the basis of previously described and newly found surface outcrops, I cannot see evidence for other than a shallow marine environment.

In the S, a rich sublittoral marine fauna was described from the Kismaros Tuff. The re-examination of the material shows that the preferred water depth is known for 20 species: 85% points to the infra- and circalittoral depth range, while 15% can be found only in the infralittoral zone. The Early Badenian age of the fauna was confirmed on the basis of nannoplankton studies. Near Kismaros, at Márianosztra village, a sublittoral marine fauna was described between the initial volcanoclastic layers.

In the E, Badenian tuffitic sand and sandstone were described in borehole Diósjenő-2. The Early Badenian, sublittoral fauna contains exclusively normal marine molluscs. W of Diósjenő village, on the E slope of Boros Hill a *Chlamys*-bearing coarse sand was found, overlain with undulating, disturbed contact by pumiceous volcanoclastics. At Szívzakasztó hillslope in the Nagy valley the well-rounded pebbles bear the marks of rock borer clams and are intercalated by fine-grained sand with *Ostrea* fragments. This clearly indicates a littoral environment and a rocky seashore in the vicinity. What is more, fossils, most frequently *Balanus* fragments and marine bivalves (*Isognomon*, *Venerupis*) as well as marine gastropods (*Gibbula*, *Nassa*) have been recovered from the initial, pumiceous volcanoclastic sequences. In the northernmost Hont Gorge, a thick Karpatian - Lower Badenian sedimentary succession underlying the volcanoclastics crops out. Nearby, beneath the volcanoclastics of the Bába Hill, pebbles of the underlying conglomerate also show the marks of rock borer clams, and the embedded mollusc fauna shows similarity to the Nagy valley fauna (*Isognomon*, *Ostrea*, *Anomia*, *Venus*, *Venerupis*, *Turritella*, *Balanus*, solitary corals).

Although the initial volcanism should have been submarine, the postulated shallow water had to be rapidly infilled, if the up to 200 m thickness of the fossiliferous volcanoclastic deposits is considered. This implies that the marine basin rapidly became a changeable coastal environment.

Body size of *Helix pomatia* in the natural and synanthropic habitats

Anna DYDUCH-FALNIOWSKA, Grzegorz CIERLIK, Malgorzata MAKOMASKA-JUCHIEWICZ, Wojciech MROZ, Joanna PERZANOWSKA, Stanislaw TWOREK and Katarzyna ZAJAC

Institute of Nature Conservation, Polish Academy of Sciences, Mickiewiczza 33, 31-120 Krakow, Poland, nozajac@cyf-kr.edu.pl

The Roman snail (*Helix pomatia* L.) is a central and East-European species, which occurs all over Poland from the Baltic Coast to lower situations in the mountains. It has been accepted that the southern part of the country belongs rather to the natural range of the species. Development of settlement, accompanying by deforestation of the country and breeding of Roman snails for culinary purposes, contributed to a considerable increase of its range in Poland. The average body size of *H. pomatia* is larger in southern Poland, in its natural range. Morphometric measurements of the Roman snail in the region of Małopolska (S Poland) have shown differences between specimens from different habitats. Snails inhabiting sites of natural and semi-natural character (forest margins, riparian forests, brushwood and meadows in river valleys and around water bodies) have large shell size. Individuals from suburban areas (urban parks, orchards, gardens, cemeteries, roadsides, railway embankments, neighbourhood of rubbish heaps and different pieces of wasteland, overgrown with ruderal vegetation, often in the vicinity of buildings) are smaller.

Few significant correlations between shell size in *H. pomatia* and the habitat types distinguished, their humidity, degree of naturalness, soil type and landscape patchiness was shown. The positive correlation for shell size was found with the variable "natural habitats" and negative with "built-up areas and rubbish heaps" and for shell width only - with "anthropogenic habitats". The shell slenderness coefficient is negatively correlated with leached and brown soils on sand and clay and "forests" and positively with leached and brown soils on loess.

Smaller shell size is connected with high landscape patchiness and areas in the vicinity of buildings (old parks, cemeteries, rubbish heaps, escarpments, flooding embankments, roadsides) - this result may be an effect of exploitation, or higher mortality of snails in synanthropic habitat in comparison with natural habitats.

***Clausilia dubia kaeufeli* Klemm 1960, a disjunct subspecies?**

Karl EDLINGER

Naturhistorisches Museum Wien, 3. Zoologische Abteilung, Burgring 7, A-1014
Wien, Austria, Karl.Edlinger@nhm-wien.ac.at

Clausilia dubia Draparnaud 1805 is a wide-spread European clausiliid species. In many parts of its distribution-area a remarkable intraspecific differentiation is observable. At the top regions of the eastern alps populations with miniaturized specimens occur. These populations were described by Klemm (1960) as the subspecies *Clausilia dubia kaeufeli*. Klemm described the form and morphological characters of the shells and suggested an uniform feature of this so-called subspecies. He suggested that *C. d. kaeufeli* occurs at altitudes of more than 1500 meters and in many cases at the same sites as the well known helicid snail *Cylindrus obtusus* (Draparnaud, 1805), an endemic species of the top regions of the Eastern Alps.

This was believed to be the consequence of a re-settlement of the top-regions by a well-established subspecies from the end of the ice-age on by Klemm.

On the other hand it is imaginable, that the massive occurrence of diminished specimens is a result of local differentiation processes, which happened more or less contemporary at many sites under similar ecological conditions.

Investigations of the variability of shell-characters by metrical and statistical methods in some populations of the so-called "sub-species" *Clausilia dubia kaeufeli* disclose remarkable metrical divergences and morphological differences within these populations on the one hand and between them on the other. In addition different accumulations of characteristics in various populations can be shown.

These results, which are corroborated by statistical evaluations, give rise to the question whether the characterization of *Clausilia dubia kaeufeli* as a subspecies, as suggested by Klemm (1960), can be justified.

A revision of the genus *Melanoides* (Prosobranchia; Thiaridae) in Lake Malawi including a description of the reproductive organs

Carolina M. ELDBLOM¹, Thomas K. KRISTENSEN¹, Joergen LUTZEN² and
Cornell DUDLEY³

¹ Danish Bilharziasis Laboratory, Jaegersborg Allé 1D, DK 2920 Charlottenlund
Denmark

² Department of Zoomorphology, University of Copenhagen, Universitetsparken 15,
DK- 2200, Copenhagen N, Denmark

³ Chancellor College, University of Malawi, Zomba, Malawi

In the present study a revision of the genus *Melanoides* (Gastropoda: Thiaridae) in Lake Malawi is given. The revision is based on the morphology of the shell and the radula. Five species of the parthenogenetic prosobranch genus *Melanoides* have been found represented in Lake Malawi. The large morphological variation within the *Melanoides* spp. in the lake has led to the conclusion that many of the species previously described are synonymous. The following species are now recognised in Lake Malawi: *Melanoides tuberculata*, *M. virgulata*, *M. simonsi*, *M. nodicincta* and *M. polymorpha*. Nine species were recognised in the lake before the present revision. One species has been re-designated to the fauna in comparison to previous studies. *Melanoides virgulata* was first described by Ferrusac in 1827 but was soon after considered synonymous with *M. tuberculata*. In this study, however, it is considered as an independent species because of the significant difference of both shell and radula compared to *M. tuberculata*. The study of the radula showed that it is significantly different in *M. tuberculata* and *M. virgulata* compared to the other species. Within the remaining species no significant difference is seen in the radula.

The study of the reproductive organs showed no species distinct characters, but contributes to the general conclusion that the genus *Melanoides* in Lake Malawi is morphologically highly variable. No males were registered during this study.

A "silver bullet" for zebra mussels: particle engineering for the control of freshwater pests

Paul ELLIOTT¹, David C. ALDRIDGE¹ and Geoff D. MOGGRIDGE²

¹ Aquatic Ecology Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK, pe206@zoo.cam.ac.uk

² Department of Chemical Engineering, University of Cambridge, Pembroke Street, Cambridge CB2 3RA, UK.

The Zebra Mussel, *Dreissena polymorpha*, is well documented as being one of the North America's most significant economic pests, annually causing billions of dollars of damage in industrial water intakes. Manual removal is temporary and expensive, leading to a huge industrial investment in additional preventative measures. Chemical treatments, particularly chlorination, are generally popular due to their effectiveness and low costs of installation. However, environmental legislation on discharge concentrations often impedes their use. Also, mussels can often counter the effects of these treatments by closing their valves upon detection of the chemicals, greatly reducing treatment efficiency.

The aim of this project is to develop a novel and efficient method for the control of Zebra mussels. We are doing this by producing toxins encapsulated in edible coatings. These toxic particles can be filtered and concentrated within the mussel, reducing the total quantity of toxin that must be applied. We are engineering the edible coatings to release their payload once inside the mussel, thus avoiding the mussels' defensive responses. The coatings will also have degradative properties such that upon environmental discharge, the toxin will have leaked out and been diluted to harmless levels. Initial tests look promising.

Diversity and distribution of Subulinidae (Gastropoda, Pulmonata, Achatinidae) from South Western Nigeria

O. Festus ENABULELE and O. Chris OKE

Zoology Department, University of Benin, Benin City, Edo State, Nigeria

Diversity and distribution of the gastropod land snails of the family Subulinidae in Southwestern Nigeria is studied. 18 taxa belonging to 7 genera were distinguished. *Subulina striatella* is the most widespread.

Palaeobiogeographical character of the Pliocene non-marine mollusc fauna from north-western Italy

Daniela ESU

Dipartimento di Scienze della Terra, Università "La Sapienza", P.le A. Moro, 5,
00185 Roma, daniela.esu@uniroma1.it

Rich assemblages of Pliocene freshwater and land molluscs are recorded by ancient authors (F. Sacco, E. Sismonda) and by recent researches in many sites of the Piedmont basin. The molluscs are often associated with Villafranchian vertebrate remains referred to Triversa Faunal Unit, at about 3Ma (base of Mammal Neogene zone MN16, Middle Pliocene). The main Villafranchian fossiliferous sites are located near Villafranca d'Asti (Asti), Fossano and Ceresole d'Alba (Cuneo) and Tassarolo (Alessandria).

New field researches carried out in the Piedmont area and new taxonomical revisions of Pliocene molluscs of Italy permit to have a better picture of the Pliocene mollusc fauna from north-western Italy and of its relations with coeval assemblages from the rest of Italian peninsula and Europe.

The Middle Pliocene assemblages of Piedmont are dominated by archaic land prosobranchs and pulmonates with a high degree of species diversity and are characterised by a high number of extinct taxa many of which not yet described.

A quite high number of extinct species is present (about two-thirds of the total) among which it is possible to distinguish:

- very few species with Mio-Pliocene chronostratigraphic distribution of Central European affinities;
- many species with a strictly Pliocene distribution, the majority of which shows a high endemic character being limited to the Middle Pliocene of the Piedmont basin; the others present a western-central European and Italian distribution;
- a few species of European origin with Plio-Pleistocene distribution which survive during Early Pleistocene in central Italy and central-western Europe.

At genus level the assemblages are characterised by some archaic thermophilous elements of Oligo-Miocene European origin.

Ecology and biology of nudibranchiate molluscs in the Trondheim fjord (Norway) and the Icefjord (Spitzbergen)

Jussi EVERTSEN and Jon-Arne SNELI

Trondhjem Biological Station, Norwegian University of Science and Technology, N-7491 Trondheim, Norway, jussie@stud.ntnu.no, jon.sneli@vm.ntnu.no

The nudibranch fauna of Norway has a long and proud history of investigations, beginning with the early descriptions of species by Ascanius, Müller and M. Sars in the period between 1770 and 1830. Later works on nudibranchs were merely the results of different expeditions and local investigations. It was not until the 1920's when Løyning and Larsen began their investigations upon the nudibranch fauna of the Drøbak Sound in the Oslo fjord that ecological aspects came into consideration in the study of the biology of Norwegian seaslugs.

The Trondheim fjord had long been in the interest of marine biologists, where the extensive studies began with bishop Gunnerus in 1760. But it was with the works of Storm, Norman and, in the first half of the 20th century, Odhner and Dons that the nudibranch fauna emerged from the depths of the fjord. So far 55 of the total 85 species recorded in Norwegian waters are known from the Trondheim fjord.

The area of Spitzbergen has also in the two previous centuries been repeatedly visited by different expeditions, but even though the nudibranch fauna is scarcely known, Mörch, Friele, Krause, Knipowitsch, Hägg, and Odhner have all published records of the 11 registered species between 1879 and 1915.

The nudibranch fauna of these two areas has not been studied since, but during these last years extensive studies have been conducted using scuba-diving technique and *in situ* observations, photography and collection. The results show a diverse nudibranch fauna with a wide range of biogeographic affinities in the Trondheim fjord, from Lusitanian and Boreal to Arctic species. Observations on associated prey species and spawning period for 40 species have been made, together with *in situ* pictures and radula examination of the species. At Spitzbergen, the Icefjord reflect a nudibranch fauna of primarily arctic species, and new information on the ecology of six of the previously 11 registered species is achieved. In view of the earlier works and the present investigation, a total list of previously recorded species and species new to the areas and the coast of Norway will be presented.

Shell morphogenesis of juvenile mytilid bivalves and phylogeny of Mytilidae

George A. EVSEEV, Olga Ya. SEMENIKHINA¹ and Natalya K. KOLOTUKHINA

Institute of Marine Biology FEB RAS, 17 Palchevsky Street, 690041 Vladivostok, Russia, ¹oja@mail.primorye.ru

Phylogenetic classifications of Mytilidae species, as well as bivalves on the whole are based on morphological features of adults. These features characterize the final stage of bivalve ontogeny in which a part of important phylogenetic features are lost and other characters are considerably changed by prolonged environmental influence. Morphological features of larvae and juveniles are not used to classify these molluscs. At the same time, features available in early stages of bivalve ontogeny, which considerably differ from the adult characters, would appear to be of great importance to comprehend bivalve phylogeny.

We examined the shell morphology of juvenile mytilids *Mytilus trossulus* Gould, *M. coruscus* Gould, *Crenomytilus grayanus* (Dunker), *Modiolous kurilensis* Bernard, *Musculista senhousia* (Benson), *Crenella decussata* (Montagu), *Septifer keenae* Nomura, and *Adula falcatoides* Habe from the Northwestern Pacific Ocean. Juveniles were both reared in the laboratory and picked out from benthic samples. Prodissoconch outlines, hinge morphology, and sculpture are the most important characters of the juvenile shells. According to these features, the taxa examined may be divided into three phylogenetic groups: the ovate shell taxa (*Mytilus*, *Crenomytilus*, and *Modiolus*), the D-shaped shell taxa (*Septifer* and *Crenella*), and the third, intermediate group of taxa (*Adula* and *Musculista*). In the first group, the taxa differ in ontogeny of primary and secondary lateral teeth, including anaboly of dysodont teeth. The D-shaped shell taxa are characterized by the diverse nepioconch and dissoconch sculpture and by the absence of definitive dysodont teeth.

Shell heterochrony of the mytilids studied is discussed, and a phylogenetic scheme of Mytilidae based on morphological features of juvenile shells is suggested. This scheme is compared to other classifications of Mytilidae based on conchological characters of adult molluscs, as well as molecular and ultrastructural data.

Anatomy and ultrastructure of the excretory system and mantle cavity of an acochlidian gastropod (Opisthobranchia)

Alexander FAHRNER and Gerhard HASZPRUNAR

Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München, Germany; kld1130@mail.lrz-muenchen.de

The anatomy and ultrastructure of the excretory system of an undescribed mesopsammic gastropod of the genus *Hedylopsis* have been examined by means of semithin serial sections, reconstructions, and transmission electron microscopy. The functional metanephridial system comprises a heart with a single ventricle and auricle in a spacious pericardial coelom as well as a single, large kidney. Podocytes in the pericardial epithelium that overlies the auricle represent the site of ultrafiltration and formation of the primary urine, whereas the flat epithelium of the kidney with extensive basal infoldings and an apical microvillous border serves to modify the primary filtrate. Solitary rhogocytes (pore cells) represent additional loci of ultrafiltration with an identical fine-structure as those of the podocytes (meandering slits with diaphragms covered by extracellular matrix). The presence of podocytes situated in the epicardial wall of the auricle is regarded as plesiomorphic for the Mollusca and is confirmed for the Acochlidia for the first time. Kidney and intestine both open into a small but distinct mantle cavity. This condition represents a primitive character within the Acochlidia only known from one further species. Special cells with a presumed absorptive function are interspersed between the epithelial cells of the mantle cavity. These cells are mainly characterized by a prominent invagination of the apical border with densely arranged, very long microvilli. The presence of a mantle cavity that has been lost in nearly all other acochlidian taxa supports the systematic placement of *Hedylopsis* sp. at the base of the Acochlidia.

Review of the Red Sea Phyllidiidae (Gastropoda: Nudibranchia)

Alexander FAHRNER¹ and Michael SCHRÖDL²

Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München,
Germany, ¹ kld1130@mail.lrz-muenchen.de, ² schroedl@zi.biologie.uni-muenchen.de

The phyllidiid fauna of the Red Sea has been investigated on the basis of specimens collected in the Gulf of Aqaba and of museum material, supplemented by literature data. Our review reveals eleven valid species, including the recently described *Phyllidia schupporum* Fahrner & Schrödl, 2000. Colour photographs and schematic drawings of all species clearly point out the characteristics of their dorsal colour patterns and facilitate their identification with the key presented herein. Whereas the phyllidiid genera are easily separated by external features such as the morphology of the oral tentacles, the colour of the rhinophores, the arrangement of notal tubercles, and the position of the anal opening, all single species can be identified due to their coloration and morphology of notal tubercles. With four out of eleven species (36%), phyllidiid endemism is high in the Red Sea. This is in contrast to recent palaeobiological theories of a post-glacial origin of the Red Sea coral reef fauna. The taxonomy, abundance, and biogeography of the Red Sea Phyllidiidae are briefly discussed.

The genus *Limax* in Corsica: An unexpected diversity and its threats (Gastropoda, Limacidae)

Gerhard FALKNER

Muséum National d'Histoire Naturelle, 55 Rue Buffon, F-75005 Paris, France.

Except for the widely distributed, often synanthropic, *Limax maximus* L. 1758, only two other species of *Limax s.str.* are listed for the Corsican fauna (Holyoak 1983, Réal & Réal-Testud 1988): *L. cinereoniger* Wolf 1803, also largely distributed in Europe, and *L. corsicus* Moquin-Tandon 1855, a species described from Corsica, to which an expanded Tyrrhenian distribution is attributed. The results of ten weeks of field work during 1999-2000 yielded the contours of a completely different picture of the *Limax* fauna of Corsica. Apart from *L. maximus*, the genus *Limax* is thus represented in Corsica by two separated species groups, which each exhibit a high differentiation into local forms. The two groups can be provisionally characterized as "*corsicus*-group" and "group of *unicolores*" (*L. cinereoniger* does not occur). The isolated populations in both groups are likely to represent all stages of polymorphism, polytypism, species in *statu nascendi*, and full species, which are characteristic for speciation processes on islands. Taxonomical discrimination has been based essentially on genital anatomy, especially the morphology of the penis tip which plays an important role in the simultaneous exchange of sperm, characters of the retractor muscle system, ontogenetical development of chromatic patterns, external morphology, and biological traits. One crucial key to the understanding of evolution mechanisms and species boundaries will lie in a comparative analysis of the extremely complicated copulation behaviour. Up to now it was possible to recognize five good species within the "*corsicus*-group" and four species in the "group of *unicolores*", which may each represent the centre of a Rassenkreis or be a final member of a ring species. *Limax corsicus* was rediscovered at its type locality. A comparison of the topotypes with Italian populations has shown that this taxon is specifically distinct at least from members of the "*corsicus*-group" in the surroundings of Massa Marittima (Falkner 1990) and Siena. *L. corsicus* is thus provisionally also accepted as one exponent of the endemic Corsican island radiation. Such a differentiated mosaic of unique and localized endemic species and forms is probably extremely sensitive to human influences. Many populations show clear signs of decline. The main threats are rural and urban development, the frequent forest fires, and wild pigs.

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Check-list of the non-marine molluscan species-group taxa of Northern, Atlantic and Central Europe (CLECOM Area I) and their distribution

Gerhard FALKNER¹ and Ted VON PROSCHWITZ²

¹ Bayerische Staatssammlung für Paläontologie und historische Geologie, Richard-Wagner-Str. 10/II, D-80333 München, Germany.

² Dept. of Invertebrate Zoology, Museum of Natural History, Box 7283, S-40235 Göteborg, Sweden.

The acronym CLECOM stands for "Check-List of the European Continental Mollusca". The project was launched under the umbrella of *Unitas Malacologica* to develop a database for the non-marine molluscs of Europe.

The area covered by CLECOM is defined as the geographical Europe, complemented by the Caucasian republics, Asiatic Turkey, Cyprus and the Macaronesian Archipelagoes. For practical purposes this huge area, with very uneven state of knowledge, has been divided into two sections. Section I comprises the faunistically rather well-known 23 countries of northern, north-western and central Europe: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Netherlands, Norway, Poland, Russian Federation (Region Kaliningrad), Slovak Republic, Sweden, Switzerland, United Kingdom. The remaining countries of the CLECOM area are defined as Section II.

In the summer 2001 a first, simple version of the database for the CLECOM I area has been made available on the Internet. The list is consultable on the homepages of the Museum of Natural History, Göteborg, Sweden (<http://www.gnm.se/clecom.htm>). A hard copy version of the database for Section I has also been made available (Bank & al. 2001). It is complemented by a supraspecific systematic classifier for the whole project area.

The database for the CLECOM I area contains presently valid names for approximately 900 species and 240 additional subspecies. Distributional information is given on the country level.

The extension to Section II will proceed hand-in-hand with the EU-launched Fauna Europaea project, which covers essentially the same area as CLECOM I + II, with the only exceptions of Asiatic Turkey and the Caucasian republics. For this extension an additional Advisory Board, which should geographically be as representative as possible, will be erected.

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Allozyme taxonomy of *Melanopsis* in Israel: a case of fine though consistent differentiation

Andrzej FALNIOWSKI¹, Joseph HELLER² and Magdalena SZAROWSKA¹

¹ Department of Malacology, Institute of Zoology, Jagiellonian University, R. Ingardena 6, 30-060 Kraków, Poland, faln@zuk.iz.uj.edu.pl

² Department of Evolution, Systematics and Ecology, The Hebrew University of Jerusalem, 91904 Jerusalem, Israel, heller@vms.huji.ac.il

Molecular differences among the species of *Melanopsis* distinguished by Heller and co-workers (Heller *et al.* 1999) were studied by means of cellulose acetate gel allozyme electrophoresis, on 26 *Melanopsis* populations from Israel: 6 of *M. buccinoidea* Olivier, 1801, 8 of *M. saulcyi* Bourguignat, 1853, 1 of *M. meiotoma* Heller et Sivan, 2000, and 11 of *M. costata* Olivier, 1804, represented by two subspecies: *M. costata costata* Olivier, 1804 and *M. costata jordanica* Roth, 1839. 14 loci (nine polymorphic) were scorable: Aat, Alp, Est-1, Est-2, Gpi, Hbdh, Idh-1, Idh-2, Iddh, Mdh, Mdhp, Mpi, Pgdh, and Pgm. Mean sample size was 28.983; mean number of alleles per locus: 1.45 (1.1-1.7); polymorphic loci per population: 36.5% (14.3-57.1); mean observed heterozygosity: 0.085 (0.041-0.121); mean expected heterozygosity: 0.112 (0.045-0.170). Linkage disequilibrium, homozygote excess, F-statistics and gene flow were estimated (Falniowski *et al.* in press). Nei genetic distance (0.000-0.232, mean 0.0761, no significant association with geographic distance) and Cavalli-Sforza & Edwards arc genetic distance (0.054-0.441, mean 0.240, significant association with geographic distance) were computed for pairs of populations. Interpopulation differences were analyzed phenetically (correspondence analysis, UPGMA), and phylogenetically (neighbor-joining and Fitch-Margoliash additive trees). The differentiation of the taxa was fine, nevertheless the results confirmed the conchometrical distinctness of *M. costata costata*, *M. costata jordanica* and *M. saulcyi*. The molecular variability of *M. buccinoidea* was wider than that of all the other studied taxa together, and overlapped the variation ranges of each. The taxon may be ancestral to the others. The position of *M. meiotoma* as a distinct species was not confirmed. It seems that speciation in the genus *Melanopsis* is a morphostatic one, and it is still uncompleted within the studied group.

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**Morphological and molecular changes during metamorphosis in
Utterbackia imbecillis (Bivalvia: Unionidae)**

Ginger R. FISHER¹ and Ronald V. DIMOCK Jr.²

¹ Biology Department, Adrian College, Adrian, Michigan 49221, USA,
gfisher@adrian.edu

² Department of Biology, Wake Forest University, Winston-Salem, North Carolina
27109, USA, dimock@wfu.edu

This study examines morphological and biochemical changes that occur as glochidia larvae of the freshwater mussel *Utterbackia imbecillis* metamorphose into juveniles. Metamorphosis encompasses two distinct stages. The first occurs during the first 3-4 days of metamorphosis and involves degeneration of the single larval adductor muscle and formation of the characteristic mushroom body by the larval mantle cells. These morphological changes are accompanied by an increase in DNA, RNA, and protein synthesis. The second stage occurs during the final 4 days of the metamorphic period, and involves formation of the major anatomical structures and organ systems of the juveniles. This stage also is accompanied by an increase in DNA, RNA, and protein synthesis.

**Ultrastructure of the mushroom body: digestion during metamorphosis
of *Utterbackia imbecillis* (Bivalvia, Unionidae)**

Ginger R. FISHER¹ and Ronald V. DIMOCK Jr.²

¹ Biology Department, Adrian College, Adrian, Michigan 49221, USA,
gfisher@adrian.edu

² Department of Biology, Wake Forest University, Winston-Salem, North Carolina
27109, USA, dimock@wfu.edu

Larvae of the freshwater mussel *Utterbackia imbecillis* metamorphose to juveniles either during their attachment to a host fish, or *in vitro* in a cell culture medium. This transformation includes degeneration of larval structures and development of juvenile morphology. Early in metamorphosis the cells of the larval mantle enlarge and project into the mantle cavity, forming a structure referred to as the mushroom body. Cells of the mushroom body are ultrastructurally very similar to digestive cells of adult bivalves. These larval mantle cells are involved in endocytosis of the larval adductor muscle and host tissue. Ingested material is passed from pinosomes to heterophagosomes, which in turn fuse with heterolysosomes where final degradation occurs. Acid phosphatase activity was detected in heterophagosomes and heterolysosomes of all animals examined. Larvae that underwent metamorphosis *in vitro* also exhibited acid phosphatase activity in the extracellular spaces among the cells of the mushroom body. Larvae reared on host fish accumulated lipids and glycogen within larval mantle cells during metamorphosis, whereas, larvae reared *in vitro* did not. The cells that constitute the mushroom body appear to be sites of intracellular digestion of the larval adductor muscle and host tissue during metamorphosis.

Constrains in developmental modes: adaptation or history?

Helena FORTUNATO

Smithsonian Tropical Research Institute, Box 169 Balboa, Panama,
fortunae@ancon.si.edu

Developmental trends are often related to latitudinal and bathymetric gradients, as well as differences in planktonic productivity. Moreover, the effects imposed by phylogeny on life histories can either direct the observed shifts in developmental types, or, at least, strongly constrain them. If adaptation is the major component, we would expect the same patterns to vary predictably over entire faunas across environmental gradients in planktonic productivity and seasonality. Alternatively, developmental modes could be constrained mainly historically, so that it is also necessary to compare groups of closely related species. These different alternatives were tested using protoconch morphology to infer developmental trends in gastropod mollusks. The data includes 102 genera and subgenera from 38 families from the Gulfs of Chiriqui and Panama (Eastern Pacific (EP) coast of Panama) and 90 genera and subgenera from 34 families from the Bocas and San Blas Islands (Caribbean coast of Panama), Honduras and Nicaragua. The EP is highly seasonal with high planktonic productivity in the Gulf of Panama, although less so in the Gulf of Chiriqui. In contrast, the Caribbean regions exhibit little seasonal variation and are oligotrophic. Results show that, although the number of direct developing taxa is similar in both oceans (60 in the EP and 68 in the Caribbean Sea), the differences in planktotrophs are dramatic. Only 22 taxa from the Caribbean Sea were classified as planktotrophs, whereas in the EP there are almost twice as many (42). Interesting enough, no significant differences between regions within the same ocean were registered. These results parallel earlier findings in developmental trends for 73 species of columbellid gastropods of the Strombina-group. During the Miocene, planktrophic species predominated in both oceans. In the Pleistocene and recent, a shift to direct development in the Caribbean Sea occurred, while remaining mostly planktrophic in the EP. Echinoderms, corals and cheilostome bryozoans show similar trends across the Isthmus of Panama strongly suggesting a common adaptive answer to environmental factors that affect larvae in the same way, regardless of the historical component. However, local adaptation within each group could be constrained and the result of differential speciation or extinction.

Molluscan diversity in tropical American oceans: an overview

Helena FORTUNATO¹, J.B.C. JACKSON^{1,2}, Jonathan A. TODD³, M. ALVAREZ¹, A. HEITZ⁴, K. JOHNSON² and P. JUNG⁴

¹ Smithsonian Tropical Research Institute, Box 2072, Balboa Panama.

² Scripps Institution of Oceanography, La Jolla, CA 92093-0244, USA.

³ The Natural History Museum, London SW7 5BD UK.

⁴ Naturhistorisches Museum, Basel, CH-4001 Switzerland

Widely reported transisthmian differences in numbers of taxa between the Tropical Western Atlantic (TWA) and the Tropical Eastern Pacific (TEP) hypothesized a dramatic decline in molluscan diversity in the TWA due to mass extinction at the end of the Pliocene. This has been regarded as a consequence of the oceanographic and productivity changes brought about by the rise of the Isthmus of Panama. As a result, the recent molluscan diversity in this region has been considered to be much lower than in the Tropical Eastern Pacific (TEP). To test this hypothesis, 245 fossil collections and 151 recent dredge samples from both sides of central American isthmus. These collections included about 160,000 shells and over 700 genera and subgenera of fossil and recent mollusks. These new data indicate that the number of taxa is roughly similar in both oceans, although the TEP yielded a much larger number of shells. The slope of cumulative diversity curves is higher in the TWA. Diversity increased here at the end of the Pliocene as the planktonic productivity decreased. Pleistocene diversity in the TWA is considerably higher than it was during the Late Miocene or even in the recent TEP. On the other hand, shells are rarer and more difficult to find in a lower productivity environment like today's TWA than in the TEP, which account for the earlier bias in estimating diversity. This, coupled with the earlier greater sampling effort dedicated to the Miocene and Early Pliocene compared with Pleistocene and recent faunas, has led to incorrect interpretations of molluscan diversity patterns throughout the region.

Functional morphology and cytology of Bivalves with sulfide oxidizing symbioses : a comparative approach in the family Lucinidae

Liliane FRENKIEL and Olivier GROS

Faculté des Sciences F97159 Pointe-à-Pitre Cedex, Guadeloupe.

Sulfide-oxidizing symbioses of bivalves and ctenidial endocellular bacteria, considered as a major evolutionary factor, have been described in 5 families. More than half of the described species, living in a variety of environments, belong to the family Lucinidae. Lucinids, as other symbiotic Bivalves, are characterized by modification of pallial water circulation, digestive tract simplification and mostly by the transformation of the gill as a bacteria-bearing organ. The relative weight of the gill tissue lies within the range of 20 to 35% compared with 10% for a non-symbiotic species. However the peculiar sub-filamental tissue, responsible for gill thickness and color varies between species.

The color of lucinid gills varies from pink to deep red and from light beige to dark brown according to species, environmental conditions, and health status. Gill filaments, organized as bacteriocytes channels, are composed of three structural zones, the most variable one being the lateral zone which comprises 2 cell types, bacteriocytes and intercalary cells, up to 4 with the addition of mucocytes and granule-cells according to species.

Bacteriocytes harbor bacteria within endocytic vacuoles. In few species such as *Lucina pectinata*, they contain abundant hemoglobin located in peculiar dark patchy cytoplasmic areas. In this species, sulfide-oxidizing bodies (SOB) have been discriminated from active secondary lysosomes, by using cyto-enzymological detection. Intercalary cells have been credited with various functions but the most plausible one is the modulation of the contact area of bacteriocytes with pallial sea-water. Mucocytes are located most often at the frontal and abfrontal end of the lateral zone but may be lacking in one or other position. Moreover, some putative mucocytes may actually be different secreting cells with unknown function. In most species of the genus *Codakia*, real mucocytes are intermingled all along the gill filaments with large cells crowded with granules containing a sulfur-rich protein. Such granule-cells, which may occupy more than 2/3 of the filament thickness, do exist in juveniles well before bacterial colonization. In *Linga pensylvanica*, glycoprotein secreting cells and peculiar cells containing dense arrays of microtubuli occupy the usual location of frontal mucocytes. The congruence between the gill structure of *L. pectinata* and *Calypptogena magnifica* vs. *C. orbicularis* and *Bathymodiolus* sp. does not seem to be fortuitous but more precise knowledge on the nature and function of key structures and molecules is needed to have a comprehensive idea of the functional significance of peculiar morphological features of the gill tissue of symbiotic species.

On the evolution of larval development in Middle Paleozoic Gastropoda

Jiri FRÝDA

Czech Geological Survey, Klárov 3/131, 118 21 Praha 1, Czech Republic,
fryda@cgu.cz

Recent models of gastropod evolution have suggested that larval planktotrophy has probably evolved twice within the class Gastropoda: within the Neritimorpha, and within the common ancestors of the Caenogastropoda and Heterobranchia. However, an on-going study of shell ontogeny in Middle Paleozoic gastropods has revealed that the number of gastropod groups developing a true larval shell (protoconch II) was much higher (Frýda 2001). Amphigastropoda (*Bellerophon* and related taxa) had a very small first whorl and their bilaterally symmetrical protoconch consisted of more than one whorl. These facts suggest that they had planktotrophic development. On the other hand, Archaeogastropoda that probably had primary lecithotrophic development did not develop a larval shell and their ontogenetic pattern remained the same for at least 400 Ma. Extinct Cyrtoneritimorpha (a group probably related to Neritimorpha and known from the Early Ordovician to the Late Permian) developed a true larval shell with a characteristic fishhook-like shape. The Paleozoic (Cambrian - Permian) Euomphalomorpha with a planispirally openly coiled protoconch developed a short, curved tubular embryonic shell (protoconch I). However, there are no data about the development of a true larval shell (protoconch II). The Early Ordovician to Carboniferous Perunelomorpha (probably an ancestral or basal group of the Caenogastropoda) developed a larval shell and a first whorl that was openly coiled. The Paleozoic (Cambrian - Devonian) Mimospirina with a sinistrally coiled teleoconch developed a large, smooth, sinistrally coiled (probably non-planktotrophic) larval shell consisting of several whorls. Caenogastropoda and Heterobranchia developed their larval shell (protoconch II) beginning at least from the Early Devonian. Taken together, during Middle Paleozoic time there were several gastropod groups developing a true larval shell (Cyrtoneritimorpha, Perunelomorpha, Mimospirina, Caenogastropoda, Heterobranchia and Amphigastropoda). Thus, it is quite evident that the evolution of planktotrophy in the Gastropoda was much more complex than has been suggested by neontologists.

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Distribution and origin of heterostrophic coiling among Gastropoda

Jiri FRÝDA¹ and Robert B. BLODGETT²

¹ Czech Geological Survey, Klárov 3/131, 118 21 Praha 1, Czech Republic,
fryda@cgu.cz

² Department of Zoology, Oregon State University, Corvallis, Oregon 97331, USA,
blodgetr@bcc.orst.edu.

Heterostrophy is defined as a condition of the protoconch where its whorls appear to be coiled in a direction opposite to those of the teleoconch. This character has been considered to be the most important synapomorphic character of the Heterobranchia (e.g., Haszprunar 1985). New data reveal that heterostrophy in the Heterobranchia is a very old feature, present for about 400 Ma (Early Devonian – Recent; Frýda & Blodgett 2001). However, heterostrophy is a character also known in Paleozoic and Mesozoic Archaeogastropoda. Slit-bearing Porcellidae and Cirridae lacking a slit have dextrally coiled early whorls and sinistrally or planispirally coiled later teleoconch whorls. The presence of sinistral heterostrophy in the latter archaeogastropod families shows that this shell feature can no longer be considered a unique character of the subclass Heterobranchia, and that it originated independently in unrelated gastropod groups. The development of a slit in the Paleozoic Porcellidae with both anastrophic and inclined heterostrophic coiling, starts just at the ontogenetic stage where the shell changes its coiling from dextral to sinistral. This fact suggests that the change in shell coiling is connected with an ontogenetic stage in which an important reorganization of the pallial cavity (respiratory) takes place. The inclined heterostrophy of the Porcellidae is a more advanced character than anastrophic coiling. The inclination of an axis of the early shell whorls requires less extensive soft body reorganization after the change of shell coiling (at least for body parts connected with shell production) than that in the case of anastrophic coiling. Thus, the origin of heterostrophy seems to be connected with a reorganization of the pallial organs during early ontogeny.

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Marine molluscs of Tanoura, Nagashima Island, demonstrate an incomparable bounty of biodiversity to be conserved in Japanese waters

Hiroshi FUKUDA

Conservation of Aquatic Biodiversity, Faculty of Agriculture, Okayama University,
Tsushima-naka 1-1-1, Okayama 700-8530, Japan, suikei1@cc.okayama-u.ac.jp

We surveyed marine molluscs at Tanoura, Nagashima Island, Kaminoseki-chô, Yamaguchi Prefecture, western Japan. The Chûgoku Electric Power Company (Chûden) has been planning a nuclear power plant there. Our faunal survey recorded at least 250 molluscs. In anaerobic tide-pools we discovered *Tomura cf. yashima* Fukuda & Yamashita, 1997 (Cornirostridae) and *Ceratia nagashima* Fukuda, 2000 (Iravadiidae; an endemic species). From the subtidal zone, an undescribed species of the nudibranch family Polyceridae was collected. Eight species registered as "vulnerable" or "rare" in WWF Japan's Red Data Book of inner-bay benthos have also been found. Thus, Tanoura has well retained the original environment of the Seto Inland Sea, which has disappeared in most other areas. Furthermore, we have found at least 30 species that are previously thought to be limited to the Pacific Ocean and areas of the Japan Sea that are influenced by warm currents. Such a high diversity has not been recorded in the Seto Inland Sea. For these reasons, there have been local and international voices have been proposing the permanent protection of Tanoura and its unique environments.

The Cornirostridae are one of keystone groups in gastropod phylogeny because of their many characters ancestral to most heterobranchs. Only a few cornirostrids, however, have been found around the world and have attracted attention of many malacologists. We have described two new species, *Tomura yashima* (Yashima Island), and *T. himeshima* (Himeshima Island) from the Suô-nada Sea. Most recently, more specimens of cornirostrids have been collected from Nagashima and Amatajima islands. Those from Nagashima appear to be different from the above two species, because of the presence of distinct spiral cords on the shells. Furthermore, some specimens of cornirostrids have been collected from Ushima and Hirashima islands by Chûden. They differ morphologically largely from other specimens collected so far. Thus, in addition to the two known species, it is likely that an additional three undescribed species occur in the Suô-nada Sea. Each of the five species may be endemic to each island.

"Shift" of the cephalic tentacles in the Assimineidae (Caenogastropoda, Risssoidea) and the taxonomic implications

Hiroshi FUKUDA, Kôichirô MIZOGUCHI and Kôhei SUZUKIDA

Conservation of Aquatic Biodiversity, Faculty of Agriculture, Okayama University,
Tsushima-naka 1-1-1, Okayama 700-8530, Japan, suik1@cc.okayama-u.ac.jp

Most caenogastropods have a pair of distinct cephalic tentacles. Tentacular nerves arise from their cerebral ganglia to the tip of the tentacles. In species whose eyes have optic nerves, the eyes are usually found in the round bulges situated at the posterior to the bases of the tentacles. Interestingly, the subfamily Assimineinae of the Assimineidae look like having the eyes on the tip of the tentacles. However, their eyes are located on the tips of elongated eye bulges because they lack tentacular nerves and have only the optic nerves. The true tentacles are extremely rudimentary. It is difficult to detect the tentacles by external examination of the head. Their location has not been clearly confirmed. In contrast, the Omphalotropidinae, which is another subfamily of the Assimineidae, have long tentacles as well as many other caenogastropods.

We investigated the anatomies of the central nervous systems of about 40 assimineines, including *Assiminea grayana* Fleming, 1828, and found that the type species of *Assiminea* has the tentacular nerves reaching the portion posterior to the eye bulges. It indicates that the cephalic tentacles are located at the posterior portion of the eye bulges. In some species (e.g. *Assiminea hiradoensis* Habe, 1942) the tentacles are barely detectable, constituting low swellings at the posterior end of the eye bulges. The tentacular nerves usually cross with the optic nerves in the cephalic haemocoel. This situation has not been reported in any other caenogastropods. Therefore, the unusual position of the nerves and tentacles is likely to be synapomorphic in the Assimineinae. "Shift" of the position of the tentacles must have occurred within the evolutionary history of the Assimineidae. In traditional taxonomy of assimineids, the Assimineinae are with the central radular teeth with a few pairs of the basal denticles and the Omphalotropidinae have the teeth with no denticle. However, some "omphalotropidine" genera showing the latter condition have the cephalic tentacles at the posterior end of the eye bulges. The similarities of radular characters may have resulted from homoplasy and not useful for the subfamilial division.

Two new species of Gastropoda Opisthobranchia from the Archipelago of Fernando de Noronha (Brazil)

Francisco J. GARCÍA¹ and Jesús S. TRONCOSO²

¹Depto. Fisiología y Biología Animal; Facultad Biología; Universidad Sevilla; Avda. Reina Mercedes, 6; Apdo. 1095, 41080 Sevilla, Spain, fjgarcia@cica.es

²Area de Biología Animal; Facultad Ciencias del Mar; Universidad Vigo; Lagoas-Marcosende; Vigo; Spain, troncoso@uvigo.es

In this communication two hitherto unknown species of Nudibranchia (Opisthobranchia) from Brazil are described. Both species were collected in the Brazilian Archipelago of Fernando de Noronha (03°51'S 32°25'W). They belong to the genera *Dendrodoris* and *Phidiana*. For each species, external and internal features are described and compared with related Atlantic species. The new species of *Dendrodoris* differs from other Atlantic species of this genus by its coloration and morphology of the reproductive system. In relation to the species of *Phidiana* it clearly differs by its colour pattern.

First data on a new Phyllomeniidae (Mollusca, Solenogastres, Sterrofustia) from South Shetland Islands (Antarctica)

Óscar GARCÍA-ÁLVAREZ and Victoriano URGORRI

Departamento de Biología Animal, Universidade de Santiago de Compostela, E-15706 Santiago de Compostela, Spain, baoscar@usc.es

During the first Spanish campaign to study of benthos in the area of the South Shetland Islands (BENTART'95) a small collection of Solenogastres was obtained. The specimen presented here was collected at station R-22, situated to the south of the Decepción Island (63°, 4300'S; 60°39,4350'W) at a depth of 248 m, on a gravel bottom.

It belongs to the Order Sterrofustia Salvini-Plawen, 1978, because it has several layers of thick spicules on its cuticle, the majority are acicular. It could be classified as belonging to the family Phyllomeniidae Salvini-Plawen, 1978, because it has distich radula and the subepithelial ventral glandular organs of the pharynx are blister-like in form. The animal is characterised by a cuticle of 30-35 mm in thickness with 2-3 layers of thick spicules of three different types:- acicular spicules shaped like the blade of a knife,- oar-shaped spicules and hooked spicules with a sharp tip over the hook. The mouth open from the posterior area of the atrium. It has a distich radula, each tooth has 6 small denticles on the inner face and 2 fused denticles at the tip of the distal part. The ventral glandular organs of the pharynx are blister-like in form and are surrounded by subepithelial glandular cells (Type A of Salvini-Plawen). It has a double dorsal intestinal caecum in the anterior region. A pedal groove with just one fold, which does not penetrate the pallial cavity. The pallial cavity is small, with thick walls and non respiratory folds. The anus is situated on the dorsal wall of the pallial cavity. Unpaired secondary genital orifice. The spawning duct is short and has two small seminal receptacles in the anterior region. The pericardioducts are linked to the spawning duct in the unpaired area. It possesses two seminal vesicles which terminate in the gonopericardioducts, near the pericardium. It has two pairs of latero-ventral copulatory spicules, one spicule is long and the other is short, situated near the anterior. It has two pairs of copulatory glands, one pair terminates in the pallial cavity, whilst the other does so close to the copulatory spicules. It does not possess a dorsoterminal sense organ.

Report on the distribution of the Solenogastres from the Iberian Peninsula

Óscar GARCÍA-ÁLVAREZ and Victoriano URGORRI

Departamento de Biología Animal, Universidade de Santiago de Compostela, E-15706 Santiago de Compostela, Spain, baoscar@usc.es

The information currently available on the zoogeography of Solenogastres is scarce. About 200 species have been described, which may represent 40% of the existing species of this mollusc. The majority of the species known come from two geographical areas: - the antarctic and subantarctic seas (45%) where numerous oceanographic expeditions have been carried out since the end of the XIX century, one of the objectives of which was to discover more about benthic fauna; - and the seas of Europe (30%) thanks to the continuous studies undertaken by the different marine biology stations and university laboratories.

In Europe the majority of this information comes from the North Sea and the Scandinavian waters of the Atlantic Ocean and the Mediterranean Sea. The French Atlantic coast and the waters of the Iberian Peninsula are the areas in which the information is scarcest. With a view to increasing our knowledge of this subject, as part of the Iberian Fauna Project, research into Solenogastres in peninsular waters is being carried out. Some important results have been obtained which have led to publications in the last few years which we summarise in this communication.

Before the start of the Iberian Fauna Project, 9 species of Solenogastres had been cited in the Iberian Peninsula. Currently, 16 species are known in peninsular waters, to which another 8 species may be added that are to be found in nearby waters, or have been cited in the Atlantic and the Mediterranean. For these reasons we believe that they should also be classed as Iberian fauna. These data lead us to believe that with new research, information on these and other Solenogastres species would increase in number in direct proportion to the efforts made. In this way, it would be possible to increase considerably our biogeographical knowledge of this group and in general the biodiversity of this geographical area.

Pleistocene shade-loving malacofauna from Fruska Gora (Serbia)

Tivadar GAUDENYI¹, Mladjen JOVANOVIĆ¹, Slobodan B. MARKOVIĆ¹ and
Pál SÜMEGI²

¹ Institute of Geography, University of Novi Sad, Trg D. Obradovica 3, 21000 Novi
Sad, Serbia /Yugoslavia, gaudi@eunet.yu, mladjenov@hotmail.com,
zbir@unsim.ns.ac.yu

² Dept. of Paleontology and Geology, University of Szeged, Egyetem u. 2-6, 6722
Szeged, Hungary, sumegi@geo.u-szeged.hu

The analysed Miseluk loess exposure is situated on in the central part of the north slopes of Fruska gora mountain. This 6 m thick, open loess profile contains recent soil (S0), horizon of Würm age loess (L 1), paleosol (S1) which presents Riss- Würm interglacial and younger part of Riss age loess horizon (L2). The granulometric record of Miseluk loess-paleosol sequences are well correlated with Nussloch (Middle Rhine area, Germany) loess exposure and SPECMAP marine oxygen paleoclimatic record of the last about 140000 years (Markovic *et al.* 2000).

Snail assemblage of 24 loess-paleosol samples contains 3980 specimens of 43 taxa (41 taxa of land snails and 2 freshwater taxa). Taking into consideration the composition of malacofauna, the area was more humid and the presence of some gallery forest species (*Punctum pygmaeum*, *Ena montana*, Clausiliidae) shows a difference according to the south slopes of Fruska gora and Danube-Tisa interfluvium which were open area and dry weather climate environment (Fukoh *et al.* 1995). Some molluscan assemblages (*Macrogastra ventricosa*, *Aegopinella ressmanni*, *Trichia edentula*) evidence the presence of Paleopreillyrian or Paleoillyrian snail formation of this (south-eastern) part of Carpathian (Pannonian) basin. In the L1 the presence of *Vallonia tenulabris* prove the colder stadium. It is suggested that Fruska gora during the late Pleistocene was characterized by mosaical environmental distribution similar as on Mecsek mountain in Hungary (Krolopp & Sumegi 1995).

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Morphometric and population genetic comparison of introduced North American and native European *Carinarion* populations (Gastropoda, Pulmonata, Arionidae)

Sofie GEENEN¹, Kurt JORDAENS¹ and Thierry BACKELJAU²

¹ Evolutionary Biology Group, University of Antwerp, Groenenborgerlaan 171, 2020
Antwerp, Belgium, sgeenen@ruca.ua.ac.be, jordaens@ruca.ua.ac.be

² Royal Belgian Institute of Natural Sciences, Vautierstraat 29, 1000 Brussels,
Belgium, tbackeljau@kbinirsnb.be

The arionid subgenus *Carinarion* comprises three species, *viz.* *Arion fasciatus*, *A. circumscriptus* and *A. silvaticus*, which are distinguished by subtle anatomical and colour differences. Starch gel electrophoresis (SGE) of allozyme variation in North American *Carinarion* populations has been interpreted as confirming the species status of these three taxa, because each of them consisted of a single multilocus genotype (strain). The "one species - one strain" idea, however, was subsequently rejected since polyacrylamide gel electrophoresis (PAGE) of allozymes showed each species comprising many, often co-occurring, strains in northwestern Europe. This raises the question as to whether the "one species - one strain" situation in North America is the result of founder effects (by the introduction of *Carinarion* sp. into North America from European stocks) and/or interstrain competition, or whether it is a methodological issue of sampling bias/effort and/or differences in electrophoretic techniques. In order to resolve this question we studied allozyme and morphological variation in nine North American *Carinarion* populations and compared these data with the existing data for European *Carinarion*.

Morphologically, North American *A. circumscriptus* and *A. silvaticus* were similar, and only subtle differences were found between the latter two and *A. fasciatus*. There were no significant morphological differences between North American and European *Carinarion* sp. Using PAGE, we detected six different strains in North American *Carinarion* sp., *viz.* four in *A. silvaticus*, one in *A. circumscriptus* and one in *A. fasciatus*. Our data clearly show that at least for North American *A. silvaticus*, the "one species - one strain" hypothesis cannot be maintained. If this also applies to the two other species remains to be decided. Furthermore, two of the four North American *A. silvaticus* strains were hitherto not found in Europe. In conclusion, the results on *A. silvaticus* tentatively suggest that the previous SGE data on North American populations reflect sampling biases and/or analytical issues, so that the "one species - one strain" hypothesis for North American *Carinarion* sp. probably is an artefact. This also implies that the taxonomic conclusions based on the "one species - one strain" idea should be reconsidered.

Evolution and ecology of *Melanoides* in Lake Malawi

Martin J. GENNER

Department of Molluscs, Zoological Museum & Institute for Biodiversity & Ecosystem Dynamics, University of Amsterdam, mjgenner@hotmail.com
Present address: Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth. UK. PL1 2PB. majg@mba.ac.uk

Lake Malawi contains spectacular faunal diversity, including well-known lineages such as cichlid fishes and ostracods. However, this landlocked ancient water body, some 700,000 - 3 Myr old, also contains an endemic species flock of prosobranch gastropods of the genus *Melanoides*. To date, eight species from the lake are formally described, but a recent pilot study found as many as fifteen putative distinct taxa, differing in shell morphology, patterning and background colour coexisting in sympatry. Moreover, there were striking differences in the taxa present within assemblages 400 km apart, suggesting either considerable intraspecific differentiation among geographic isolated populations, or only a fraction of the total lake species richness has been identified. Here I present these preliminary data and discuss distribution patterns with reference to theories of speciation within Lake Malawi faunal groups. I also introduce my future work programme in which I will be addressing evolutionary and ecological relationships of *Melanoides* using a combination of molecular, morphometric and ecological survey techniques. Specifically I will investigate if species status can be attributed to these putative taxa, whether habitat discontinuities act as barriers to gene flow, and if ecological differentiation occurs. These data from the extant fauna will then be used to identify faunal changes within the fossil record from deep cores to be taken by the IDEAL and EURO-IDEAL drilling programme 2002-2004, ultimately enabling rates of diversification to be examined in relation to lake-level fluctuations driven by paleoclimatic change.

The molluscan fauna of the Berchtesgaden National Park (Bavaria, Germany)

Jochen GERBER

Department of Zoology (Invertebrates), Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, Illinois 60605-2496, USA, jgerber@fieldmuseum.org

The Berchtesgaden National Park covers 210 km² in the Northern Calcareous Alps, between 413 and 2713 m in elevation. The Park and its vicinity are the southeasternmost corner of the German territory. The area has attracted the attention of malacologists since two centuries because of its species richness and unique species composition. Several gastropod species have the eastern limits of their distributions in the area, others display a disjunction between a major southern alpine area and an enclave in the Northern Calcareous Alps, including the Berchtesgaden area. The only records of *Orcula gularis* (Rossmässler, 1837) in Germany are from a locality in the National Park.

Between 1997 and 2000, different parts of the National Park could be sampled for land and freshwater molluscs with support by the National Park Administration. In addition, the majority of the molluscs collected by R. Gerecke and his co-workers in the park in the course of a long term investigation of alpine springs were at disposition. These recent samples, together with a critical evaluation of the published data, are the basis for this summarization of the current knowledge of the mollusc fauna of the Berchtesgaden National Park. The data are nevertheless preliminary, as especially the higher elevations and the western third of the park are under-represented in the data set.

Species of special interest, such as the recently re-discovered *Orcula gularis*, are discussed, examples of distribution maps are given and the zoogeographic composition of the mollusc fauna is presented.

**The reproductive cycle of *Zidona dufresnei* (Donovan, 1823)
(Caenogastropoda, Volutidae) from the Southwestern Atlantic Ocean**

Juliana GIMÉNEZ and Pablo E. PENCHASZADEH

CONICET. Lab. Invertebrados, Depto. Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, Pab. II, C1428EHA, Buenos Aires, Argentina, fax 54-11-48055736, jgimenez@bg.fcen.uba.ar.

Gonadal development of *Zidona dufresnei* (Caenogastropoda, Volutidae) was studied, over a period of two consecutive years, through analysis of gonadal tissue samples. Individuals were sampled monthly at Mar del Plata harbor, Argentina. Gonadosomatic index (GSI) was estimated for males and oocyte size was used to estimate the stage of gonadal development in females.

The reproductive season in this species in the sampled locality extended from October to March (austral spring-summer). During summer, a stage of advanced gonadal development and spawn predominated in the adult population. In autumn, gonads were generally under atresia; during wintertime, they underwent a period of recovery that lasted until spring, when gametes were released again. Synchronism between both sexes is evident. Marked periods of spawning were followed by resorption periods and then a growing phase, being very clear that reproductive seasonality was linked to changes in bottom water temperature. These results suggest that *Z. dufresnei* gonads have a simple yearly cycle of gamete production with two major activity peaks.

Feeding deterrence of the Mediterranean sacoglossan *Elysia timida* (Risso, 1818) (Opisthobranchia, Gastropoda) against *Thalassoma pavo*

Francisca GIMÉNEZ-CASALDUERO¹ and Claudia MUNIAIN²

¹ Dpto. Cs. Amb. y Rec. Nat. Universidad de Alicante, San Vicente del Raspeig, 03690, Alicante, Spain, Francisca.Gimenez@ua.es

² Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Angel Gallardo 470 (C1405DJR) Buenos Aires, Argentina, claudiamuniain@velocom.com.ar

Opisthobranchia have diversified in habitat and feeding biology, often highly specialized on food. Some natural products from opisthobranchs have been described as having an antipredator activity, but very few studies have demonstrated that the chemical compounds play a defensive role.

We tested feeding deterrence and the relationship between the sacoglossan *Elysia timida* (Risso, 1818) and the fish *Thalassoma pavo* (Linnaeus, 1758), in laboratory experiments using live animals and artificial models of *E. timida*. The experiments comprise two models, a "real", which imitated the molluscs with the same colour pattern, embedded in chemical extracts of *E. timida*, and another one, a reference "model" with neither colour pattern nor chemical extracts. The fish were collected at two Mediterranean localities, Cabo Palos and Mazarrón (Giménez-Casalduero 1997, 1999). The chemical extracts of *E. timida*, isolated as polypropionates (Cimino & Ghiselin 1998, Gavagnin *et al.* 1994), are deterrent preys for *Th. pavo*, and their effect is sufficiently noxious that the fish tend to avoid them.

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Contact zones in *Albinaria*: is there a unique story?

Sinos GOKAS¹, Moysis MYLONAS² and Konstantinos SOTIROPOULOS¹

¹ Zoological Museum, Department of Biology, University of Athens,
Panepistimioupolis, 15784, Athens, Greece, sinosg@biol.uoa.gr.

² Natural History Museum of Crete, Department of Biology, University of Crete,
71110, Irakleion, Greece, director@nhmc.uoc.gr.

The populations of the speciosus (over 80 species) northeastern Mediterranean genus *Albinaria* are distributed allopatrically, seldom parapatrically, and sympatry is uncommon. Yet, certain nominal species are genetically indistinguishable, inter-fertile in the lab, and molecular analyses revealed even intergeneric introgression (Giokas *et al.* 2000). Genetic studies show contradictory results: presence or absence of heterozygote deficiency, and interspecific reproductive isolation or introgression. Schilthuizen (1994) supports a peripatric (sub)speciation model in small isolated populations for hybrid zones that result from secondary contact and are maintained by a balance between dispersal and selection against hybrids.

We report and discuss three more contact zone cases. First, a narrow contact zone at Monemvasia (Peloponnesos) between the molecularly and morphologically distinct *A. discolor* and *A. campylauchen* parapatric populations. Disruption of normally effective ecological and behavioral barriers, hybridization and selection were investigated. We found increased gene flow at the contact zone, presence of rare alleles, and high genetic variability along with deficiency of heterozygotes, probably due to inbreeding. *A. campylauchen* specimens with inappropriate combinations of morphology and behavior suffered heavy mortality during aestivation. This selective disadvantage suggest a possible postzygotic isolation mechanism, and an exogenous selection hypothesis. Second, a shifting contact zone between the parapatric dextral *A. vothii* and sinistral *A. schuchii* at Lagia (Peloponnesos). No-hybrids were traced, and the two species have different (non-cryptic and cryptic) aestivation ethology. Further genetic and ecological study at this zone, will test hypotheses of contact zone persistence. Third, a narrow linear hybrid zone between allo-parapatric populations of *A. coerulea* and *A. lerosiensis* at the island of Kos. Preliminary genetic analysis revealed directional gene flow from *A. lerosiensis* to *A. coerulea*, and corresponding genetic and morphological clines.

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The phylogeographic history of *Arianta arbustorum* (Gastropoda, Pulmonata, Helicidae)

Edmund GITTENBERGER, Dick GROENENBERG and William H. PIEL

National Museum of Natural History, P.O. Box 9517, NL-2300 RA Leiden, The
Netherlands, Gittenberger@Naturalis.NNM.NL

Leiden University, Institute of Evolutionary and Ecological Sciences.

The evolutionary history of the European land snail *Arianta arbustorum* is controversial. This diverse, polytypic species has two remarkably distinct forms: one, with a globular shell and a closed umbilicus, is found from lowland to high altitude; the other, with a depressed shell and an open umbilicus, is only found at high altitude. What caused the appearance of these two forms? Some believe that the depressed shell is a locally derived character that is ecotypically adapted to steep rocky limestone environments at high altitudes. Others believe that the depressed shell is a relic of an ancestral condition, and that these snails may have survived the Pleistocene glaciations on nunatak-like montane refugia. Under the latter hypothesis, the globular shell is the derived character and the presence of such forms in alpine valleys and at high altitudes is the result of post-Pleistocene recolonisation following the melting of the glaciers. We sequenced a portion of the mitochondrial gene cytochrome oxidase I for 89 snails of the species *A. arbustorum*, one *A. chamaeleon*, and six outgroup taxa from three genera, in order to understand the phylogeographic history of the species. Despite some confounding artefacts due to gene tree reticulation within the species, the resulting phylogeny clearly shows that the depressed shell is the plesiomorphic condition, while the globular shell is the derived, apomorphic condition. Moreover, the separation of the globular- and depressed-shell forms appears to predate the Pleistocene glaciations, suggesting that these snails arrived at their present alpine localities through fundamentally different means. While the depressed-shell snails survived the glaciations in pockets of alpine refugia, the globular-shell snails arrived there post-glacially by colonising the large stretches of alpine territory left vacant due to local extinction of the depressed-shell form. Additionally, our results indicate that the globular-shell form probably retreated to a western lowland refugium and several eastern lowland refugia during the Pleistocene glaciations.

An evolutionary ecology approach to the presumptive adaptive and endemic radiations of freshwater Cerithioidea (Mollusca, Gastropoda) in East Africa and on Sulawesi

Matthias GLAUBRECHT

Museum für Naturkunde, Humboldt University, Invalidenstrasse 43, D-10115 Berlin, Germany, matthias.glaubrecht@rz.hu-berlin.de

It has been proposed that in biology, concepts play an equally important role as natural laws in physics and chemistry. Given also their heuristic significance, biological concepts - such as, *e.g.* intralacustrine speciation, radiation, coevolution, ecological niche, competitive displacement etc. - are in need of case studies for evaluation and illustration of their general validity. Using the endemic radiations of limnic gastropods of the superfamily Cerithioidea from the East African Lake Tanganyika and from the central lakes on Sulawesi (*i.e.* Lake Poso and the lakes of the Malili system, *e.g.* Danau Matano, Mahalona, and Towuti) as models, the evolutionary ecology (EE) approach is outlined. EE is here understood as "aiming to reconstruct the origin and alteration of the ecological interrelations of organisms and their respective environment in the course of evolution, as documented in the various biological features" (including *e.g.* morphology, molecular genetics, and biogeography). Thus, EE functions as a research program for acquiring a more synthetic perspective in zoology and malacology than generally strived for by its constituting reductionistic disciplines.

Based on phylogenetic analyses of the Cerithioidea and by using morphological and molecular data on various hierarchical levels (from families to populations), the role of extrinsic and intrinsic factors for speciation and radiation is investigated for the presumptive adaptive and endemic radiations of species flocks of the so-called "thiarids". Within the framework of a new cerithioidean phylogeny that correspondingly identifies five limnic families as independent clades (*i.e.* Melanopsidae, Pleuroceridae, Pachychilidae, Thiaridae *s. str.* and Paludomidae), the two different model lake systems are compared with respect to the distinct contribution of extrinsic and intrinsic factors. It will be shown (i) why and how earlier attempts to evaluate these factors were essentially suffering from lacking insight into the systematics and morphology (*i.e.* the reproductive biology) of the limnic gastropods involved, and (ii) that crucial differences in the geological setting (*e.g.* rifting in the ~12 myr old Lake Tanganyika *vs.* Sulawesi's composite terrane origin with ~1-2 myr old lakes) are more influential than previously assumed. Finally, a synthetic scenario is outlined incorporating historical and ecological aspects as well as crucial biological features such as viviparity and trophic specializations.

Melanopsis diversity and disparity in space and time: adding the Recent perspective to the Paratethys radiation of Melanopsidae during the Neogene

Matthias GLAUBRECHT

Museum für Naturkunde, Humboldt University, Invalidenstrasse 43, D-10115 Berlin, Germany, matthias.glaubrecht@rz.hu-berlin.de

Origin and transformation of species and species groups figure most prominently in debates over evolutionary mechanisms. The plethora of species of the limnic Cerithioidean *Melanopsis* Ferussac, 1807 have repeatedly served as model for various studies in neontology and palaeontology, such as *e.g.* evolutionary transformation in so-called "Formenreihen", speciation, radiation and heterochrony. However, the exact nature of many of those nominal taxa, *e.g.* their occurrence in space and time in concert with the question about their systematic status and evolutionary fate, have only rarely been explicitly studied for Recent and fossil *Melanopsis*. Therefore, it is aimed here in a first part, (i) to set the theoretical context with respect to various approaches in the delimitation of species and the systematic treatment of geographical variation, (ii) to review the historical development of different perceptions in treating geographical representatives in Recent and fossil taxa, and (iii) to outline useful systematic concepts, for example those of "Artenkreise" or superspecies, that are successfully and widely accepted and applied in other biological fields (*e.g.* ornithology), but so far not in malacology. In a second part, the disjunct distribution of *Melanopsis* in space and time is presented for the Mediterranean region and islands in the Indowestpacific in connection and with a discussion of their closest relatives among other members of Melanopsidae. Melanopsidae are known since the Upper Cretaceous of Europe and the Oligocene from New Zealand. While the widely distributed *Melanopsis* has a long evolutionary history that is documented through most of the Tertiary in the Mediterranean region, the three confamiliar taxa *Esperiana*, *Holandriana* and *Microcolpia* show only very restricted distributions on the Balkan peninsula. It is anticipated that underestimating the (eco-)phenotypic plasticity of freshwater gastropods in the past has hampered the reconstruction of the evolutionary history of *Melanopsis*. As an alternative to the scenarios put forward by palaeontology it is hypothesized that repeated isolation in relatively small populations lead to the occurrence of many polymorphic forms that have lost genetic cohesion of a once common gene pool to various degrees and are thus the result of temporal and spatial discontinuity of the limnic environment. A revised view concerning the systematics of *Melanopsis* and the evaluation of fossil evidence is subsequently put into perspective with a palaeogeographical model of the Mediterranean basin and the Paratethys.

Molluscan communities on Eastern Mediterranean deep-water mud volcanoes

Serge GOFAS¹, Carmen SALAS¹, Karine OLU² and Myriam SIBUET²

¹ Departamento de Biología Animal, Facultad de Ciencias, Universidad de Málaga, E-29071 Málaga, Spain, sgofas@uma.es, casanova@uma.es

² Département Environnement Profond, IFREMER Brest, BP70, F-29280 Plouzané, France, Karine.Olu@ifremer.fr, msibuet@ifremer.fr

The deep-water cold seeps and mud volcanoes in the Eastern Mediterranean have been explored in 1998 during the joint Dutch-French MEDINAUT cruise, using deep-sea submersible "Nautile" and support vessel "Nadir", of IFREMER. Two areas, in two distinctive tectonic settings, were investigated. One of the settings was the Olimpi mud volcano field on the Mediterranean ridge, an accretionary prism associated with subduction along the Hellenic Arc south of Greece. The other setting was the Anaximander Montains, a group of continental fragments rifted from Turkey in post Miocene time. This exploration has revealed an oligospecific fauna with hitherto poorly known species, in which the most prominent animal groups are the Mollusca, presented here, and the Vestimentifera.

Three of the bivalve species were known from a single deep-sea sample obtained off the Nile delta in the late 19th century by the Austrian R/V "Pola". These are *Idas modiolaeformis* (Mytilidae), *Isorropodon perplexum* (Vesicomidae), and *Thyasira striata* (Thyasiridae). These were known hitherto only from the original description, and occurred in large numbers in the MEDINAUT samples. Two other abundant lucinid species are closely related to widespread European shallow water species. The genera *Idas*, *Thyasira*, and the lucinids are known to host chemotrophic bacteria which allow them to thrive in this kind of methane-rich environments.

The gastropods are represented by three common species. Two are not endemic to the mud volcanoes, but occur here in unusually high numbers: *Putseysia wiseri* (Trochidae) and *Taranis alexandrina* (Turridae). One common species, with many live taken specimens, is a *Clelandella* sp. (Trochidae), undescribed and distinct from the widespread shelf species *C. miliaris*. The turrid is a predator, whose occurrence may be related to the abundance of biomass and not directly to the mud volcano community, whereas the trochids are grazers which may feed on bacterial film but should also be investigated for possible endosymbionts.

The molluscan fauna on the Eastern Mediterranean mud volcanoes is striking by its abundance in specimens and size of species, in contrast with most of the deep areas of the Eastern Mediterranean which is virtually devoid of fauna and suggested to Edward Forbes the abandoned "azoic theory".

Phylogenetic analysis of the terrestrial genus *Pyrenaearia* (Gastropoda, Pulmonata) by means of DNA sequences from the mitochondrial cytochrome oxidase subunit I (COI)

Benjamín J. GÓMEZ, Arantza ELEJALDE, M^a. José MADEIRA, Jonathan RUBINES and Maite CABRIA

Laboratorio de Zoología, Departamento de Zoología y Dinámica Celular Animal, Facultad de Farmacia, Universidad del País Vasco. C/ Paseo de la Universidad, 7. Vitoria 01006, Spain, gpggomob@vc.ehu.es

The genus *Pyrenaearia* Hesse, 1921 is an endemic of the north of the Iberian Peninsula, mostly restricted to the Cantabrian Mountains and the Pyrenees. There are 12-16 species considered in the genus at the moment, some of them occupying a very restricted geographical area. These species are characterized mainly on the basis of shell morphology, while the reproductive system shows no diagnostic features at the specific level. The shell morphology is greatly influenced by environmental parameters, such as the altitude, so that new taxonomic criteria are required in order to verify the validity of the taxa as well as to know their phylogenetic relationships. With this aim we have made a molecular study including all of the nominal taxa of this genus. This study is based on the comparison of the sequence data of the cytochrome oxidase subunit I (COI) of the mitochondrial DNA. DNA extraction has been performed following the phenol-chloroform-isoamyl-alcohol procedure. Initially, amplifications have been made using the primers LCO1490 and COR722 with M13 ends. Amplicons of 700 bp have been reamplified with a primer designed for this work to give DNA fragments of 500bp. Sequences of the COI fragments have been determined by ABI Prism 310 and the program Sequence Analyser 3.0. Before alignment, all chromatograms have been checked and reading errors have been corrected, if necessary. Alignments of the sequences have been made with the ClustalW option. Phylogenetic analyses of the data set have been performed in PAUP 3.1 and with the PHYLIP package. We have characterized every morphospecies of the genus at the molecular level. We show the sequences of the different species of *Pyrenaearia* and the phylogenetic trees we have constructed on the basis of the molecular results. We offer a discussion of the phylogeny of the genus on the basis of the morphological classification previously considered and the new molecular data.

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Taxonomical and ecological aspects of the freshwater mollusks of Antioquia Department (Colombia, South America)

María Isabel GÓMEZ¹, Gabriel ROLDÁN PÉREZ¹ and Maria Cristina DREHER-MANSUR²

¹ Limnology Laboratory, Biology Department, University of Antioquia.

² Museu de ciencia e tecnologia da PUCRS – Brasil.

For two years a study of the freshwater mollusks of Antioquia Department (Colombia, South America) was carried out. The purpose of the study was to create an inventory of the species, to find the influence of the altitude and vegetation in its distribution and to seek the relation of species and water quality. The study was performed between 0-2600 m of altitude. 23 species belonging to 17 genera and eight families were found. Species of the family Thiaridae were correlated with tropical dry forest, hydrobid species with premountain rain forest and species of the Sphaeridae and Physidae with low mountain wet forest. Thiarid species were indicators for clean water, ampullarids and physids for moderately polluted water, and the sphaerid and hydrobid species for heavily polluted water.

The study was financed by FONDO FEN-COLOMBIA.

Biodiversity, endemism and evolution of opisthobranch gastropods on Indo-Pacific coral reefs

Terrence GOSLINER

California Academy of Sciences, Golden Gate Park, San Francisco CA, USA,

tgosline@calacademy.org

The Indo-Pacific tropics support more than three thousand species of opisthobranch gastropod molluscs. The greatest species richness is found within the reefs of the western Pacific from the Philippine Islands, Indonesia and Papua New Guinea. Areas of high diversity and endemism have been traditionally identified as regions of particular concern for assessment of conservation priorities and hotspots. With increased understanding of phylogenetic relationships of highly diverse taxa, other important data are available for consideration in determining conservation priorities:

1. Are endemic taxa representative of basal or highly derived lineages? 2. Are groups of endemic taxa the result of single instances of adaptive radiation or are endemic biotas composed of representatives of several different lineages within a monophyletic group? 3. Are sister species of endemic taxa found in relatively close geographic proximity to their sisters or in distantly separated portions of the Indo-Pacific? Phylogenetic studies of many clades of opisthobranchs strongly suggest that Indo-Pacific representatives generally form monophyletic lineages that the sister clades to Atlantic and eastern Pacific lineages. This fact suggests that the Indo-Pacific represents an historically significant evolutionary and biogeographical unit. Different taxa within the Indo-Pacific may exhibit radically different patterns of speciation, diversification and evolutionary history, thus adding to the challenge of developing unified conservation strategies for preserving the diversity of life that inhabit the world's richest coral reefs.

The genetic structure of subdivided populations: a case study using microsatellites in the highly-selfing freshwater snail *Bulinus forskalii*

Jennifer L. GOW¹, Catherine S. JONES¹, Leslie R. NOBLE¹ and David ROLLINSON²

¹ Zoology Department, Aberdeen University, Aberdeen, UK, j.gow@abdn.ac.uk, c.s.jones@abdn.ac.uk, l.r.noble@abdn.ac.uk

² Zoology Department, Natural History Museum, London, UK, dr@nhm.ac.uk

Bulinus forskalii is a hermaphroditic freshwater planorbid snail, which has a wide distribution throughout much of tropical Africa. In parts of its range, including Cameroon, Sao Tome and Gabon, it acts as the intermediate host for the medically important trematode *Schistosoma intercalatum*. Thought to preferentially self-fertilise, this species inhabits a wide variety of climatic zones and habitat types, ranging from near desert conditions through savannah to equatorial rain forest, and from temporary pools to perennial water bodies. The forces acting on the genetics of subdivided populations were analysed by conducting a spatial survey of variability of eleven polymorphic microsatellites in *B. forskalii* populations from Cameroon (Gow *et al.* in press). Classical genetic parameters (estimators of H_O , H_E , F_{IS}) indicated high levels of heterozygote deficiencies within populations, a result consistent with very high selfing rates. The role of selfing in determining within population genetic variation was further illustrated by the numerous genotypic linkage disequilibria found. Selfing is expected to depress the variability within populations, however, variable levels of gene diversity were found. This indicates that historical demographic processes, such as, population size variation, bottlenecks or founding events possibly resulting from the isolation and temporary nature of the habitat, may also be important determinants of loss of genetic polymorphism within populations. The high level of population differentiation detected suggests limited effective dispersal is occurring and genetic drift is playing a dominant role in shaping population structure. A non-significant pattern of isolation by distance emphasises the influence of selfing, habitat isolation and temporality in molding *B. forskalii*'s genetic structure.

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The periwinkle *Littorina saxatilis* (Gastropoda, Littorinidae) on British shores: differentiation in the face of gene flow

John GRAHAME, Craig S. WILDING and Roger K. BUTLIN

Centre for Biodiversity & Conservation, School of Biology, University of Leeds, Leeds LS2 9JT, UK, j.w.grahame@leeds.ac.uk

We have applied the technique of Amplified Fragment Length Polymorphism (AFLP) analysis to the intertidal snail *Littorina saxatilis*, in which shell shape varies clinally across vertical gradients on rocky shores. We show that there is a small proportion (about 5%) of the AFLP loci which show greater differentiation than expected compared with the results estimated from a simulation model using values of mutation and migration derived from the data. This indicates selection across the cline, either direct or indirect through linkage. We show that there is evidence of association of some of these loci with well-known aspects of shell variation. We discuss our results in the context of expectations from non-allopatric speciation models that propose an initial divergence of a small part of the genome driven by strong disruptive selection while divergence at other loci is prevented by gene flow.

**Complete sequence of the mitochondrial genome of a nudibranch,
Roboastra europaea (Mollusca, Opisthobranchia)**

Cristina GRANDE¹, José TEMPLADO¹, Juan Lucas CERVERA² and Rafael
ZARDOYA¹

¹ Museo Nacional de Ciencias Naturales, CSIC. Madrid, Spain.

² Universidad de Cádiz, Cádiz, Spain.

Recent morphological and molecular studies have questioned the traditionally accepted monophyly of the Opisthobranchia. However, the conclusions of these studies were tentative. On one hand, this group of gastropods shows extensive parallel evolution which difficult reconstruction of phylogenetic relationships based on morphological characters. On the other hand, previous molecular studies have been based on rather short sequence data sets (partial nuclear 28S, 18S and mitochondrial 16S rRNA genes) and on a very few number of species. To test the monophyly of opisthobranchs and to further clarify their phylogenetic position, we determined the complete nucleotide sequence of the mitochondrial genome of *Roboastra europaea*, a representative of a highly derived order of Opisthobranchia (Nudibranchia). The nucleotide sequence of this genome was aligned with those of other published molluscan complete mitochondrial genomes. In particular, we compared the new sequence with that of *Pupa strigosa* (Kurabayashi & Ueshima 2000), a member of the most basal order within Opisthobranchia (Cephalaspidea).

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Visual control of arm movement in *Octopus vulgaris*

Ulrike GRIEBEL, Ruth A. BYRNE, Michael KUBA, Daniela MEISEL and Rupert
RIEDL

Konrad Lorenz Institute for Evolution & Cognition Research, Adolf-Lorenz-Gasse 2,
A-3422 Altenberg, Austria.

It has been assumed for a long time that arm movement in *Octopus vulgaris* is to a large extent autonomous. In this study we investigated the octopus' ability to visually direct the movement of a single arm in a specific direction. Seven animals were tested with a transparent Plexiglas T-maze that allowed the insertion of only one arm at a time. For each trial, a food item was placed on one side of the maze (in accord with a restricted random sequence). To avoid chemical cueing, the T-maze was placed at water level in such a way that there was no contact of the water within the horizontal T-bar with the water in the tank. Each animal was tested for at least 100 trials. Two animals were able to perform the task at better than chance levels. One of the two successful octopuses was tested again in a black opaque T-maze to evaluate the possibility that non-visual cues might have been responsible for the success in the original experiment, but the animal performed at chance level without visual cues. The fact that only two out of seven animals used visual information at better than chance level for the fine tuning of the arm movements during this task suggests that chemotactile sensory feedback may provide the more important information resource for hunting.

Southern Ocean Mollusc DataBASE: SOMBASE - a tool for biogeographic analysis in diversity and ecology

Huw GRIFFITHS, Katrin LINSE and Alistair CRAME

British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK,
hjk@bas.ac.uk

Benthic molluscs are one of the most speciose groups in the world's oceans. Over 1000 species have been reported from the Southern ocean including, over 700 species of gastropods and over 300 species of bivalves.

The objectives of our project are to (1) establish comprehensive databases of the distribution, shell morphology, and selected ecological characters of Antarctic molluscan taxa, (2) analyse the data and derive patterns, and (3) interpret the results and display them on interactive maps.

Our database contains detailed distribution records (Lat, Long, Depth, Substrate) for gastropod species found in the Southern Ocean as well as detailed information of each species. Shell-size, shell features, colour, reproductive method, and feeding methods are some of the fields featured in the database. The database has the potential to be expanded further to include selected regions outside the Southern Ocean and eventually into a global database.

The database is a valuable tool for handling and analysing data. The inclusion of ecological and morphological data means that this database can be queried in several different ways, and at various levels of detail, depending on the user requirements.

We are using a combination of a user-friendly Microsoft Access 2000 front end, Oracle as a data store, and a link to ARCVIEW for creating the maps. This is an ideal solution in terms of ease of data entry and obtaining meaningful reports. Using Oracle as a data store allows multiple users, possible connection to the internet and a "real-time" connection to the GIS software.

During the conference this poster will be accompanied by a computer based demonstration of the database and its capabilities.

Biology of the pest slug *Arion lusitanicus* in central Europe

Brigitte GRIMM

The Natural History Museum, Mollusca Research Group, Cromwell Road, London
SW7 4BD, grimm@kfunigraz.ac.at

Arion lusitanicus is the main pest-slug in many parts of central and northern Europe (e.g. Schmid 1970, von Proschwitz 1992), causing severe damage in crops and ornamental gardens. Therefore, investigations on this highly important pest organism were, and still are, of great relevance not just from a scientific, but also from an economical point of view.

Aspects of the biology of this species, including its seasonal cycle, population density, and dispersal in farmland, are of special interest, especially also with a view to well-targeted control measures. All these basic biological facts were investigated in southern Austria (near Graz, Styria).

Arion lusitanicus was found to be univoltine and semelparous. Hatchlings were registered both during the autumn of the year in which the eggs were laid, and in the following spring. By far the largest part of the generation matured the following summer (June to August), with the peak of egg-laying in late August / early September. No evidence for self-fertilization was found in laboratory experiments. Hatching was investigated under various constant temperatures and in the field. Results were compared and proved to follow a formula originally applied to insects.

The first field experiments successfully to use *A. lusitanicus* individually marked with magnetic transponders (Grimm 1996) yielded information about its dispersal and the areas occupied by individual slugs. The size of these areas (convex polygons) was negatively correlated with population density: Mating sites were found to be distinctly closer to the geometric centres of activity than the sites used for egg-deposition.

In all the various aspects of slug behaviour investigated, large individual differences were found, suggesting a great plasticity in this highly successful generalist species.

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Host-symbiont specificity, transmission of symbiont, and host development: the lucinid model

Olivier GROS

Faculté des Sciences Exactes et Naturelles, Département de Biologie, Université des Antilles et de la Guyane

Sulfur-oxidizing symbiosis occurring in shallow-water species are similar to those described in hydrothermal vent invertebrates. The symbiont transmission mode in lucinids was investigated by PCR. No amplification products were obtained from mature gonads suggesting an environmental transmission mode in this bivalve family. This transmission mode was confirmed for *Codakia orbicularis* and *Lucinoma aequizonata* in which development occur without symbionts. In *C. orbicularis*, the chemoautotrophic symbionts are acquired after the metamorphosis from a free living symbiont form. Structural changes occur in the cellular organization of the gills after the establishment of symbiosis. Thus, aposymbiotic juveniles possess differentiated gill filaments similar to those described in wild juveniles, except for the bacteriocytes which appear as undifferentiated cells devoided of bacteria. After exposure to crude sand, symbiosis-competent bacteria enter by endocytosis at the apical pole of undifferentiated cells which progressively differentiate into classical bacteriocytes similar to those found in the adult gill filaments.

Bacterial symbionts of the superfamily Lucinoidea form a distinct monophyletic lineage. Previous investigations have shown that the specificity of such symbiotic association was unique to each host species (Distel *et al.*, 1994): one bacterial symbiont species for one invertebrate host. Nevertheless, our results show that at least six species of lucinid bivalves representing four genera (*Anodontia alba*, *Codakia orbicularis*, *C. orbiculata*, *C. pectinella*, *Divaricella quadrisulcata*, and *Linga pensylvanica*) harbor the same bacterial species in their bacteriocytes as suggested by phylogenetic analysis based on 16S rDNA sequencing. These molecular data have been recently confirmed by infection of aposymbiotic juvenile sets of *C. orbicularis* by purified bacterial fractions from the others lucinid species.

The gill-endosymbionts ERIC or REP patterns obtained from each host analyzed are different suggesting that host species are colonized by different bacterial strains. However, a unique genomic fingerprinting pattern has been obtained from the two gills of a same individual host. These data suggest that either (i) only one bacterial strain colonize the gills of one individual, or (ii) there is a homogenous mixed population of bacterial strains regularly distributed throughout both gills.

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Invited Lecture; Symposium: Molluscan Chemosymbiosis

Rhopalomenia spec. nov.: a new *Cavibelonia* species from West Scotland (Solenogastres, Mollusca)

Angelika GRÜNDLER

Institute of Zoology, University Vienna, Althanstr. 14, A-1090 Vienna, Austria, a9403429@unet.univie.ac.at

During the Scottish CHALLENGER cruise in 1983 many samples containing Solenogastres were collected from the North-Atlantic Deep Sea Region west of Scotland. Among them are two specimens from a single station (59°43'N, 12°33'W, 1270 m) belonging to an hitherto undescribed species of the family Rhopalomeniidae (*Cavibelonia*, Solenogastres).

The two specimens of *Rhopalomenia spec. nov.* are mature, about 10 mm long and 0.8 mm in diameter. Their body cover consists of calcareous, hollow skeletal needles and scales close to the foot. The ventral groove bears a single fold. The pallial cavity features no respiratory organs but large suprapallial glands. The mouth opening is separated from the atrium. The radula is lacking. There are two pairs of ventral foregut glandular organs, one pair of type A (subepithelial), the other of type C (epithelial). The long foregut opens into the midgut, which has an unpaired anterior caecum. A dorsoterminal sense organ is located terminally at the posterior end. Each pericardioduct forms a vesicula seminalis (proximal) and a receptaculum seminis (distal).

Poster; Open Session; Student Contest

The evolution of *Planorbis brusinae* Lörenthey - another example of gradual anagenetic change from the miocene Lake Pannon

Sándor GULYÁS

University of Szeged, Department of Geology and Paleontology, H-6722 Szeged,
Egyetem u. 2-6, Hungary, gubanc@yahoo.com, gubanc@kiwwi.hu

Geologically speaking examples for gradual anagenetic evolution are very rare in the fossil record. However, a number of such cases have been documented so far both for melanopsids and cardiids from the miocene Lake Pannon. Thus endemic fauna of this lake provides an excellent opportunity for investigations and testing of such models.

This type of morphological change has been documented on members of another family Planorbidae, in case of a possible lineage leading from *Planorbis ptychophorus* to *Planorbis brusinae*. The whole change took about 4.5 million years.

A gradual increase in overall shell size can be observed on our examples along with the development of a strong keel on the umbilical side. Furthermore, an increase in the convexity of the shell sides occurred creating high, globose shells from the originally more flat, discus-like shapes. The whole change is accompanied with a gradual flattening of the umbilicus creating a totally flat umbilical side in case of *Planorbis brusinae*. In addition a sharpening of transverse growth lines occurred giving a cogwheel like rim to the forms of this latter species.

Representatives of the lineage come from higher-energy, shallow water sands pointing to a possible role of ecological factors in the morphological change, creating more vigorous shells adapted to a high-energy environment. This question is still under investigation.

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Intraspecific variation of *Gyraulus (Gyraulus) varians varians* Fuchs from Lake Pannon

Sándor GULYÁS, Gyöngyi FERENCZY, Imre MAGYAR and Miklós SZÓNOKY

Department of Geology and Paleontology, University of Szeged, H-6722 Szeged,
Egyetem u. 2-6, Hungary, gubanc@yahoo.com, gubanc@kiwwi.hu

In case of the species *Gyraulus (Gyraulus) varians varians*, originally described from Radmanest a large-scale variation in the shell form and ornamentation can be observed. Fuchs assigns this species to the genus *Planorbis* mentioning the large-scale variation in the number of striations and keels as well as the rate of deflection of the apex and the ultimate whorl as an important factor in derivatio nominis of the species. Later Marinescu puts the members of this group into the genus *Gyraulus*.

Older specimens of *Gyraulus (Gyraulus) varians varians* from Radmanest (9.5 ma) display a gently deep-set spire running almost parallel with the line of the upper strong keel. The umbilical side is bordered with another strong keel. The umbilicus is deeply indented, turret-like. The ultimate whorl and the aperture are largely deflected. In case of the younger specimens from Tihany (9 ma) the spire is gradually indented and the rim of the upper keel on the apertural surface is slightly uplifted. Meanwhile a gradual shallowing in the position of the umbilicus compared to the older Radmanest forms can be observed. The aperture and the ultimate whorl are also less deflected. Large-scale variance observable on our forms assumes the presence of several taxa. Small, less decorated forms such as *Planorbis lendli* - possibly juvenile forms - were separated on the bases of a single specimen within such a highly varying group.

Variance in form is quantified via outline analysis (EFA) of the forms in 2D. Size was determined with traditional morphometric measurements (H/W). Other variants quantifying keel and striation numbers, angle of aperture deflection and inset of apex and umbilicus have been utilized as well. Total morphological variance was analyzed with the help of relevant multivariate methods - PCA, DA. Results of discriminant analysis and PCA underlie our hypotheses, that despite the large-scale variation specimens seem to constitute a single species with a gradual morphological transformation of the older Radmanest forms to the younger Tihany forms as part of some sort of adaptation. The separation of small, less decorated forms as distinct species within this group is not justified.

In order to shed light onto the ecological factors in the creation of such overall variance, analysis of shell ultra-structures have been carried out with SEM.

Axial cross-sectional shell analysis with the help of dental x-ray on Lake Pannon Planorbidae

Sándor GULYÁS¹ and Miklós SZÓNOKY²

¹ University of Szeged, Department of Geology and Paleontology, H-6722 Szeged, Egyetem u. 2-6, Hungary, gubanc@yahoo.com, gubanc@kiwwi.hu

² Balázs Sivók, University of Szeged, Faculty of Medicine, Dental Clinic, H-6720 Szeged, Tisza Lajos körút 64, Hungary.

Axial cross sections of gastropod shells provide an excellent way for determining shell size and form changes throughout ontogeny and phylogeny. Both the rate and the angle of coiling can be determined. Furthermore, the measurements and calculations of Raup's classic coiling parameters - translation, expansion and distance of generating curve from the axis- allow for the quantitative modeling of shell forms as well.

A gradual uplifting of the apex with parallel sinking of the umbilicus can be observed on a number of Lake Pannon Planorbids both during ontogeny and phylogeny. In order to quantify these changes one needs to obtain some sort of a cross-section of the gastropod shells as well. Being minute and rather fragile specimens traditional thin-section preparation was not a feasible solution for the problem.

With the help of colleagues at the Dental Clinic of the University of Szeged we developed a method for the preparation of cross-sections via utilization of dental x-ray machines. The specimens were glued onto cardboard pieces of 4x5 cm with water-soluble glue in axial view. For the preparation of the slides we used Kodak Ultra Speed dental film in the size of 3x4 cm. Exposures were taken on cone-tube dental x-ray machine type Trophie Radiologie (55 kv, 8 mA) via utilization of the so-called Fitzgerald, long-cone shooting technique. Further shots were taken using a digital sensor attached to a local microcomputer for digital image analysis purposes. Optical density measurements and artificial coloring of shell layers were carried out with a dental software package, Dental R-System 2.1 in order to visualize shell formation and variation in shell thickness.

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Major modification of the feeding apparatus in Mollusca - an evolutionary, structural and functional approach

Robert P. GURALNICK

University of Colorado Museum and EPO Biology, University of Colorado, Boulder CO 80305 USA, guralnic@spot.colorado.edu

Modifications of the molluscan feeding system have long been recognized as a crucial feature in molluscan diversification, related to the important process of gathering energy from the environment. However, an understanding of the structural and functional aspects of major evolutionary transitions within the Mollusca has been lacking. I focus on two major ecologically and evolutionarily significant dichotomies in molluscan feeding kinematics. The first is whether radular teeth flex laterally (flexoglossate) or do not (stereoglossate). The second is whether the radular ribbon slides over the odontophore cartilage during the feeding stroke or not. My method is to use a combination of phylogenetic inference and biomechanical modeling to understand the transformational and causal basis for flexure or lack thereof and sliding of the ribbon or lack thereof. I also use the same datasets whether structural subsystems making up the feeding system are structurally, functionally, and evolutionarily integrated or dissociated. For the first major transition - stereoglossy - statistical analysis of state changes revealed by the phylogenetic analysis shows that radular and cartilage subsystems evolved independently. Regarding kinematics of stereoglossy, the phylogenetic analysis shows that flexure arose at the base of the Mollusca and lack of flexure is a derived condition in one gastropod clade, the Patellogastropoda. Significantly, radular morphology shows no change at the node where kinematics become stereoglossate. However, the stereoglossy state in the Patellogastropoda is correlated with structural dissociation of the subradular membrane and underlying cartilages. Correlation is not causality, so I present a generalized biomechanical model explaining the structural conditions necessary for the plesiomorphic kinematic state (flexoglossy). The outcome of the model suggests that plesiomorphically the radular teeth must flex laterally as they pass over the bending plane as a result of the mechanical restrictions in the flexible but inelastic subradular membrane and close association between subradular membrane and cartilages. Relating this model to the specific character states of the clades, we conclude that lack of flexure in patellogastropods is caused by the dissociation of the subradular membrane and cartilage supports. Preliminary results from studying the transition from sliding of the radula independent of the odontophore shows sliding of ribbon over the odontophore has been lost in heterobranchs and is caused by shifting of muscle attachments at the base. Further work should clarify the exact character state changes.

Individual growing trends of *Chilina fluminea fluminea* (Maton, 1809) (Gastropoda, Chiliniidae) in Punta Lara, Ensenada, Argentina

Diego E. GUTIÉRREZ GREGORIC, Alejandra RUMI and Jorge M. PORCHILE

Invertebrate Zoology Div., Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900 La Plata, Buenos Aires, Argentina.
fergut@netverk.com.ar

The species of the family Chiliniidae Gray, 1828 have distributions limited to the southern-most sector of the Neotropical Region (Castellanos & Miquel 1991). In Argentina, some of them are transmitting agents of schistosomic dermatitis to the humans. In general, they have not been sufficiently studied and is hardly any biological, ecological or morphological information. Therefore, we have chosen the *Chilina fluminea fluminea* as a study model, very often over Río de la Plata coast river and intermediary host of larval stages of digenetic trematodes which causes dermatitis (Szidat 1951). The present results form the basis for a possible management and control plans. The aim of this work is to describe the individual growing trends about length of *Ch. fluminea fluminea*, according to the von Bertalanffy's model. The snails were collected from of July to October 1999 in ponds at the coast of Río de la Plata river in Punta Lara City (34°47'S; 57°59'W). To determine the smallest size of the sample (N=80) we used the Shannon & Weaver's diversity index, ordering the lengths in 12 classes, which correspond to relative ages. The lengths were estimated on the last whorl, using a caliber of ± 12 mm of precision. The polymodal decomposition shown two cohorts by date, as a result of reproductive hibernal efforts. The biggest length of the last whorl, calculated by the Walford's graph method, was of 17.2 mm. The application of the von Bertalanffy's equation about the last whorl length (k:1.652, R²:0.944, to:0.482) demonstrated that the model describes the population well. The maximum recruitment was in July and August (winter months), different from the other gastropods of the Río de la Plata river reproducing mainly in spring and autumn. This is of particular interest because the majority of species in this family lives in the temperate to cold Patagonia region. *Ch. fluminea fluminea* is one of the few species reaching subtropical regions.

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Mating in the nudibranch *Aeolidiella glauca*: an enigma

Martin HAASE¹ and Anna KARLSSON²

¹ Conservation Biology Group, Department of Integrative Biology, University of Basel, St. Johannis-Vorstadt 10, CH-4056 Basel, Switzerland,
Martin.Haase@unibas.ch

² Department of Animal Ecology, Evolutionary Biology Centre, Norbyvägen 18D, SE-752 36, Uppsala, Sweden, Anna.Karlsson@ebc.uu.se

Sexual selection has played a major role in shaping the wide variety of mating patterns found in species with separate sexes, but little is known about its effects on simultaneous hermaphrodites. Yet, many hermaphrodites possess complex reproductive systems and mating behaviour is often elaborate, suggesting that sexual selection is at work. Unlike other nudibranchs, *Aeolidiella glauca* transfers sperm via external spermatophores that are attached to the partner's back. Despite elaborate courtship the actual spermatophore transfer, which always involves two animals only, is of short duration. In most matings spermatophores are reciprocally exchanged. Shortly after transfer, the ventral spermatophore cover dissolves, and some sperm gather on the epidermis. A few even penetrate into epidermal cells, occasionally causing considerable damage. Most sperm, however, migrate along the body surface towards the gonopore. In a mate choice experiment *A. glauca* avoided to mate with slugs already carrying a spermatophore. Current mating status did not seem to affect this behaviour since both recently mated slugs and slugs that had been isolated avoided spermatophore -carrying partners. There are two obvious reasons why slugs should avoid recently mated partners. First, they may reduce the risk of getting a partner depleted in self-sperm. Second, the risk of sperm competition may be decreased. However, we found no difference in self-sperm reserves between previously mated slugs. Most slugs instead had sufficient sperm stored for spermatophore production. Therefore, the most likely explanation for *A. glauca*'s peculiar mate choice is that by avoiding a recently mated partner a sperm donor may reduce its risk of being subjected to sperm competition.

Mitochondrial differentiation in a land snail suggests survival of the Pleistocene ice ages under permafrost conditions

Martin HAASE¹, Bernhard MISOF², Thierry WIRTH^{1,3}, Helmut BAMINGER¹
and Bruno BAUR¹

¹ Conservation Biology Group, Department of Integrative Biology, University of Basel, St. Johannis-Vorstadt 10, CH-4056 Basel, Switzerland,
Martin.Haase@unibas.ch, Bruno.Baur@unibas.ch

² Institute for Evolutionary Biology and Ecology, University of Bonn, An der Immenburg 1, D-53121 Bonn, Germany, bmisof@evolution.uni-bonn.de

³ Max-Planck Institute for Infection Biology, Schumannstr. 21/22, D-10117 Berlin, Germany

The genetic differentiation and diversity of populations having colonized formerly unsuitable habitats depends to a great extent on the speed of expansion. Slow dispersers maintain their refugial diversity while fast dispersal leads to a drastic reduction of genetic diversity in the newly colonized areas. During the Pleistocene, almost the entire current range of the polymorphic land snail *Arianta arbustorum* has repeatedly been covered with ice or subjected to permafrost conditions. Due to the low potential for dispersal of land snails, slow colonization of the wide current range from southern refugia can be excluded. Alternatively, fast, passive dispersal from southern refugia or survival in and expansion from multiple refugia within the otherwise inhospitable area subjected to permafrost, as paleontologists have suggested, may account for the current distribution of *A. arbustorum*. In order to distinguish between these two scenarios we reconstructed a phylogeography based on the sequences of a fragment of the cytochrome oxidase I (COI) from 133 individuals including three morphologically defined subspecies collected in 45 localities. The high degree of diversity and divergence detected suggests that *A. arbustorum* is a rather old species in which the population structure, isolation, and the hermaphroditic nature of this predominantly outcrossing species have reduced the probability of lineage extinction. The three subspecies did not host exclusive mitochondrial lineages and geographic distance and mitochondrial differentiation were not congruent. Thus, the differentiation of COI either precedes that of shell morphology, or we witness haplotype introgression by hybridization combined with selection on shell shape. The rather patchy pattern of haplotype distribution suggests that colonization of formerly unsuitable habitats was achieved from multiple populations from within the permafrost area and that lineages were widely distributed already during the Pliocene.

Phylogeny of pteriomorph Bivalvia inferred from 18S, 28S rDNA, and morphological data

Sabine HAMMER and Gerhard STEINER

Institute of Zoology, Vienna University, Althanstrasse 14, A-1090 Vienna, Austria,
sabine.hammer@vu-wien.ac.at, gerhard.steiner@univie.ac.at

Phylogenetic studies on the Pteriomorphia, a major division of the Bivalvia with Ordovician origins, have yielded contradictory results. This can be attributed mainly to highly convergent and parallel evolution in numerous morphological characters. Here, we use two ribosomal data sets to elucidate pteriomorph relationships with molecular characters, which are expected to be less prone to convergence due to similar life styles (Steiner & Hammer 2000). The 18S rDNA data set contains 72 pteriomorph and 28 molluscan outgroup sequences; the 28S rDNA (domains D1-D3) data set contains 33 pteriomorph and 2 protobranch outgroup sequences. The combined data set contains 30 ingroup and 2 outgroup taxa. The morphological data set for family-level taxa has 20 selected characters. Parsimony, maximum-likelihood (ML), spectral analysis methods are used for phylogenetic analysis.

The relative rate test returns significantly lower rates in the 18S rDNA for the Pteriomorphia than for all the other molluscan groups; rate comparisons among the pteriomorph families shows higher values for the 28S rDNA, but only moderate correlation between the genes. In general, the branches of family-group taxa have strongest support. The analysis of the 18S data yield 106946 most parsimonious trees (MPT), however, the strict consensus tree shows only a single polytomy for the major groups. The 28S data yield two MPT with the only polytomy being within the Arcoidea. The two genes support similar topologies differing only in the arrangement of the basal groups Mytilida and Arcoidea. The most striking discrepancies between the molecular and morphological results concern the different position of the Limidae and Pinnidae. The unweighted combined analysis yields a single MPT with the same branching order of major groups as in the 28S topology, but with increased branch support.

Parallel or convergent evolution of morphological characters is assessed and discussed under the topology of the combined data. The pteriomorph data set is an example for the advantages of a combined molecular-morphological analysis yielding increased resolution and branch support.

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Special anatomical configuration of the posterior body in *Imeroherpia* n. sp. (Sterrofustia, Solenogastres, Mollusca)

Claudia H. HANDL

Institut für Zoologie der Universität Wien, Althanstraße 14, A-1090 Vienna, Austria,
Claudiahandl@netscape.net

Imeroherpia sp. n. is a Solenogaster from the West European Basin (POLYGAS A-Cruise; 2246 -2325 m). The hitherto monotypic genus *Imeroherpia* (*Imeroherpia quadridens* Salvini-Plawen) is the only representative of the family Imeroherpiidae.

Imeroherpia sp. n. shows all family characters of Imeroherpiidae: thick cuticle with solid needle-shaped spicules, a tetraserial radula, ventral foregut glandular organs subepithelial-epithelial (= type B of Salvini-Plawen 1978) and copulatory stylets with associated glands. A fused atriobuccal opening, presence of a dorsoterminal sense organ, a paired secondary gonoporus, presence of lateral midgut pouches and separate cerebral connectives are characters of the genus *Imeroherpia*.

However, *Imeroherpia* sp. n. shows a very distinctive configuration of the internal organs of the posterior body: The entire space inbetween the organs of the gonopericardial complex is occupied by large lumina, instead of connective tissue as in most Solenogastres species. The epithelium of these lumina is very thin and delicate, resembling coelomic epithelium. However, the lumina are actually voluminous posterior midgut sacculations, which clearly open into the midgut.

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Molecular evidence for the origin and early radiation of the Neogastropoda (Mollusca, Gastropoda)

M. G. HARASEWYCH¹ and Patrick M. GILLEVET²

¹ Department of Systematic Biology, National Museum of Natural History,
Smithsonian Institution, Washington, DC 20560-0118, USA,
Harasewych@nmnh.si.edu

² Institute for Bioscience, Bioinformatics, and Biotechnology, George Mason
University, 10900 University Boulevard, MSN 4E3, Manassas, Virginia 20110, USA,
Gillevet@ib3.gmu.edu

Neogastropod represent an extremely rapid and successful adaptive radiation of predatory marine gastropods that occurred during the Cretaceous and had a major impact on benthic marine faunas. Although Neogastropoda are easily recognized on the basis of shell morphology, radular morphology or anatomy of the alimentary system, their relationships to other gastropods are poorly understood. Some authors have suggested an "archeogastropod" or lower caenogastropod origin for Neogastropoda, while others have advocated various higher caenogastropods ranging from Littorinimorpha to Ficoidea as the likely sister group.

The relationships among higher taxa within Neogastropoda have been particularly difficult to discern due to high rates of homoplasy, especially of some anatomical characters, coupled with incidence of highly derived (autapomorphic) and therefore phylogenetically uninformative characters. Both the number and relationships of major clades within Neogastropoda have thus been subject to a broad variety of interpretations.

It has long been advocated that the Neogastropoda arose by polyploidy. We suggest that many of the homoplasies that have confounded studies of neogastropod evolution are the consequence of differences in expression or orthologous or paralogous structural genes encoded in the nuclear genome. Much of neogastropod evolution appears to have been driven by the regulation of gene expression rather than by the underlying structural genes. Such problems of paralogy and gene expression are avoided by the study of genes encoded in the mitochondrial genome. Partial gene sequences of the cytochrome c oxidase I gene and the 16S ribosomal DNA gene are used to identify the sister group of the Neogastropoda, and to clarify the early evolutionary history of the group, particularly with regard to the relationships of the toxoglossan groups and the Cancellariidae.

Is there a molluscan trochophore?

Gerhard HASZPRUNAR, Bernhard RUTHENSTEINER and Andreas WANNINGER

Zoologische Staatssammlung München, Münchhausenstr. 21, D-81247 München,
Germany, haszi@zi.biologie.uni-muenchen.de

Recent phylogenetic analyses based on phenotypic or genotypic characters have confirmed the old idea that the molluscan stem species was provided with a biphasic life cycle, *i.e.* a true larva. To specify the original molluscan larval type we investigated trochophore-like larva from patellogastropods, scaphopods and polyplacophorans by means of serial semithin sections and reconstructions, electron microscopy (TEM and SEM), immunocytochemical stainings combined with Confocal Laser Scanning Microscopy (CLSM), and gene (engrailed) expression. Special reference has been given to shell development, myogenesis, neurogenesis, sensory and excretory systems, and the prototroch.

Our studies revealed a remarkable diversity of the larvae investigated concerning all aspects of the larval body which will be outlined in the lecture. Because of the lack of data on larvae of the aplacophoran taxa, the reconstruction of character-states for the molluscan stem-larva is limited: It is very likely that the primary larva of the Mollusca was a lecithotrophic trochophore *sensu* Rouse (1999), whereas test-cell types (certain Solenogastres and protobranch Bivalvia) and planktotrophic veligers are probably of secondary origin. The larva was provided with an apical ciliary tuft and with a prominent prototroch but was devoid of a metatroch, neurotroch or telotroch. Originally a worm-like muscular grid covered an acoelomate body cavity with intercrossing dorsoventral muscle fibres, a single pair of protonephridia was present. A functional gut, heart and excretory system occurred long after metamorphosis.

The new data on the various larvae again suggest a common origin of all Trochozoa (Entoprocta & Mollusca, Sipuncula, Myzostoma, Echiura & Annelida). However, all results and in particular the comparative data on myo- and neurogenesis of the Polyplacophora point to the view that there is no trace but even direct contradiction of annelid-like segmentation during molluscan ontogeny. Detailed studies by modern methods on aplacophoran species and examples from the outgroups are particularly required to reconstruct further details of the original molluscan trochophore larva.

The "*Strombus roegli* Phase" – A Warm Spell in the Oligocene Western Tethys

Mathias HARZHAUSER

Natural History Museum, Burgring 7, 1014 Vienna, Austria,
mathias.harzhauser@nhm-wien.ac.at

A new giant, winged *Strombus* from Oligocene-Lower Miocene nearshore deposits of the Mesohellenic Basin (NW Greece), the Esfahan-Sirjan Basin (Central Iran) and the Qom Basin (Central Iran) was introduced as *Strombus (Dilatilabrum) roegli* Harzhauser, 2001. The exceptionally large size of *S. roegli* and its abundance are interpreted as a Chattian strombid event in the eastern part of the Western Tethys indicating distinct warming. At all sections the strombid bearing layers are characterised by siliciclastic sediments with corals, larger foraminifera and a highly diverse mollusc fauna, indicating marine conditions in lagoonal and/or shallow sublittoral settings. *Strombus roegli* is the largest *Strombus* recorded from the Western Tethys and seems to be the largest Oligocene strombid, apart from the "old-fashioned" *Oostrombus irregularis*, which lived in association with *S. roegli*. Among the modern strombids only *S. (Tricornis) gigas*, *S. (Tricornis) latissimus*, and *S. (Tricornis) goliath* attain the size of *S. (Dilatilabrum) roegli* and all are warm-water dwellers of the tropical zone. Hence, *S. roegli* and also the co-occurring giant *Oostrombus irregularis* can confidently be interpreted as tropical species. The sudden occurrence and the remarkable abundance of *S. roegli* in the Early Chattian in the Eastern Mediterranean part of the Western Tethys may thus be correlated with a distinct warming trend. The fact that the species has never been recorded from Late Chattian or Aquitanian deposits in the Central Mediterranean and obviously had an earliest Lower Miocene refuge in the south-eastern Western Tethys (Qom Basin and Esfahan-Sirjan Basin) hints at a cooling trend in the Mediterranean area during the latest Oligocene. Moreover, the climatic conditions of the Aquitanian did not allow a re-immigration of *S. roegli* into the Mediterranean basins from its Iranian shelter. Even in its south-eastern refuge the animal became extinct at least at the Aquitanian/Burdigalian boundary, since Burdigalian sections in the Iranian Qom Basin lack any evidence for large strombids. Instead, the characteristic Lower Miocene *S. (Lentigo) bonelli* exclusively represents the genus in the Central Iranian Burdigalian. The described Oligocene acme of this tropical *Strombus* is strongly reminiscent of the well-known Tyrrhenian *S. (Lentigo) latus* phases during the Pleistocene and seems to have been triggered by comparable mechanisms.

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Evolution of Miocene potamidid assemblages in the Mediterranean and the Central Paratethys – a faunistic and ecological comparison

Mathias HARZHAUSER¹ and Thorsten KOWALKE²

¹ Natural History Museum, Burgring 7, 1014 Vienna, Austria,
mathias.harzhauser@nhm-wien.ac.at

² Geological-Paleontological Institute and Museum, Bundesstrasse 55, 20146
Hamburg, Germany.

Early to late Middle Miocene potamidid assemblages from the Eastern Mediterranean and the Central Paratethys were investigated with special reference to the early ontogenetic shells. A gradual change in composition of littoral communities was observed from the Oligocene to the Early Miocene. *Tympanotonos margaritaceus* and *Granulolabium plicatum* persist in equal abundance to the Early Miocene where they still dominate the brackish gastropod assemblages. The most important difference to the Paleogene communities is the rise of *Terebralia*. Besides rare specimens of the *Terebralia subcorrugata*-group, which can be traced back to the Oligocene of France, and probably also to the Iran, the *Terebralia bidentata-lignitarum* group becomes an ubiquitous member of the littoral assemblages in the entire Eastern Mediterranean. In contrast, *Terebralia* stays rather rare during the Eggenburgian in the Central Paratethys but blooms in the Karpatian. *Granulolabium (Tiaracerithium) pseudotiarella* is known from the Aquitaine and Northern Italy. It seems to have had its optimum in the Atlantic as well as in the Eastern Mediterranean during the Aquitanian, but never reached the Paratethys. Due to a slight drop in temperature during the Oligocene, this tropical subgenus was replaced by *Granulolabium (Granulolabium)*, especially by *Granulolabium plicatum*. Its distribution was limited towards the north-west to the southern Aquitaine at the Atlantic coast during the Oligocene. During the Early Miocene it spread into the Mediterranean, extended up to the Aquitaine, and finally vanished from the European coasts at the beginning of the Middle Miocene. During the Burdigalian, *Tympanotonos margaritaceus* and *Granulolabium plicatum* vanish, too, the latter being replaced by representatives of the *Granulolabium bicinctum*-group. In the Karpatian, the ecological niche of the extinct *Tympanotonos* is already inhabited by *Potamides (Ptychopotamides) papaveraceus*. During the Badenian *Terebralia bidentata* becomes the predominating potamidid. In the Sarmatian, however, the species is of subordinate importance. Its decline is compensated by a Sarmatian acme of the genus *Potamides*. Especially the morphological similar *Potamides disjunctus* seems to replace *Terebralia bidentata*.

The adaptive demography of three sympatric pulmonate snails in the artificial lake Kerkini (Serres, N. Greece)

Marianthi HATZIOANNOU and Maria LAZARIDOU-DIMITRIADOU

Department of Zoology, School of Biology, Aristotle University of Thessaloniki, 540
06 GR, Thessaloniki - Greece, mlazarid@bio.auth.gr

This paper is a part of a general study concerning the growth, life cycle and bioenergetics of the freshwater gastropods of the artificial lake Kerkini (N. Greece). It concerns the density and distributional patterns of three coexisting freshwater pulmonates, *Physa acuta* (Drap., 1805), *Lymnaea stagnalis* (L., 1758) and *Lymnaea auricularia* (L., 1758), which are found at the north side of the lake in shallow waters rich in aquatic plants. The ultimate objective being the examination of the adaptations of the life cycle of the above snail populations in an unstable environment of an artificial lake, it was necessary to determine the influencing parameters. As such they were considered the water chemistry (temperature, pH, dissolved oxygen, total hardness, orthophosphate, chloride) and biotic factors as the abundance of aquatic vegetation and the density of the studied snails. These parameters were correlated to the abundance of the different snail species.

Demographic analysis of the population of *P. acuta*, which was the most dense showed that it composed of three generations per year with a life expectancy from 5 to 8 months, whereas *L. stagnalis* was consisted of two generations per year with a life expectancy from 18 to 24 months and *L. auricularia* population two generations per year with a life expectancy of 12 months.

During the investigation period the density of the pulmonates (number of animals/l) was higher in the surface (0-20 cm) than in the sampling units taken from greater depths (20 cm - 1 m). The plant biomass was the main factor regulating the density of all three species. Dissolved oxygen, total hardness and orthophosphates were found to have a lower coefficient of participation. It was also found an interspecific density regulating relationship among the three studied snail species.

Biogeography of north-west European land snails – Test of the vicariance model

Bernhard HAUSDORF¹ and Christian HENNIG²

¹ Zoologisches Institut und Zoologisches Museum der Universität Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany, hausdorf@zoologie.uni-hamburg.de

² Fachbereich Mathematik - SPST, Bundesstrasse 55, 20146 Hamburg, Germany, hennig@math.uni-hamburg.de

In a biogeographical analysis of the north-west European land snail fauna some predictions of the vicariance model are tested. According to the vicariance model, an ancestral biota was fragmented by an emerging barrier. The barrier interrupted the gene flow between the populations separated by the barrier and, thus, this vicariance event resulted in allopatric speciation of many of the species constituting the ancestral biota. In this way, two new biota emerge, which are separated by the barrier. By repetitions of the described process, the world is subdivided into areas of endemism with many species restricted to these areas. The species originating in an area of endemism by vicariance form a biotic element, a group of taxa the ranges of which are more similar to each other than should be expected by chance. Thus, we investigated with a Monte Carlo simulation whether the ranges of the north-west European land snails are clustered. There is a significant clustering of distribution areas. One widespread and five regional biotic elements were identified, but half of the distribution areas could not be classified in any cluster by a model based Gaussian clustering. The high percentage of un-classifiable distribution areas indicates already that processes other than vicariance played a major role in shaping the north-west European land snail fauna. Furthermore, the vicariance model predicts that closely related species do not occur within an area of endemism, but are distributed in different areas of endemism and, hence, belong to different biotic elements. We show with a chi-square test that closely related north-west European land snail species (species of the same (sub-)genus), belong significantly more often to the same biotic element than should be expected by chance. This indicates that speciation was not mainly due to vicariance events separating the areas occupied by the regional biotic elements, but to peripatric, parapatric or sympatric speciation within these areas. These areas (Pyrenees, western Europe, southern Alps, eastern Alps, Carpathian Mountains) might indicate the positions of Pleistocene glacial refuges of land snails, especially of forest dwelling species, which could not survive in the tundra-steppe belt between the North European and the Alpine ice sheets.

Evolution of the "*Corona Complex*" in the genus *Melongena* (Gastropoda: Melongenidae)

Kenneth A. HAYES and Stephen A. KARL

University of South Florida - Dept. of Biology SCA 110, 4202 E. Fowler Ave., Tampa, FL 33620, USA, khayes2@chuma.cas.usf.edu, karl@chuma.cas.usf.edu

Due to their intriguing biogeography and outstanding fossil record, gastropods in the genus *Melongena* offer a particularly attractive opportunity to study the evolution and systematics of an intertidal invertebrate. Presently, despite the use of traditional phenetic analysis in conjunction with data from the current geographic distribution, systematic relationships and the evolutionary history of the "*Corona Complex*" remain unclear. Additional techniques will be required to broaden our understanding of the evolution of this species complex. Using mitochondrial DNA sequences and microsatellite allele frequencies we are addressing some of the more difficult questions concerning the evolution within this genus. These data will allow the interpretation of present-day distribution patterns, past and present population parameters and the relationships within the species complex. They also can provide an understanding of the events that have led to these patterns and a clearer assessment of speciation in this marine invertebrate. Hypotheses regarding phylogeography and evolution of the "*Corona Complex*" will be presented and an analysis of preliminary data will be discussed.

The diversity of the freshwater limpet, *Septaria* (Gastropoda, Neritidae)

Alison HAYNES

Institute of Applied Sciences, University of the South Pacific, P.O. Box 1168, Suva,
Fiji, Fax (679) 300 373

Fifty-one nominal species of the Indo-Pacific genus *Septaria* are held in European and American Museums. Of these, only 13 are now regarded as valid species. Specimens were collected from streams and rivers of Fiji, Samoa, American Samoa, Vanuatu, Solomon Islands, French Polynesia, New Guinea, New Caledonia, Guam, Ponepe, South India, Mauritius, Seychelles and the Philippines between 1983 and 1997. They were dissected to reveal their radula, operculum and reproductive anatomy. Although the shells, radulae and opercula of many species were similar, the reproductive anatomy of each species was distinctive. Type specimens and other *Septaria* (*Navicella*) specimens held in Natural History Museums were matched with those recently collected. The valid species are: *S. apiata* (Le Guillou in Recluz, 1841), *S. borbonica* (Bory St Vincent, 1803), *S. bougainvillei* (Recluz, 1841), *S. cumingiana* (Recluz, 1842), *S. janellei* (Recluz, 1841), *S. livida* (Reeve, 1856), *S. luzonica* (Souleyet in Recluz, 1841), *S. macrocephala* (Le Guillou in Recluz, 1841), *S. porcellana* (Linnaeus, 1758), *S. sanguisuga* (Reeve, 1856), *S. suffreni* (Recluz, 1841), *S. taitana* Mousson, 1869, *S. tessellata* (Lamarck, 1816).

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Saving by freezing? Scallops in cold and temperate waters

Olaf HEILMAYER and Thomas BREY

Alfred Wegener Institute for Polar and Marine Research, Columbusstrasse, 27568
Bremerhaven, Germany, oheilmayer@awi-bremerhaven.de

All living organisms must pay a price for staying alive, usually termed basal or maintenance metabolism. Maintenance costs are affected by many parameters, but in ectotherms temperature plays the most significant role. Energy spent on basal metabolism is ecologically wasted in the sense that it is not used for growth, activity or reproduction. It is obvious that for a given intake of energy relatively less is wasted at lower temperatures. Many studies showed that ectotherms from low temperature environments are characterized by slow annual growth, low levels of activity and low standard metabolic rates compared with temperate species (Brey & Clarke 1993, Clarke 1987, Peck, in press). Providing that all other parameters such as assimilation efficiency would be independent of temperature, ecological growth efficiency should be higher in cold waters.

The purpose of this study is to explore how parameters of population dynamics in the widely distributed Pectinidae are related to temperature and basic metabolism. To prove the hypothesis that living in the cold is 'cheaper' and thus a distinct energetic advantage is gained over warmer water forms, we compared the standard metabolic rate (measured as oxygen consumption rate), growth rate and growth performance (f) of the endemic Antarctic scallop (*Adamussium colbecki* Smith, 1902) with those of scallop populations worldwide.

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The use of modern GIS mapping techniques in assessing biodiversity

Joseph HELLER

Department of Evolution, Systematics and Ecology, The Hebrew University of
Jerusalem, Jerusalem 91904, Israel, Heller@vms.huji.ac.il

Identifying patterns of variation in the composition of animal species over large geographic regions and their causal factors has long been a major issue of biogeography. The development of powerful Geographic Information Systems (GIS) during the last decade has opened new possibilities for the analysis of biogeographic patterns. GIS is a computerized technology that provides efficient tools for the storage, analysis and representation of geographically-referenced data. In this presentation, a multivariate approach based on GIS technology for the identification and interpretation of large-scale patterns of faunal variation is described. The approach combines the data reduction capabilities of multivariate techniques (ordination and classification) with GIS tools for the manipulation of geographically-referenced species data. The specific steps in the analysis are (1) construction of a grid covering the study area at an appropriate resolution, (2) overlaying the grid with a database of spatially-referenced species records, (3) determining the number of times each species was recorded in each cell, (4) constructing a matrix of grid cells by species where each entry indicates the number of records of a particular species in a particular cell, (5) analysis of the matrix using ordination and classification techniques, (6) construction of maps representing the results of the multivariate analyses, and (7) analysis of these maps with respect to digital maps of relevant environmental factors. The applicability of this approach was evaluated by analyzing the response of the land-snail fauna of Israel, to underlying variation in mean annual rainfall. As was expected, patterns of faunal variation were significantly correlated with underlying rainfall gradients. The classification analysis suggests two major provinces of terrestrial gastropods in Israel: a Mediterranean Province (subdivided into mountainous and coastal subprovinces), and a semi-arid province. Patterns of faunal variation were correlated with the underlying variation in rainfall, but the effects of rain on the composition of the fauna were greater in dry than in more rainy regions. Above 450 mm, no relationships could be detected between faunal variation and rainfall.

The overall results indicate that the integration of GIS tools with standard multivariate techniques may serve as a valuable methodology for the identification and interpretation of biogeographic patterns.

The microstructure of gastropod shell repair: An evolutionary ecological and biomimetic study of *Lavigeria* from Lake Tanganyika, East Africa

Karen HINKLEY, Ellinor MICHEL and Mehmet SARIKAYA

University of Washington, Materials Science and Engineering, 301 Roberts Hall,
Seattle WA, USA.

University of Amsterdam, PO Box 90766, 1090-GT Amsterdam, The Netherlands.

The snails of Lake Tanganyika are a celebrated case of co-evolution, having heavy, strong, and highly sculptured shells that may help them resist the ravages of attack by crabs specialized to break their shells. Like many predators, the crabs attack frequently, but in some species they are successful only a small percentage of the time as evidenced by frequent shell scars. The peeling action of the crab may be stopped by the crossed lamellar layers of shell material at 90° acting like a plywood laminate, too strong to be easily broken. Our focus is on several species of *Lavigeria*, which although sympatric and closely related, exhibit different levels of shell scarring and crossed-lamellar layer thickness. Up to 70% of snail populations have been attacked, with some individuals attacked up to five times in their lifetimes (see Phifer, this volume). Our focus has to integrate SEM imaging and field studies to determine for both evolutionary ecological and biomimetic perspectives. With SEM we found different thickness of crossed lamellar layers in undamaged, adult *Lavigeria* of different species, and ontogenetic variation, with fewer layers in juveniles. We also describe the microstructure of sculptural elements, such as ribs and cords.

Shell repair needs to be quick and efficient to retain shell integrity. We are testing whether repairs are organized, exhibiting the crossed lamellar layers of normal shell growth, or unorganized as in human scar tissue and if structural integrity is altered. In field studies we compared rates of shell deposition in shells peeled in a controlled manner, mimicking crab attack but in a replicable manner, and normal shell growth. We compare results with data on natural attempted predation levels in the source populations. Future work will include strength tests of scarred and normal shell tissue using Atomic Force Microscopy, Scanning Electron Microscopy and X ray diffraction.

Oogenesis in a viviparous and oviparous freshwater snail (Caenogastropda) from Israel

Alan N. HODGSON¹, Frida BEN AMI² and Joseph HELLER²

¹ Dept. Zoology & Entomology, Rhodes University, Grahamstown, 6140, South Africa, A.Hodgson@ru.ac.za

² Dept. Evolution, Systematics & Ecology, The Hebrew University of Jerusalem, Jerusalem, Israel, frida@vms.hu.il

The ultrastructural features of oogenesis are described in viviparous (*Melanoides tuberculata*) and oviparous (*Melanopsis buccinoidea*) freshwater snails. Yolk formation in both species appears to be primarily autotrophic. In *M. tuberculata*, protein yolk that is formed by the endoplasmic reticulum and Golgi bodies appears first. As vitellogenesis proceeds, the ooplasm not only accumulates two types (based on their morphological appearance) of large protein yolk granules and quantities of glycogen, but also some lipid. By contrast, in *M. buccinoidea* the early stages of vitellogenesis involve the formation of large amounts of lipid (the main storage product in these eggs). Mid- to late-stage oocytes begin to accumulate one type of protein yolk granule and glycogen. In both species hypertrophic follicle cells are closely associated with the developing oocytes and it is suggested that they play an essential role in oocyte nutrition.

Conservation genetics of the freshwater pearly mussel, *Margaritifera margaritifera* (L., 1758)

Anna HOLMES, Cathy JONES and Leslie R. NOBLE

Department of Biodiversity & Systematic Biology, National Museum & Gallery Cardiff, Cathays Park, Cardiff, CF10, UK, Anna.Holmes@nmgw.ac.uk

The freshwater pearl mussel (*Margaritifera margaritifera*) is an endangered species in Britain and is threatened throughout most of its European range. The family is markedly conservative throughout its long evolutionary history (Cretaceous & Recent) with no more than 6 extant species recognised. Given the rapid decline in population size, conservation measures could include translocation of individuals as re-introduction, although in those cases where this has been attempted there has been little success. Therefore, there is a need to understand the genetic separation of populations before further experiments are undertaken.

A previous study involved three Irish, Welsh and three northern England populations. Two of the Irish populations showed good separation. Using DRAWTREE, the results showed long tree lengths for the Irish populations and short branches for the northern England and the Welsh populations. It has been hypothesised that genetic separation may be due to population longevity related to Pleistocene extinctions - both Irish populations inhabit rivers not affected by the last glacial maximum.

In this study the pilot project is expanded to encompass the southwest and northeast of England, France, Czech Republic and Austria. RAPDs (Random Amplified Polymorphic DNA) are used because many genes in *M. margaritifera* are conservative and do not give conclusive results. The random primers used were chosen as they had given good results in the previous study. Using RAPDs allows comparison within and between populations and has previously been proven as a positive methodology to show intraspecific variation.

Intra- and inter-specific allometry of the reproductive organs in the slug genus *Arion*

John M.C. HUTCHINSON¹ and Heike REISE²

¹ Max-Planck-Institut für Bildungsforschung, Lentzeallee 94, D-14195, Germany, hutch@mpib-berlin.mpg.de

² Staatliches Museum für Naturkunde Görlitz, PF 300 154, D-02806 Görlitz, Germany, smng.reise@t-online.de

The scaling of genital size with body size has become an area of interest, because whether the scaling coefficient is below or above 1 tests hypotheses about the evolution and function of genitalia (*e.g.* lock and key hypothesis *vs.* sexual selection). Little data exist for gastropods, despite the typically high proportion of the body that is devoted to reproduction, and their elaborate genitalia and courtship behaviour.

We studied 5 congeneric terrestrial slugs of similar general morphology and ecology, but of different size and selfing frequency. Every two weeks for two years, at a woodland site in southern England, we collected every specimen found of *Arion intermedius*, *A. distinctus*, *A. circumscriptus*, and *A. subfuscus*. *Arion ater s.l.* was collected less thoroughly over one year. Adult wet mass varied between species by a factor of at least 60, and within species the largest adults were 80 to 260 times the mass of the smallest juveniles collected. From a subsample of slugs we dissected out the digestive gland and reproductive organs, weighing these wet and in some species measuring dimensions. Allometry was analysed using double logarithmic plots, with scaling coefficients calculated by reduced-major-axis regression.

Mass of the digestive gland varied isometrically with body mass, but the average proportion of total weight varied between species from 10 to 18%. In contrast, the distal genitalia started to develop late and then exhibited a scaling coefficient during growth of 1.7 to 2.9. However, this may be a misleading indication of allometry amongst mature individuals. Adult *A. circumscriptus* in spring are up to 9 times heavier than those at a similar developmental stage in summer, and the scaling coefficient of the distal genitalia amongst adults was only 0.75. This resembles the scaling coefficient comparing adults of the different species. One would predict that selfing species have evolved smaller distal genitalia: one of the two predominantly selfing species (*A. circumscriptus*) had distal genitalia smaller than predicted by the interspecific regression line, but this was not true for the other selfer (*A. intermedius*). The scaling of the total weight of the reproductive organs other than the distal genitalia was rather similar to that of the distal genitalia; but here *A. intermedius*, the smallest species, lay well below the regression line for the larger species. We also present data on the allometry of smaller component parts of the reproductive tract.

Evolution of the semi-slug in Helicarionidae (Pulmonata, Limacoidea)

Isabel HYMAN

School of Biological Sciences (A08), University of Sydney, 2006, NSW, Australia, ihyman@bio.usyd.edu.au

Semi-slugs are partially detorted snails with reduced, thin shells that they cannot fully retract into. Semi-slugs and slugs are found in many groups of stylommatophoran snails. Based on current classifications these conditions must have evolved multiple times, but in most groups little is known about the relationships between slugs and snails. In Helicarionidae, a group of pulmonate molluscs found throughout Australasia, southeast Asia, Africa and parts of the Americas, both snail and semi-slug forms occur. This group is poorly known, and three recent systematic studies, all of which used different sets of characters, have shown Helicarionidae to contain a different suite of taxa and to hold different relationships with other limacoidean groups (Tillier 1989, Hausdorf 1998, Wade *et al.* 2001). Preliminary studies indicate that there is a need for a systematic revision of the group using a comprehensive set of morphological and molecular characters.

The primary aim of this study is to determine the number of times the semi-slug form has evolved in Helicarionidae, using a combination of characters from the internal and external morphology and from molecular analyses. The latter technique has only been used for small subsets of this group (Wade *et al.* 2001), and should prove to be a useful addition to the standard techniques, particularly because anatomical comparisons between slugs and snails can be difficult. A biogeographical study will also be conducted.

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Molluscan fauna of Antalya Miocene basin and its paleogeographic-paleoecologic features (Western Taurids, S. Turkey)

Yesim ISLAMOGLU¹ and Güler TANER²

¹ MTA General Directorate, Geological Department, Balgat-Ankara, Turkey.

² Ankara University, Science Faculty, Geology Engineering Department, Besevler-Ankara, Turkey.

This study describes the molluscan fauna of Antalya Miocene basin dominated by mainly coarse clastic sediments situated between Isparta – Antalya – Alanya in the southern part of Turkey. The total of 42 species of Gastropoda and Bivalvia includes 3 undescribed species. Paleogeographic and paleoecologic studies show that during early and middle Miocene both Mediterranean Tethys and Central Paratethys species occurred together. In the middle part of the basin, the species representing brackish water such as *Irus (Paphirus) gregarius*, *Hydrobia (Hydrobia) frauenfeldi frauenfeldi*, *Pirenella gamlitzensis gamlitzensis* are specific for Central Paratethys and they have been found in the Late Burdigalian = Karpatian. In addition to this, the species such as *Terebralia lignitarum*, *Terebralia subcorrugata*, *Tinostoma woodi*, *Sanguinolaria (Soletellina) labordei*, *Pelecypora (Cordiopsis) islandicoidea*, and *Pelecypora (Cordiopsis) polytropa nysti* which are both Mediterranean Tethys and Paratethys elements are also found. The other fauna consisting mainly of *Crassostrea gryphoides* indicating brackish environment is found in deposits of Langhian = Early Badenian age.

In the western part of the basin, a different molluscan fauna is documented, which is dated to early Tortonian and including characteristic Tortonian species such as *Cypraea (Bernaya) fabagina mioporcellus*, *Xenophora infundibulum*, *Odostomia (Megastomia) conoidea*, *Arcularia (Arcularia) ringicula*, *Cerithium appenninicum dertosulcata*, *Mitrella (Mitrella) liguloides*, *Charonia stefaninii*, and *Hinia (Uzita) porrecta*. Moreover, three new species are recognized in the region, two in the genus *Alvania* and one in *Voluta*.

According to paleoecologic features of the fauna, during the late Burdigalian - Langhian = Karpatian - early Badenian, the sea covering the Antalya basin had low salinity and mostly brackish feature. Later, in Tortonian the salinity was higher relatively.

Xenoturbella (phylum uncertain): the appearance and loss of everything during its development

Olle ISRAELSSON

Department of Integrated Biology, University of California Berkeley, 3060 VLSB, Berkeley CA 94720-3140, USA, olle@uclink.berkeley.edu

Xenoturbella Westblad, 1949 is a strange marine, non-parasitic animal (up to 4 cm long) with two epithelial layers, a basiepidermal nerve plexus and a ventral mouth, but without an anus, concentrated nervous system, or any other distinct organs expect for a "statoeyst" with flagellated "statoconia". Despite its peculiarities and possible relevance to the early phases of the metazoan evolution, *Xenoturbella* has been neglected by most textbooks. Since its discovery, it has been the subject of most diverse interpretations: as one of the most primitive metazoans due to its simplicity in organization, as a primitive relative of acoelomorph flatworm, or as a paedomorphic holothurian or enteropneust.

However, the simply body plan is neither due to paedomorphy nor to plesiomorphy but to metamorphosis from a complex larva (Israelsson 1997, 1999). No living embryos have been observed earlier. The larvae have, e.g., alimentary tract, mantle cavity and concentrated nervous system while the adults lack as such structures. The embryology as well as molecular data indicate that *Xenoturbella* actually is a lophotrochozoan, probably within or close to molluscs.

Solving its systematic position does not make it less puzzling. Why would an animal that is neither parasitic or microscopic nor short-lived lose all its organs and change its concentrated nervous system with ganglia to a loose network of neurons, especially when its larva has all the features the adults lacks? *Xenoturbella* has a general importance for the understanding of evolution. It shows that it is possible for an organism with a specialized body plan (larvae with complex morphology) to develop into a totally different type of organism (adults without organs).

Why be a thief? The benefits of kleptoparasitism to the marine snail *Trichotropis cancellata*

Erika V. IYENGAR

323 Corson Hall, Cornell University, Ithaca, NY 14853, U.S.A., evc3@cornell.edu

The marine snail *Trichotropis cancellata*, originally described as a suspension feeder, has recently been documented as a facultative kleptoparasite, stealing food from the mouths of tube-dwelling polychaete worms (Pernet & Kohn 1998). Surveys spanning two years at six subtidal sites near San Juan Island, Washington, U.S.A., determined that kleptoparasitism is an important feeding strategy for all sizes of *T. cancellata* and may be the dominant feeding mode. The proportion of snails in association with hosts shifts during the year, with the largest proportion in the summer. Although multiple snails occur on hosts, single snail infections are most common.

Experiments demonstrated that parasitic snails grow significantly more than suspension feeders. Female snail fecundity is positively correlated with snail size. Thus, kleptoparasitism should be evolutionarily advantageous compared with suspension feeding. This is a parasitic interaction, as *Serpula columbiana* worms grow less when supporting a parasite. Although many parasites are host-specific, *T. cancellata* can parasitize multiple tube-dwelling polychaete species. These hosts vary significantly in size, and were predicted to differ in the resources they provide to parasites. However, in the summer, snails grew the same amount when parasitizing *Serpula columbiana*, *Schizobranhia insignis*, *Pseudopotamilla ocellata* and *Eudistylia vancouveri*. In the winter, snails grow faster on *Eudistylia* and *Schizobranhia* than on *Serpula*. Worm size is an insignificant predictor of snail growth (both in summer and winter). It may be only in times of food stress that snails fare differently on various hosts.

Suspension feeding is a dominant feeding mode in the marine realm, is performed by members of many diverse taxa, and has evolved at least seven times within the prosobranchs (DeClerck 1995). Still, suspension feeding is rare among marine snails. Why are not more snails suspension feeders? For *Trichotropis cancellata*, parasitism allows faster growth than suspension feeders, indicating that in this species suspension-feeding snails are food-limited.

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Bivalve diversity in the Gulf of Thailand: Comparing data from 1880-1900 with data from 1960-2001

Kathe R. JENSEN

Asian Institute of Technology, P.O. Box 4 Klong Luang, Pathumthani 12120, Thailand, jensen@ait.ac.th

Datasets from three periods have been compared: (1) The collections in Cambodia and Thailand made by M. Pavie in the 1880ies and by Th. Mortensen in the northeastern Gulf of Thailand in 1899-1900. (2) Data from the southeastern part of the Malayan Peninsula and Singapore, collected between 1950 and 1978. (3) Collections by Thai and Cambodian TMMP members and published in a series of papers between 1995 and 2001. The highest number of species was 379, recorded in 1909. Of these, 25 were described as new species, and 40 had not been collected by the Danish expedition. Several families, e.g. Nuculidae, Nuculanidae, Sareptidae, Thyasiridae, Montacutidae, have previously not been recorded. Veneridae was the most diverse family in all studies. Tellinidae, deep burrowers in undisturbed soft sediments, was second in Mortensen's collection (100 years ago). Arcidae, Cardiidae, Mytilidae and Pectinidae, shallow burrowers or epifaunal species, are represented by many species in all collections. The low number of boring bivalves from most recent collections is probably due to lack of sampling in the proper habitat. The same may be true for Lucinidae. The number of endemic species is probably very low. Most of the species, which are apparently endemic, belong to the commensal Montacutidae and Kelliidae, and were collected by an experienced echinoderm specialist, who was no doubt very careful about extracting these animals from the sediment. Taking into account the probability that some of the more than 450 species recorded from the Gulf of Thailand are synonymous and some may have become locally extinct, it seems likely that at least 300-350 species could be present. However, most qualitative surveys list only about 100 species, and quantitative surveys yield even fewer species. Thus current estimates of bivalve diversity in the Gulf of Thailand are much too low, and sampling techniques should be amended. Because bivalve shells are easy to collect and maintain in museum collections, many of the oldest specimens can still be found in museums. This makes bivalves suitable for longterm monitoring of biodiversity.

Inventoring marine molluscs in Cambodia

Kathe R. JENSEN¹ and Ing TRY²

1 Asian Institute of Technology, P.O. Box 4 Klong Luang, Pathumthani 12120,
Thailand, jensen@ait.ac.th

2 Department of Fisheries, 186 Norodom Blvd., P.O. Box 582 Phnom Penh,
Cambodia, tmmp.cam@bigpond.com.kh

In the 1880ies, the French colonial officer, M. Pavie, collected mollusc shells in Cambodia and Thailand. He collected about 230 species of marine molluscs, and most of his collection may still be located in the Natural History Museum in Paris. Since then no scientific records of marine molluscs have been made in Cambodia. In November 1999 the Tropical Marine Mollusc Programme (TMMP) held a training course in biodiversity of marine molluscs in Sihanoukville, Cambodia. Seven Cambodian participants were registered for this course, but at least twice that number actually attended the course. This showed the great need for information about marine living resources in Cambodia. About 150 species of marine molluscs were identified during the few days of the course. In the present project we survey the marine living resources of the Sihanoukville region. The marine Mollusca are very important in Cambodian waters, both as food for local people, for export, aquaculture and for shell craft products. We have collected marine molluscs from sandy beaches, mangrove mudflats, rocky shores, and from commercial trawlers. Also, we have bought some specimens from local markets and shell shops. The specimens have been photographed with a digital camera, and most of them have been preserved for storing in a recently established reference collection in Sihanoukville. So far we have collected about 250 species, but the identity of some still has to be confirmed. Our first objective was to create a pictorial database of all marine organisms found in the Sihanoukville region. In addition we wanted to publish a few posters of the most common and commercially important species to create public awareness. We have now published one poster with 26 common species of bivalves, and a second one with gastropods is ready for printing. Each picture is accompanied by the scientific species name and a common name in English and Khmer. The success of the first posters in creating public awareness and a sense of ownership of the marine natural resources resulted in a change of focus in this project. The Cambodian people do not see a great need for an electronic database, whether it has pictures or not. Hence we have decided to give the publication of more posters and pictorial guidebooks with English and Khmer text high priority in the future.

Toward a phylogeny of the Chromodorididae (Mollusca, Nudibranchia)

Rebecca F. JOHNSON

Department of Invertebrate Zoology, California Academy of Sciences, Golden Gate Park, San Francisco, California 94118, and Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, California 95064, USA,
rjohnson@calacademy.org

Although, chromodorid nudibranchs are probably they most celebrated and photographed of all nudibranchs, their phylogeny remains poorly understood. Rudman (1984) drew a dendrogram of hypothesized relationships based on morphological characters, but did not conduct a parsimony based phylogenetic analysis. Gosliner & Johnson (1999) conducted a preliminary phylogenetic analysis based on morphological information taken from the literature. The family Chromodorididae has been shown to be monophyletic, sister to the Actinocyclusidae, using morphological data and more detailed phylogenetic work has been done on individual clades within the Chromodorididae, but an independent, testable hypothesis of relationship for the entire group has not been presented. A phylogeny of the Chromodorididae based on molecular data is presented here.

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**Fitness consequences of phally polymorphism in *Deroceras laeve*
(Gastropoda, Pulmonata, Agriolimacidae)**

Kurt JORDAENS¹, Patrick VAN RIEL¹, Gary BERNON², Natalie VAN HOUTTE¹
and Thierry BACKELJAU^{1,3}

¹ Evolutionary Biology Group, Department of Biology, University of Antwerp
(RUCA), Groenenborgerlaan 171, B-2020 Antwerp, Belgium,
jordaens@ruca.ua.ac.be

² United States Department of Agriculture, APHIS, W. Truck Road, Otis Angb, MA,
USA.

³ Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels,
Belgium.

All pulmonate land gastropods are hermaphrodites. In several species, however, some individuals do not develop male copulating organs (*i.e.* aphyallics). This polymorphism in the development of the male genital organs (phally polymorphism) probably evolved as a consequence of high selfing rates. Indeed, most species that show phally polymorphism, if not all, are predominant selfers. Hitherto, phally polymorphism has only been studied in detail in the freshwater basommatophoran *Bulinus truncatus*. Here, we propose our first results on the population genetic structure of the terrestrial marsh slug, *Deroceras laeve* and show that the species is a predominant selfer. Yet, occasional copulations observed in a previous study and our lab suggest that outcrossing may occur. In a first attempt to compare the fitness of selfers and outcrossers, we compared egg production and egg hatching success of euphallic (*i.e.* regular hermaphrodites) and aphyallic individuals raised in isolation (and thus selfing) and pairs of slugs (outcrossing possible). The results will be discussed in the view of the maintenance of phally polymorphism within this species.

**Molecular phylogeny of African *Biomphalaria* (Basommatophora:
Planorbidae) with emphasis on species from the Albertine Rift lakes in
Uganda**

Aslak JØRGENSEN¹, J. Russell STOTHARD² and Thomas K. KRISTENSEN¹

¹ Danish Bilharziasis Laboratory, Jaegersborg Allé 1D, DK-2920 Charlottenlund,
Denmark

² Biomedical Parasitology Division, Natural History Museum, London SW7 5BD,
UK.

About 12 species of *Biomphalaria* are present in Africa and probably all species are intermediate hosts for schistosomes. Mandahl-Barth established in 1957 a system for the African species consisting of four species groups based upon morphological characters: *alexandrina*-, *choanomphala*-, *pfeifferi*- and *sudanica*-groups. The morphological characters belonging to the shell, copulatory organ and radula are partly overlapping between species and exhibit some intraspecific variation even between specimens from the same locality. Species belonging to the different species-groups have been sequenced for the genomic cytochrome oxidase I region (COI) and the mitochondrial 16S.

Currently four species of *Biomphalaria* are recognized from the Great Lakes in Uganda, *i.e.* *B. choanomphala*, *B. smithi*, *B. stanleyi* and *B. sudanica*. They belong to the *choanomphala*- and *sudanica*-groups according to the system established by Mandahl-Barth. In Lake Albert, *B. stanleyi* exhibit great morphological variation in the size of the aperture and a developmental series, from typical specimens with broad apertures to specimens that closely resembles *B. choanomphala* with a narrower aperture, can be established. The primary aim of the present study is to evaluate the current species group classification and investigate the phylogenetical relationships of some of the African *Biomphalaria* species with emphasis on the species present in the Albertine Rift and Lake Victoria. The present study furthermore investigates the genetic variation of *B. stanleyi* and *B. choanomphala* in Lake Albert, Uganda.

Comparative anatomy and functioning of the stomachs of Buccinoidea (Gastropoda, Neogastropoda)

Yuri I. KANTOR

A. N. Severtsov Institute of Problems of Evolution, Russian Academy of Sciences,
Leninski Prospect 33, Moscow 117071, Russia, kantor@malaco-sevin.msk.ru

The superfamily Buccinoidea is highly evolutionary successful, abundant and diverse group of carnivorous marine gastropods, dominant at high latitudes and at bathyal-hadal depths. Buccinoidea, being a highly derived group (Kantor 1996), at the same time possess some archaic characters of the stomach, not found in any other neogastropods – the presence of a crystalline style (Brown 1969) in some Nassariidae and a gastric shield in Nassariidae, Columbelloidea, and Buccinidae (Smith 1967, Marcus & Marcus 1962). Until now stomach anatomy of very few species has been examined.

In the course of this study stomach of 20 species, belonging to families Buccinidae (6 spp), Buccinulidae (4 spp), Melongenidae (3 spp), Fascioliidae (5 spp), Nassariidae (1 sp) and Columbelloidea (1 sp) has been examined for the first time. General stomach morphology is very variable within Buccinoidea, but allows distinction at the familiar level and can be useful in higher taxonomy of the superfamily, as well in separation closely related families, such as Buccinidae, Nassariidae and Fascioliidae.

Examination of the ciliary currents in the stomach of live molluscs clearly demonstrated that there are no currents leading from the stomach into openings of digestive gland duct(s), while there is a strong flow of fluids and fine particles from the digestive gland into the stomach. These observations clearly indicate that absorption of digested food does not occur inside digestive gland, on the contrary to generally accepted point of view. Therefore physiology of process of food digestion in Neogastropoda needs critical re-examination.

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Some molluscs and paleoecology of three Neogene lakes (Karaburun, Soma and Domaniç-Tunçbilek) in Western Anatolia

Sevinç KAPAN-YEŞİLYURT¹ and Güler TANER²

¹ General Directorate of MTA Balgat-Ankara, Turkey,
sevinckapan_yesilyurt@hotmail.com

² Ankara University Faculty of Science Depart. of Geol. Eng. Tandoğan-Ankara,
Turkey.

In this study, gastropod and bivalve fauna belonging to three Miocene lakes located at Karaburun (İzmir), Soma (Manisa) and Domaniç-Tunçbilek (Kütahya) in Western Anatolia have been examined. It is interpreted that the relationships between these lakes with the fauna giving ages as stage level.

A shallow and short-lived lake with a specific hydrodynamic conditions and an endemic fauna throughout Maeotian has been found at Karaburun (İzmir). It also contained species such as *Chilostoma (Drobacia) maeotica*, *Cepaea krejci*, *Planorbarius thollierei*, *Planorbis planorbis* and *Poiretia* sp.

Another lake at Soma (Manisa) existed from the Maeotian until the Pontian-Dacian-Romanian. This lake had marshy and coaly levels in Pontian due to level of the lake has been changed by tectonics. In Dacian and Romanian, the lake was fed by rivers and also material from the volcanic activity of the region. The above mentioned evolution of the lake was inferred from the fauna including *Chilostoma (Drobacia) maeotica*, *Pisidium amnicum*, *Planorbarius thollierei*, *Gyraulus (Gyrulus) inornatus*, *Unio prominulus*, *Melanoides (Melanoides) curvicosta* and other *Melanopsis* species.

The third lake has been found at Domaniç-Tunçbilek (Kütahya) starting with Pontian levels. In Dacian and Romanian, tectonically induced water level changes are observed. The lake was fed by rivers and shows freshwater and brackish water fauna including *Planorbarius corneus*, *Radix (Adelinella) phrygovata*, *Valvata (Cincinna) variabilis*, *Melanoides (Stenomelania) abchasica*, *Bulimus (Tylopoma) avellanus*, *Segmentina filocincta*, *Radix (Radix) peregra* and *Corbicula fluminalis*.

Although these three lakes have many similarities, their fauna is different enough to conclude that each of them had different ecological conditions.

Feeding behavior in worm snails (Vermetidae) - A successful adaptation to sessile life in coral reefs

Isabella KAPPNER

Field Museum of Natural History, Department of Zoology (Invertebrates), 1400 S Lake Shore Drive, Chicago, IL 60605, USA, ikappner@fieldmuseum.org

Dendropoma maxima is the largest species of sessile vermetid gastropods. In the northern Gulf of Aqaba (Red Sea) it lives predominately at places of the tropical reef flat/ reef crest transition zone with an intermediate water-exchange rate (diffusion factor 5.5-6.5). The snail occurs in densities of 11.1 ± 6.3 ind. m^{-2} and lives in 1.4 ± 0.1 cm diameter tubes embedded in the carbonate framework of the reef. It secretes mucous feeding nets extending ~10 cm around the individual, so that in places entire sections of the fringing reef are carpeted with "communal" mucus nets of neighboring individuals. The sticky nets indiscriminately trap suspended particles from suspension, are withdrawn at regular intervals, screened for indigestible items (fecal pellets, shell fragments and particles >2 mm), and consumed. Net retraction frequency, as determined by time-lapse video in the laboratory and in the field, appears to be related to the availability of food with significant differences between day (1.35 ± 0.16 hauls per hour) and night (2.39 ± 0.44 hauls per hour), corresponding to differences in the availability of phyto- and zooplankton. Microscopic observations show that significantly more zooplankton was captured during the night than during the day. Community ingestion amounts to 0.9 ± 0.5 g C. m^{-2} and day, showing that mucus net feeding traps plankton at rates comparable to other sessile suspension feeders in the same coral reefs.

New data on the molluscan fauna of the Azov Sea

Igor A. KHALIMAN

Tavricheskaya Agrotechnical Academy, Melitopol, Ukraine.

The analysis of scientific and proper studies concerning the number of species in the region allows to consider the question of migrants in the Azov sea unsolved as ever. The decreasing flow of rivers leads to emerging new zones of subsistence of malacofauna elements in the attached basins, primarily the Black Sea. Presently, the presence of several gastropod and bivalve species is questionable for the lack of reliable recent reports of living specimens. Empty shells of *Gibbula albida* (Trochidae), *Cerithium vulgatum* (Cerithiidae), *Truncatella subcylindrica* (Truncatellidae) widely spread in the Black Sea were found early in the 20th century. Also, the presence of *Ostrea lamellosa* (Ostreidae) and *Pecten ponticus* (Pectenidae) in the Azov Sea is questionable. Our material consists of several dozens of fresh shells of *Ostrea lamellosa* and *Pecten ponticus* found on the southern coastline of Biryuchy island. Numerous specimen were also found in the sea 1000 - 1500 m off Kirillovka settlement at at clay plateau 2.5 - 4.5 m deep. In January 2001, a few fresh partially damaged shells of *Gibbula albida* were found in the waters at the sea side of the Fedotov spit.

West of Kirillovka settlement more than 100 specimens of *Cerithium vulgatum* were found, many of them retaining colors and patterns of periostracum. In this region was also found a single fragment of a *Truncatella subcylindrica* shell.

In the samples taken from the north-western part of the Azov Sea we found many empty shells of *Solen vagina* (Solenidae). This species has never been mentioned in the previous reports on the region's fauna and most likely it is to be considered a new one for the Azov Sea.

These discoveries indicate a high probability that the above mentioned species inhabit the north-western part of the Azov Sea.

Life history variation and sexual dimorphism in the *Lavigeria* (Thiaridae) species flock of Lake Tanganyika (Tanzania)

Irene KINGMA and Ellinor MICHEL

Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, PO. box 90766, 1090-GT Amsterdam, The Netherlands,
irene.kingma@student.uva.nl, michel@science.uva.nl

With over 30 endemic species known the thiarid gastropod species flock of the *Lavigeria* of Lake Tanganyika presents challenges for understanding intralacustrine speciation. We present the first quantitative data on reproductive strategies and morphological variation in seven species from the Kigoma region. Sympatric species differ consistently in brood size, embryo size and developmental pattern, which may indicate that diversification is related to differences in reproductive strategy and predation on juveniles.

The offspring of different species differ enormously in morphology, number and size. We see two groups of species with contrasting brooding strategies. One group has large broods, small offspring and little growth during the developmental trajectory while the other group has small brood size, large offspring and significant growth during interuterine development. In our view the first group has an opportunistic brooding strategy with the parent maximizing its reproductive output by investing little energy in each young and thus increasing the total brood size. The second is a more specialized strategy, where the parent invests more energy in the viability of the offspring leading to smaller brood sizes. From gut content analysis and tank studies we learned that molluscivorous cichlid fish prefer *Lavigeria* to other gastropod species (Nduwarugira 1999). When presented with a choice between small or large juvenile snails they prefer the smaller ones (N. Zorich pers.com.). Reproductive strategy may evolve easily in *Lavigeria* and is not constrained by adult morphology - the unusually large sister species *L. grandis* and *L. coronata* have alternate approaches. Distribution also does not always follow immediate predictions from reproductive mode - species with many, smaller offspring may have point or lake-wide distributions, while a lake-wide species is characterized by few, large offspring.

We used multivariate morphometrics to test for sexual dimorphism in six *Lavigeria* species. In three species we observed sexual dimorphism, with females subtly but significantly larger than males, while in two others the sex-ratio of our sample suggest it might present although our sample of males for these species was too small to demonstrate dimorphism.

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On the reproduction of *Cylindrus obtusus* (Draparnaud, 1805) (Gastropoda, Helicidae), an endemite of the Eastern Alps in Austria

Doris KLEWEIN¹, Gabriele BAUMGARTNER², Elisabeth SINGER² and Helmut SATTMANN³

¹ Gentzgasse 17/1/7, A-1180 Vienna, Austria.

² Institute of Zoology, University of Vienna, Althanstr. 14, A-1090 Vienna, Austria.

³ Natural History Museum, Vienna; Burggring 7, A-1014 Vienna, Austria,
helmut.sattmann@nhm-wien.ac.at

Cylindrus obtusus is an endemite of the Eastern Alps in Austria, restricted to limestone habitats mainly at altitudes above 1500 m a.s.l. Little is known about the ecology and biology of this species. Studies on the population biology have shown that populations are apparently rather isolated locally and that dispersal is low. Due to slow shell growth and a short activity period, *C. obtusus* might need several years to become adult (Bisenberger *et al.* 1999). Almost nothing is known about the reproduction biology of *C. obtusus* (Kleewein *et al.* 2000). Twenty-nine adult individuals of *C. obtusus* were kept in an outdoor cage at an altitude of 1300 m a.s.l. from June 2000 to May 2001. From June to November the cage was checked for the presence of eggs at least once a month. Eggs were removed, measured and kept separated. Eggs were found in early summer exclusively. A total of 8 clutches were found. The clutches contained 4 or 5 eggs each, of which 93% hatched. The period from egg laying to hatching is in between 2 and 9 weeks. This reproduction strategy with a low annual reproduction rate can be explained by low mortality losses and/or high age of the individuals.

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Epibiotic-macrophyte dynamics between the grazer *Modulus modulus* and the seagrass *Thalassia testudinum*

Eduardo KLEIN and M. DOS REIS

Departamento de Estudios Ambientales and INTECMAR, Universidad Simón Bolívar, P.O. Box 89.000, Caracas, 1080, Venezuela, eklein@usb.ve.

At the present time, there is a trend to study the strength of the local top-down and bottom-up controls on the dynamics of marine communities. In order to evaluate the grazing effect of *Modulus modulus* on the epibiotic community colonizing the leaves of the seagrass *Thalassia testudinum* a field and laboratory study was conducted at a semi-enclosed bay at Morrocoy National Park, Venezuela. The natural abundance of the gastropod and the epibiotic community biomass were estimated over three transects with 50 randomly selected quadrats of 0.25 m² each along a depth gradient. A controlled grazing experiment was carried out using different gastropod densities (0, 30, 89 and 300 ind/m²) and the epibiotic and plant primary production was followed during 100 days. In the field, we observed that the density of *M. modulus* increased significantly with depth ($p=0.022$), probably due to the stressing conditions at shallower zones (strong variations in salinity and temperature). Also, a negative correlation between epibiotic biomass and gastropod density ($r=0.50$) was observed. The analysis of the gastropod feces confirmed the use of diverse components of the epibiotic community as food items. Laboratory studies failed to demonstrate the grazing effect of *M. modulus* on the primary productivity of the seagrass. The plant showed a period of optimal productivity during the first 30 days (0.97 ± 0.30 g DW m²/day) and then it decreased continuously until the end of the experiment without showing any difference between the treatments (0.35 ± 0.25 g DW m²/day in 60 days). However, *M. modulus* did significantly reduce the epibiont biomass at the treatments with the highest gastropod densities (0.16 ± 0.01 mg AFDW/cm² at 0 ind/m² vs. 0.11 ± 0.01 mg AFDW/cm² at 300 ind/m²). The evidence suggests that *M. modulus* has an important role in the top-down regulation of the biomass of epibionts in experimental conditions. Nevertheless, extrapolation to the natural habitat must be done considering several additional environmental and biological factors.

Phylogeny of the Anaspidea (Gastropoda, Opisthobranchia) - What do we know so far?

Annette KLUSSMANN-KOLB

Institut für Zoologie, Johannes Gutenberg Universität, Müllerweg 6, 55099 Mainz, Germany, klussman@mail.uni-mainz.de

The Anaspidea are one of the smaller groups of Opisthobranchia, comprising about 120 species united in 10 genera. Anaspids, and especially the genus *Aplysia*, have long been of interest to biologists because of the relatively large cells in the nervous system which has been the basis for numerous neurophysiological studies. They are also interesting because they have evolved various defensive strategies (e.g. inking, secretions of the opaline gland).

Several taxonomic classifications of the Anaspidea have been published in the past (e.g. Eales 1944, Marcus 1972), but the phylogenetic relationships within the taxon are not completely understood yet. A thorough phylogenetic analysis based on morphological data has not been performed up to date. However, Medina & Walsh (2000) recently presented a phylogenetic analysis of the order based on molecular data.

The current investigation is based on an extensive review of the taxonomic literature on the Anaspidea including the monogeneric Akeridae. The placement of this latter taxon has been an issue of controversial debate in the past. In the present study, more than 30 morphological characters used for classification in the past have been re-investigated histologically and macroscopically, and their utility for phylogenetic analysis has been evaluated. From these characters a data matrix for 18 species belonging to eight genera has been assembled and analysed with PAUP 4.0. From the analyses it is clear that the diagnostic characters used in the past to separate taxa on the species or genus level do not yield enough information to resolve the phylogenetic relationships among the genera. In conclusion, new sources for characters will be discussed. (This study is supported by the Deutsche Forschungsgemeinschaft KL 1303)

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Miocene Mollusca of Mountain Avala near Belgrade

Slobodan KNEZEVIC and Meri GANIC

Faculty of Mining and Geology, University of Belgrade, Kamenicka 6, Belgrade,
Yugoslavia, aganic@sezampro.yu

At the base of Mountain Avala, south of Belgrade, there are Miocene sediments of Central Paratethys of Sarmatian, Pannonian and Pontian age. In vicinity there are sea beds of Badenian age (middle Miocene). These Miocene beds have rich fossil faunas of invertebrates. These faunas are from important localities of Lake Pannonian of upper Miocene. South-Eastern Avala locality Karagac strem (upper Miocene), is classic site of upper Pannonian age of Serbian. In the fossil-rich molluscan assemblage of Karagac, specific endemic Gastropoda and Bivalvia are found.

A new view on the systematics of the Southeast Asian freshwater gastropod *Brotia* (Cerithioidea, Pachychilidae): integrating morphological and molecular data

Frank KÖHLER and Matthias GLAUBRECHT

Institute of Systematic Zoology, Humboldt University Berlin, Invalidenstr. 43, 10115
Berlin, Germany, frank.koehler@rz.hu-berlin.de

The viviparous freshwater genus *Brotia* H.Adams, 1866 (Caenogastropoda, Cerithioidea, Pachychilidae) has an Oriental distribution, with more than 50 species ranging from Eastern India to the Great Sunda Islands and the Philippines. Current studies on the anatomy revealed that this gastropod is member of the Pachychilidae, and not of the Thiaridae as suggested by earlier authors.

Cladistic analyses were conducted on a morphological data set as well as on mitochondrial DNA sequence data, which revealed that *Brotia* as traditionally conceived of is composed of three monophyletic lineages. Although all species are (ovo)viviparous, the different clades are characterized by different brooding anatomies and strategies. Accordingly, it is hypothesized that brooding has evolved three times independently among the SE Asian pachychilids that were up to now subsumed as *Brotia*, viz. (1) within the clade comprising all species on Sulawesi which possess an uterine brood pouch, (2) among two species endemic to the Philippines which retain their eggs in the mantle cavity, and (3) within the clade comprising all species from the Southeast Asian mainland, Sumatra, Java and Borneo which possess a subhaemocoelic brood pouch. Furthermore, the latter lineage can be subdivided into two groups by means of the embryonic shell morphology. All these aforementioned species groups are spatially separated from each other. As the Pachychilidae is a relatively ancient clade with a recent distribution indicative of a Gondwanan origin, the distribution pattern of the SE Asian taxa is hypothesized to reflect not only relative recent geological events such as e. g. the drowning of Sundaland during the Pleistocene, but also older events such as the separation, drifting and later amalgamation of terranes as is suggested by current hypotheses on the geological history of SE Asia.

The feeding process in molluscivorous *Conus*

Alan J. KOHN

Department of Zoology, University of Washington, Box 351800, Seattle, Washington
98195, USA.

In the gastropod genus *Conus*, each radular tooth functions independently as a critical component of the delivery system for conotoxins, neurotoxic venoms that are injected into prey organisms and paralyze them prior to ingestion. The morphology of *Conus* radular teeth varies among species according to their specialization on a major prey type, primarily polychaete annelids, fishes, or other gastropods. The few prior studies describing details of the feeding process focused on species that prey on polychaetes and fishes, in which the radular tooth functions like a hollow harpoon. When injected, it catches and holds the prey while venom is pumped through its lumen by muscular action of the proboscis, the prey is paralyzed and pulled into the rhynchodaeum by contraction of longitudinal proboscis muscles, and swallowed whole. The tooth passes through the *Conus* alimentary tract with the prey. The observation that the guts of molluscivorous species of *Conus* sometimes contain several of their own teeth as well as prey remains suggested that the feeding process differs from that of vermivores and piscivores, particularly that more than one tooth is injected into a single prey organism. Here I describe the behaviorally much more complex feeding process in a molluscivorous species for the first time. As predicted, it involves sequential injection of several teeth, each of which is released into the prey and is thus more analogous to an arrow from a bow than to a harpoon. A video illustrates details of the process and the responses of the gastropod prey to multiple envenomations.

Family Sphaeriidae as a separate lineage of freshwater heterodont bivalves: the intergroup relationships and possible outgroups tested by morphological characters analysis

Alexei V. KORNIUSHIN

I.I. Schmalhausen Institute of Zoology, B. Khmel'nitsky str. 15, 01601 Kiev, Ukraine,
akorn@carrier.kiev.ua

Reconstruction based on 69 morphological characters in 57 taxa of Sphaeriidae (considered in the traditional sense), 2 species of Corbiculidae (*Corbicula fluminea* and *Neocorbicula limosa*) and a venerid outgroup (*Chamelea gallina*) (Korniushin & Glaubrecht, in prep.) basically agree with the recent molecular investigations (Park & Ó Foighil, 2000) in providing support to the first family and its 2 subfamilies (Euperinae and Sphaeriinae). Since close relationship between freshwater corbiculids and sphaeriids was not supported by either data set, these groups may represent separate freshwater lineages. The problem of marine or brackish water sister group for Sphaeriidae is still unresolved, but recent observations have shown that the mangrove bivalve *Geloina erosa* (Solander) traditionally assigned to Corbiculidae shares with Sphaeriidae at least 2 synapomorphies: separation of the exhalant and the inhalant siphon retractors and shortening of the outer radial mantle muscles (in relation to the inner ones). Furthermore, this species is similar to Euperinae in having multiple retractors of the inhalant siphon and to Sphaeriinae in the arrangement of its inner radial mantle muscles in bundles. The simplified hinge and stomach that distinguish the Sphaeriidae can be explained by reductions, and the complicated sphaeriid nephridium with several unique structures is evidently an adaptation to the freshwater environment. In light of these data, placement of *Geloina* among Corbiculidae seems disputable and its close relationship to Sphaeriidae possible. Two major lineages of Sphaeriidae (Euperinae and Sphaeriinae) are characterized by different modes of reproduction (incubation of big yolky eggs directly in gills in the former group and development of small eggs in brood pouches in the latter) as well as by synapomorphies in mantle musculature, stomach, nephridium, and other structures. Being well supported, these groups may deserve the higher taxonomic rank, as suggested by Starobogatov (1992).

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Review of endemic species of heterodont bivalves from the ancient lakes

Alexei V. KORNIUSHIN¹ and Matthias GLAUBRECHT²

¹ I.I. Schmalhausen Institute of Zoology, Kiev, Ukraine.

² Museum für Naturkunde, Berlin, Germany.

Endemic species of Sphaeriidae are known from lakes Baikal, Tanganyika, Victoria, Ochrid, Prespa, Biwa and Titicaca, where they occur together with widely distributed species. Revision of shell and alcohol material from some of these lakes has confirmed diagnostic shell characters of these species, while anatomical characters show their affinity to those taxa that are distributed in adjacent regions (Korniushin *et al.* 2000). Since it has been found that the endemic sphaeriids belong to different genera and subgenera, some of the features they have in common (such as, *e.g.*, high triangular shell and broad hinge plate) might have developed independently, probably as adaptations to specific factors of the lacustrine environment.

Endemic species of Corbiculidae are known from Lake Biwa and several lakes on Sulawesi (*e.g.* Lake Poso, the Malili Lakes and the Lindu River basin). In contrast to sphaeriids, these endemic corbiculids differ from widely distributed species in their anatomical characters (*e.g.* size of posterior adductor, form of siphons and their papillae) and especially in their modes of reproduction (*i.e.* incubation of larvae in both demibranchs in *Corbicula possoensis* P. & F. Sarasin from Lake Poso and incubation of advanced stages in *C. lindoensis* Bollinger from the Lindu River system).

However, no cases of extensive speciation are reported for bivalves in ancient lakes, and only one recently described endemic genus is recognised (Bogan & Bouchet 1998). The level of morphological divergence is apparently lower among bivalves than among gastropods, especially in the oldest lakes such as Lake Baikal or Tanganyika. Thus, in contrast to some syntopic gastropods, evolutionary stasis (*i.e.* very slow rate of morphological evolution) and lack of speciation and adaptive radiation are peculiar features of the studied groups.

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Alpine land snails: studies on *Arianta* and *Cylindrus* - an overview of our work from 1988 - 2000

Hans KOTHBAUER, Helmut BAMINGER, Gabriele BAUMGARTNER, Agnes BISENBERGER, Martin HAASE, Doris KLEWEIN, Renate KOTHBAUER, Martin KRAUSHOFER, Hans NEMESCHKAL, Helmut SATTMANN¹ and Elisabeth SINGER

¹ Corresponding author: H. Sattmann, Natural History Museum Vienna; Burgring 7, A-1014 Vienna, Austria, helmut.sattmann@nhm-wien.ac.at

Arianta arbustorum, a landsnail that is highly variable in shell shape, size, colour and patterns and also remarkably tolerant in its habitat demands, is quite abundant in large parts of Europe. Numerous different "forms", "races" and other subspecific taxa were named, particularly in the 19th century. Our studies on morphometry, genetics, ecology and behaviour yielded in seemingly contradictory results. We conclude that *A. a. styriaca sensu* Baminger (1997) is a true geographical subspecies.

Two other described species of the genus *Arianta*, *A. chamaeleon* and *A. schmidti*, are endemites of the Southern Alps. Comparative morphological and genetic studies demonstrate that *A. chamaeleon* and *A. schmidti* are good species. Ecologically, a clear niche differentiation between *A. arbustorum* and *A. chamaeleon* is shown.

Cylindrus obtusus is an endemite of the alpine region of the Northeastern Limestone Alps in Austria. An interesting variability of the measures of the genital tract in different populations was recorded. Initial data on the biology and ecology show that populations are locally rather isolated and dispersal is low. Due to its slow shell growth and short activity period *C. obtusus* probably needs several years to become adult.

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**Phylogenetic relationships among species of the genus *Meretrix*
(Heterodonta: Veneridae) inferred from mitochondrial DNA sequences**

Tsuyoshi KUMAGAI and Tomowo OZAWA

Department of Earth and Planetary Sciences, Graduate School of Environmental
Studies, Nagoya University, Chikusa-ku, Nagoya 464-8602, Japan,
ozawa@eps.nagoya-u.ac.jp

Members of the pelecypod genus *Meretrix* are familiar inhabitants of coastal sandy substratum throughout Asia and are one of the most economically important edible clams in Asia.

In this study, nucleotide sequences of fragments of two mitochondrial genes (658 bp of cytochrome c oxidase subunit I and 382 bp of 16S ribosomal RNA, total length 1040 bp) from 37 individuals representing all the known species (total 10 species) of the genus *Meretrix* were determined to infer their phylogenetic relationships.

Molecular phylogenetic trees were constructed by the neighbor-joining (NJ), maximum parsimony (MP) and maximum likelihood (ML) analyses using the combined sequence data sets. In the analyses, five clades were recognized with high bootstrap supports as follows; 1 (East Asian clade) (*M. lamarckii* (*M. lusoria* (*M. petechialis*, *M. meretrix*))), 2 (Southeast Asian clade 1) (*M. lyrata*) (including two local forms), 3 (Southeast Asian clade 2) (*M. stricta*, *M. zonalis*), 4 (Indian Ocean-Java Sea clade) (*M. casta*, *M. n. sp.*) and 5 (Indian Ocean clade) (*M. ovum*). The topologies of the trees and the fossil records of ancestral species of some clades suggest that these five clades were diverged within a relatively short period in the late Early to early Middle Miocene. In shell length and shell inflateness, the species of the Eastern Asian clade are easily distinguishable from the species of the East Asian and Indian Ocean clades.

In addition, the timing of speciation was estimated using the molecular clock analyses and fossil records. This timing closely corresponds with the ages of major Neogene marine climatic events, indicating that the speciation was closely linked to the climatic change.

**Effects of the habitat type on the mollusks assemblages structure in the
lowland Pripyat River floodplain, Belarus**

Tatjana LAENKO

Institute of Zoology NAS Belarus, 27 Akademicheskaya st. 220072, Minsk, Belarus,
zoo467@biobel.bas-net.by

The species richness, abundance of mollusks communities and the structure of mollusks assemblages were studied in the lowland Pripyat River floodplain of Belarus. The Pripyat River is the biggest tributary of the River Dnyepr, which runs into the Black Sea through Belarus and Ukraine.

Pripyat floodplain water bodies are characterized by large amounts of organic (humic) matter, moderate mineralization, low oxygen saturation (40-85%), and decreasing pH, conductivity and hardness in the gradient from the river to inner water bodies. Floodplain water bodies belongs to hydrocarbonate-calcium II type.

Ecotopes suitable for mollusks differed with series of characteristics such as types of vegetation and sediments, hydrochemical and hydrological attributes, forming various type of floodplain water bodies.

A total of 43 species of Mollusca (29 Gastropoda and 14 Bivalvia) were identified during both spring and summer season. An analysis of mollusks communities was carried out using multivariate statistical methods. The dynamic community structure correlated with habitat characteristics, that may be heterogeneous even within single pools. The community structure reflected the impact of hydrological changes.

Links between species abundance and their life history became apparent. It is likely that the most significant parameters affecting species distribution are the type of vegetation and of sediment. Seasonal changes of the these parameters correlated with the mollusks assemblages structure in most of examined ecotopes.

Morphological, ecological and mitochondrial DNA 16S sequence distinctions between and within *Saccostrea* (Bivalvia: Ostreidae) populations in Hong Kong and Australia

Katherine LAM and Brian MORTON

The Swire Institute of Marine Science and Department of Ecology and Biodiversity,
The University of Hong Kong, Hong Kong, kskylam@graduate.hku.hk,
bmorton@hkucc.hku.hk

Saccostrea is considered to be the common oyster of Indo-Pacific shores. A chaotic taxonomy for the genus has, however, resulted from morphological plasticity among ecotypes. Some *Saccostrea* "forms" have been cross-referred to by different names by different authors (Torigoe 1981). Oyster populations with distinct morphotypes were collected from five shores experiencing different degrees of wave exposure in Hong Kong, and Western Australia, New South Wales and Queensland, Australia. Although shell characteristics were different among populations, shell allometry analysis by multi-dimensional scaling could not separate them. DNA sequences of mitochondrial partial 16S ribosomal DNA, with ~500 base pairs, have been determined for six species of *Saccostrea*, i.e., *S. cucullata*, *S. commercialis*, *S. glomerata*, *S. mordax* and *S. amasa*, from Hong Kong and Australia.

Australian *S. commercialis* and *S. glomerata* have an identical 16S sequence whereas *S. mordax* and *S. amasa*, which were regarded as synonyms, have a 0.012 difference. Hong Kong and Australian *S. cucullata* also differ by 0.017. All oyster populations examined had a low intra-population variation of <0.005, except for Hong Kong *S. cucullata*, which had a value of 0.036. This intra-population variation, however, was still lower than the inter-specific one of 0.104, suggesting that 16S sequence is a useful genetic marker to evaluate phylogenetic relationships among *Saccostrea* species with their problematic taxonomies.

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Integrated approaches to conservation of land snails in Kenya

Charles N. LANGE

National Museums of Kenya, Department of Invertebrate Zoology, P. O. Box 40658
Nairobi, Kenya, Nmk@Museums.or.ke

In Kenya, land snails comprise one of the most threatened biological diversity. This is mainly because about 80% of the snail species are forest dwellers (Verdcourt 1972) and only about 2% of the land area is forested (Sayer *et al.* 1992). Secondly, despite the small forest sizes, majority of them are suffering disturbances and depletion (Wass 1995). These regional snails are primarily characterised by short geographical ranges and high endemism (Tattersfield 1998, Lange 2000).

In attempt to manage the conservation crisis surrounding the national terrestrial molluscan biodiversity, the Department of Invertebrate Zoology of the National Museums of Kenya, has initiated several programmes over the last four years. These initiatives include a national molluscan biodiversity monitoring program, databasing of the national fauna, development of a molluscan research resource centre (reference collection and literature), Local and international marketing for increased investment in regional molluscan biodiversity research and the proposed captive propagation of the critically endangered species.

As a result of these initiatives, molluscan biodiversity hotspots and centres of endemism were identified and are being modelled in the conservation maps. Secondly, many snails unknown to Kenya have been discovered. Subsequently, the conservation status of the national terrestrial molluscs has been subjected to rigorous review and many species initially in the "data deficient" category are undergoing appropriate listing in the IUCN RED DATA BOOK. There is increasing awareness of molluscan biodiversity and conservation in some national biodiversity research and conservation institutions. The projects are being sustained despite challenges due to limited resources. A detailed account of these initiatives are presented in the poster.

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Propagation and culture of Unionidae in fish hatcheries

James B. LAYZER

U.S. Geological Survey, Tennessee Cooperative Fishery research Unit, Tennessee
Technological University, Cookeville, TN USA 38505, jim_layzer@tntech.edu

Historically, streams in the southeastern United States contained the most diverse mussel assemblages in the world; however, degradation of water quality and physical habitat eliminated mussels from many of these streams. Recent improvements in water quality and habitat in many rivers suggest that they may once again be capable of supporting a rich mussel fauna, but are isolated from potential sources of colonizers. Propagation, culture, and reintroduction is the only practical way to repopulate these streams, particularly for species with small populations restricted to only a few streams. Since 1994, the Tennessee Cooperative Fishery Research Unit has been evaluating the use of fish hatchery raceways for production of mussels. Three methods of propagation were evaluated: introduction of adult mussels and known host; artificially infesting hosts with glochidia before introduction; and introducing 1-day-old juvenile mussels propagated in the laboratory. Although mussels spawned in the raceway, and glochidial infestations on host fishes occurred, production was low. Juveniles of two species propagated by releasing glochidial-infested fish were cultured for three years; during their 4th growing season, they matured and spawned in the raceway. A third species, introduced as 1-day-old juveniles also spawned during the 4th growing season. Each method of propagation has advantages: introduction of adult mussel and uninfested hosts is most suitable for tachytictic mussel species; glochidial infestation rates can be controlled and maximized by artificially infesting hosts prior to release; optimal substrate conditions can be provided in culture baskets in the raceways for juveniles propagated in the laboratory. Although survival of juveniles cultured unrestrained in the raceway substrate has been about 3% during the first growing season, growth rates were high, and between year survival >95%. In contrast, growth in culture baskets has been lower but survival has been much greater (up to 53%). The ability to propagate and culture some mussel species throughout their entire life cycle is encouraging; however, these techniques have not proven successful for other species. Current research is focused on identifying optimal physical conditions for culturing additional species.

Hydrothermal vent bivalve diets: initial report

Marcel LE PENNEC¹, Peter G. BENINGER², Gaël LE PENNEC¹ and Julien POMMIER¹

¹ Institut Universitaire Européen de la Mer, Site Technopôle Brest Iroise, 29280
Plouzané France, Marcel.LePennec@univ-brest

² IsoMer, Faculté des Sciences, Université de Nantes, 44322 Nantes Cédex France,
Peter.Beninger@isomer.univ-nantes.fr

Although a few hydrothermal vent bivalve species (*e.g. Acharax alinae*) are exclusive and obligate symbionts, with a near-total degeneration of the digestive tract, most of the species examined to date present a bivalent trophic strategy, relying to a greater or lesser extent on ingested particulate matter. Preliminary scanning electron microscopic examination of particles on the gill and in the digestive tract of various hydrothermal vent bivalve species show a pattern related to depth and proximity to vent emissions. For deep-sea species such as *Calyptogena phaseoliformis* (-5200 m), gut contents are chiefly composed of small, highly degraded, undetermined organic particles. In species found in more "shallow" deep waters, such as *Bathymodiolus thermophilus* (-2500 m), a wide range of particles with diverse origins is found: epipelagic diatoms, coccolithophores, crustaceans, and bacteria. In *Bathypecten vulcani*, found at the periphery of the vent diffusion zone, and which may not rely on endosymbionts for its nutrition, a similarly great variety of particles are found in the gut. The feeding biology of vent bivalves thus appears more complex than has been assumed to date.

Status of the malacological collection at The Bailey-Matthews Shell Museum, Sanibel Island, Florida, USA

José H. LEAL, Jon GREENLAW and Richard WILLIS

The Bailey-Matthews Shell Museum, P. O. Box 1580, Sanibel, FL 33957, USA,
jleal@shellmuseum.org

The new Bailey-Matthews Shell Museum (BMSM; opened in 1995) on Sanibel Island houses a malacological collection comprising about 250,000 lots, represented at this point mostly by dry shells. This material originates from donations of private collections or results from field trips/expeditions, for a total of 370+ accession events. "Starting a museum from scratch" has been a daunting task; on the other hand, this enabled staff to circumvent some of the most common problems that arise, in established museums, from re-cataloguing, adapting, or converting collection data. Staff and volunteers have endeavoured during years 1995-1997 to physically organize the collection into an acceptable linear sequence of cabinets. This allowed for planning, and enabled the museum to define appropriate fields and structure for the catalogue. Computerized cataloguing of the collection started in 1999, with introduction of a Microsoft Access-based system designed and programmed by BMSM staff. The catalogue is structured for data-entry via tables of authorities for taxonomic names (from genus "upward" to class), geographic locations at various levels, and accession data (donor and accession number). Different queries allow staff to prepare collection labels and other types of reports. The catalogue, which is about 6 % complete, also provides for closely linked loan management. With help from the Southwest Florida Library Network, data from the catalogue has recently been made available online: Remote users may perform searches using a number of possible combinations of taxonomic categories, geographic location, donor, and habitat.

Ecological physiology of nitrogen assimilation in chemoautotrophic bacteria-bivalve symbioses

Raymond W. LEE and Joanna L. JOYNER

School of Biological Sciences, Washington State University, Pullman, WA 99164
USA. Rlee@mail.wsu.edu

Symbioses between marine bivalves and chemoautotrophic sulfur-oxidizing bacteria are highly successful at deep-sea hydrothermal vents and other marine reducing environments like mangrove swamps and sewage sludge outfalls. While it has been known since the discovery of these symbioses that the pathways of carbon assimilation are similar to those employed by plants, the mechanisms of nitrogen acquisition have been less well studied. Environments in which these symbioses are found are rich in ammonia and/or nitrate. Unlike in carbon assimilation, both the host and symbiont are potentially involved in nitrogen assimilation. Several bivalve symbioses have been shown to assimilate ammonia and nitrate at rates sufficient to meet their nitrogen needs (Lee & Childress 1994). Unlike carbon assimilation, several enzymatic pathways are potentially involved in primary assimilation: glutamine synthetase (GS) or glutamate dehydrogenase (GDH) of either host or symbiont. Previous work has involved characterization of GS of chemoautotrophic symbionts (Lee *et al.* 1999). Recent work has shown that inhibition of GS by methionine sulfoximine blocks ammonia assimilation in *Solemya velum*. Therefore GS appears to be a primary pathway of inorganic nitrogen assimilation. Other studies have focused on the role of amino acids in sulfide detoxification. In solemyid clams, taurine is the most abundant free amino acid in tissues and appears to be a major product of ammonia assimilation (Lee *et al.* 1997). Synthesis of taurine may provide a route for sulfide detoxification. Investigations involving *Solemya velum*, demonstrate that taurine production is stimulated by the presence of sulfide in the medium. In contrast, non-symbiotic bivalves from reducing environments did not exhibit taurine production in response to sulfide exposure. Thus, in addition to providing nutritional benefit, nitrogen assimilation may also provide a protective benefit in a hostile environment. Investigations are presently underway to investigate the respective roles of host and symbiont in taurine synthesis.

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A phylogenetic study of the Sphaeriidae (Mollusca, Bivalvia) based on morphology and DNA sequence data

Taehwan LEE

Museum of Zoology, University of Michigan, 1109 Geddes Avenue, Ann Arbor, MI
48109, USA, taehwanl@umich.edu

Sphaeriid clams are prominent and ubiquitous members of freshwater ecosystems, exhibiting various peculiar biological features including hermaphroditism, self-fertilization, ovoviviparity, brooding direct-developing young, and pronounced polyploidy. Recent independent studies of different data sets, *i.e.* morphology and molecular sequences, resulted in incompatible sphaeriid phylogenies. In addition, sphaeriid intrageneric relationships have not been tested phylogenetically. Therefore, I have compiled morphological evidence together with molecular sequences in order to test a number of phylogenetic hypotheses proposed for various levels of sphaeriid relationships. Here I present a phylogenetic analysis of the Sphaeriidae based on a morphological dataset including brooding and life history characters, and molecular sequences from the partial fragments of three different regions, nuclear ITS (ca. 550-680bp), mitochondrial COI (ca. 500bp), and mitochondrial 16S rDNA (ca. 500bp).

Proposing a β -type concept based on semi-automatic measurement

Volker LEITGEB

Naturhistorisches Museum Wien, Burgring 7, A-1014 Vienna, Austria.

The key concept of taxonomy is that of type specimens. According to the rules of the ICZN, a new taxon is established by publishing its diagnostic characters and depositing type specimens in public collections. The benefit of this concept is the stability of the types, being invariable and therefore enabling a critical review of the status quo at any time.

Yet, routine work poses problems with this concept, especially for non-specialists. The most important one relates to the fact that new taxa are often identified by specimens that display the specific characters in overabundance. Although this is perfectly understandable, this means that many specimens are morphologically intermediate between types of closely related species. Identification of field-collected shells often produces a morphometric array of resemblances with very little help for the non-specialist. This effect is reinforced when only the differential characters of new taxa were published. If these differential criteria originate from different complexes of characters with a heterogeneous pattern of distribution, non-specialists are soon at a loss.

To improve this situation, the introduction of β -types is proposed. Such a series of β -types are specimens representing all characters the center of the statistic distribution of a taxon and the differences to the type specimen. The β -typus not static, but changes with every modification to the delimitations of the taxon. Prerequisite for its establishment is the morphometric assessment of a statistically relevant number of specimens of a taxon. A β -type series should demonstrate the taxon in his common appearance therefore being a suitable foundation for comparative determination.

The idea described above demands huge numbers of statistically assessed specimens. To support everyday work, a method for generating worldwide accessible and extendable data sets on scaled digital images from defined shooting positions is under development.

Hemocyanin: clues for molluscan evolution

Bernhard LIEB and Jürgen MARKL

Johannes Gutenberg-University of Mainz, Institute of Zoology, Müllerweg 6,
Germany, lieb@mail.uni-mainz.de

Hemocyanin is the blue copper containing oxygen carrying protein of many members of the molluscan phylum. It occurs as ring-shaped decamers, didecamers or multidecamers. The monomer consists of very large polypeptide chains, ranging from 350 kDa to 450 kDa in mass being comprised of 7 or 8 different "functional units". Sequence data are available from *Helix pomatia*, *Sepia officinalis*, *Octopus dofleini*, *Haliothis tuberculata* and *Megathura crenulata* (Drexel *et al.* 1987; Lieb *et al.* 2000; Miller *et al.* 1998). Our previous sequencing work on the two hemocyanin isoforms of the vetigastropods *Haliothis tuberculata* and *Megathura crenulata* indicated that this protein might be useful to analyze phylogenetic relationships within the Gastropoda (Lieb *et al.* 2000). Using the cephalopod-gastropod split to calibrate a molecular clock we could calculate the diversification point of the ancestors of Haliotidae and Fissurellidae to 260 ± 23 MYA and the pulmonate-vetigastropod split to 373 ± 32 MYA (Lieb *et al.* 2000). We recently started to investigate whether hemocyanin is a useful phylogenetic character to elucidate the branching order of the different molluscan classes. First sequence data are available from *Lepitochiton cinereus* (Polyplacophora, Ischnochitonidae) and *Nucula nucleus* (Bivalvia, Nuculidae) and will be discussed.

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The evolution of early development in gastropod molluscs

David R. LINDBERG¹ and Robert P. GURALNICK²

¹ Department of Integrative Biology and Museum of Paleontology, University of California at Berkeley, Berkeley CA 94720, drl@uclink4.Berkeley.Edu
² Colorado University Museum and EPO Biology, University of Colorado at Boulder, Boulder, CO 80309, Robert.Guralnick@Colorado.EDU

Cell lineage data for 30 exemplar gastropod taxa representing all higher taxa and the outgroups Scaphopoda and Polyplacophora were examined for phylogenetic signal. Three methods were used: (1) statistical analysis including regression and time series analysis, (2) cladistic analysis, and (3) relative warp analysis. Most cell lineages show phyletic trends of accelerating or retarding their formation relative to one or more outgroups and other more basal ingroup taxa. The phyletic trend present in these data is best represented by the regression of the total number of cells against the sum of the branch length for each taxon based on the Ponder & Lindberg phylogeny. PAUP* analyses of the cell lineage data set under three sets of character type assumptions produced similar tree topologies. The topology of the strict consensus trees for both the unordered and ordered assumptions were similar, while the dollo assumption recovers some of the early gastropod evolution as represented by the grade Patellogastropoda through Neritopsina, but does not resolved relationships within the caenogastropod + heterobranch clade. Directionality of character transformations is present and important in this data set, but developmental rate characters (like all other morphological and molecular characters) are also subject to homoplasy, and while the overall direction does not appear to vary, there is considerable variation in rate of change both within and between taxa. Lastly, we treated cell fate maps as branching morphologies using warp analysis. The bending energies from thin-plate spline analyses were also used as branch lengths between OTU and HTUs in the Ponder & Lindberg tree. Long branch affects associated with polyplacophoran are readily apparent, and while not as severe as the chitons, the scaphopod branch is also noticeably longer than most gastropod OTUs. Moreover, the longest branches are found in the youngest taxa (the caenogastropod + heterobranch clade), while within the earlier patellogastropod-neritopsina grade branch lengths are shorter with the vetigastropods having the longest branch.

Biogeographic subregions of shelled Mollusca (Gastropoda, Scaphopoda & Bivalvia) in the Southern Ocean

Katrin LINSE

British Antarctic Survey, High Cross, Cambridge CB3 0ET, U.K., kl@bas.ac.uk

The distribution of shelled Mollusca in the Southern Ocean has been investigated using both published data (e.g. Hain 1989, Branch *et al.* 1991, Linse 1999) and new data. A species-distribution table for molluscs of 14 well investigated geographic areas was constructed comprising 706 species of shelled gastropods, 10 species of scaphopods, and 317 species of bivalves. The 14 geographic areas included in this database were Adelie Land, Antarctic Peninsula, Davis Sea, Enderby Land, Falkland Islands, Kerguelen Islands, Magellanic mainland, Marion and Prince Edward Islands, Palmer Archipelago, Weddell Sea, Ross Sea, South Georgia, South Orkney Islands, and South Shetland Islands. It was assumed that the recorded species numbers for these regions are representative because of the comprehensive sampling in these areas.

A distance matrix based on the species-region-matrix with 1033 cases (shelled Mollusca) x 14 variables (areas) was constructed by calculating the percentage of dissimilarity between the areas and then grouped by cluster analysis using UPGMA (unweighted pair-group method using arithmetic average).

In the dendrogram five cluster could be separated at a level of similarity of 86%. The Magellanic mainland and the Falkland Islands (the Magellan region) form one cluster and are compared with the remaining cluster. South Georgia and the Kerguelen Islands do not cluster with any other areas. The remaining regions are separated into two clusters: 1) East-Antarctic regions: Enderby Land, the Davis Sea, Adelie Land, and the Ross Sea, and 2) Weddell Sea, the Antarctic Peninsula, the Palmer Archipelago, the South Shetland Islands, the South Orkney Islands, and interestingly Marion and Prince Edward Islands.

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Hydrothermal vent and cold seep molluscs: view from the fossil record

Crispin T. S. LITTLE¹ and Kathleen A. CAMPBELL²

¹ School of Earth Sciences, University of Leeds, Leeds LS2 9JT, UK,
c.little@earth.leeds.ac.uk

² Department of Geology, The University of Auckland, Private Bag 92019, Auckland,
New Zealand, ka.campbell@auckland.ac.nz

In the presentation we will review the occurrence of molluscs in ancient hydrothermal vent and cold seep communities, discuss the role of chemosymbiosis in these communities, and map out future work in the field. The entry of molluscs into vent and seep environments occurred early in the Palaeozoic, as a limited diversity of molluscs (monoplacophorans, bivalves and gastropods) is present in the oldest known vent (Silurian, ~430 Ma) and seep (Devonian, ~380 Ma) fossil assemblages. A few Palaeozoic vent and seep assemblages are dominated by bivalves, but others contain no molluscs, or are outnumbered numerically by brachiopods. Due to poor preservation many Palaeozoic vent and seep molluscs are difficult to identify. Others belong to extinct groups, common in contemporaneous non-vent and non-seep fossil assemblages. These factors do not allow chemosymbiotic lifestyles to be established with any certainty for these ancient taxa. The record is better in the Mesozoic and Cenozoic, especially for seeps. Towards the later Mesozoic, brachiopods become increasingly rare in vent and seep communities, and bivalves and gastropods become the dominant shelly taxa, both in abundance and diversity. The Mesozoic marks the first appearance in vents and seeps of a group of chemosymbiotic bivalves (mytilids, lucinids, and solemyids) which are important constituents of modern chemosynthetic communities, but also have Palaeozoic, non-vent, non-seep origins. The first provannid gastropods and vesicomid bivalves appear in late Jurassic and early Cretaceous seeps, respectively. These two families are today restricted to chemosynthetic communities and have many chemosymbiotic species. Many modern vent and seep molluscs, particularly the smaller gastropods, have yet to be identified in the fossil record, although this pattern may change as taxonomic work progresses on recent gastropod finds at Mesozoic and Cenozoic seep and vent sites. In summary, Phanerozoic vent and seep deposits contain a rich and growing record of fossil molluscs, which serves as the litmus test for comparison of phylogenetic hypotheses generated by molecular data from living chemosymbiotic molluscs.

Short and long-term variability in growth of *Eurhomalea exalbida* (Bivalvia, Veneridae) from the Beagle Channel (54° 50'S)

Betina J. LOMOVASKY¹, Thomas BREY², Elba MORRICONI¹ and Jorge CALVO¹

¹ Centro Austral de Investigaciones Cientificas (CADIC), C.C 92 Ushuaia, Tierra del Fuego, Argentina, betinal@hotmail.com

² Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, Germany.

The age and growth rate of a population of *Eurhomalea exalbida* from the Beagle Channel, southern Argentina, were studied from shell sections and a mark-recover experiment with field specimens. Shell sections revealed a pattern of subsequent opaque and translucent bands in the umbo.

The mark-recover experiment showed that the opaque increment was formed during spring, which was the season of fastest growth. Only younger, non-reproductive specimens grew significantly in summer, too. The translucent band was formed during fall and winter when growth was negligible. Hence, shell growth is strongly seasonal and the annual shell growth pattern consists of one opaque and one translucent band corresponding to periods of fast and slow growth.

The von Bertalanffy growth function $H_t = 73.98 \text{ mm} * (1 - e^{-0.180 * (t + 0.147)})$ fitted the height-at-age data of 214 aged specimens best ($R^2 = 0.86$). The clams can reach a maximum age of 70 years.

By determining size, individual age and year of formation of 2337 annual umbo increments (106 individuals), a 56-year record of relative average annual shell increment could be established. This record showed strong long-term fluctuations in shell growth, which were partially related to long term fluctuation in sea surface temperature. Thus historical growth patterns of *Eurhomalea exalbida* may be used as a proxy for past marine environmental or climatic conditions.

Age pigments (Lipofuscin) in the bivalve *Eurhomalea exalbida* from the Beagle Channel (54° 50'S)

Betina J. LOMOVASKY¹, Elba MORRICONI¹, Thomas BREY² and Jorge CALVO¹

¹ Centro Austral de Investigaciones Cientificas (CADIC), C.C 92 Ushuaia, Tierra del Fuego, Argentina, betinal@hotmail.com

² Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, Germany

Autofluorescent granules were detected in the hard clam *Eurhomalea exalbida* in connective tissue among gonadal alveolus, inside gonadal alveolus in males, in connective tissue around the intestine, in the intestinal epithelium and in the digestive gland. Observation under fluorescence and Sudan Black B and PAS positive reactions indicated that these granules are lipofuscin. The lipofuscin concentration in the connective tissue around the intestine was quantified by image analysis and expressed as total area fraction (%AF) occupied by lipofuscin granules.

Stepwise linear regression between %AF lipofuscin and shell length, height, width, mass and individual age revealed that individual age is the only parameter affecting %AF significantly ($r^2=0.867$; $p<0.001$; $n=16$). The same results were obtained with log-log regression ($r^2=0.900$; $p<0.001$; $n=16$).

Our findings suggest that the lipofuscin pigments found in *E. exalbida* do accumulate with individual age and not with individual size. If this holds true for bivalves in general, lipofuscin may be suitable for age analysis in species with less clear shell growth band patterns.

The impact of native predators on an invasive whelk: sea otters and seashells by the seashore

Steve I. LONHART

Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, 95065, USA, lonhart@biology.ucsc.edu

The recent expansion of Kellet's whelk (*Kelletia kelletii*: Buccinidae) into central from southern California added a novel species to kelp forest communities. These whelks act both as important predators of native prey species and as a novel prey resource for native predators (e.g., sea otters, crabs, sea stars, octopus, and drilling gastropods). Since 1996 I have removed shells from permanent plots at the Hopkins Marine Life Refuge in Monterey Bay to identify potential predators of the whelk and determine the types and frequencies of shell damage. Most shell debris consisted of "window" damage (42%), whorls only (25%), or spires only (21%). Feeding trials with captive sea otters (*Enhydra lutris*) demonstrated that otters were capable of producing "window" damage. In addition, shells collected in the field indicate that the process that creates windows can also separate the body whorl from the spire. Similar whelk shells in southern California were extremely rare and very old. Thus, the recently established whelk populations in central California are severely impacted by sea otters, which account for nearly 90% of the shells observed in the field. Furthermore, the apparent failure of local reproductive efforts by resident whelks in central California suggests these populations are "sinks" that could become locally extinct. Such an extinction would represent a rare marine example of native predators contributing to the failure of an invader.

Population and growth estimates of an invasive whelk using mark-recapture techniques

Steve I. LONHART

Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, 95065, USA, lonhart@biology.ucsc.edu

Marking individual organisms in the field is a common method used in ecological studies. Mark-recapture techniques are used to estimate abundance, mortality, habitat use, dispersal, and growth rates. The hard calcareous shells of marine mollusks are particularly well suited for tagging studies, facilitating several marking and tagging techniques. I used two techniques to mark a subtidal marine snail *Kelletia kelletii* that recently invaded central California. Individual whelks were marked with numbered tags glued to the body whorl and spire, and were also notched along the lip of the aperture. Preliminary data indicate numbered tag retention can be high, depending on the type of adhesive used, and that aperture notches are readily distinguished after shell repair. Adult whelks display high site fidelity, with some individuals recaptured annually within the same 2500 m² area since 1997. Average adult whelk density from 1995 to 2000 was 0.04 m⁻², much lower than within their native range of southern California. Preliminary growth rate estimates from the field suggest whelks grow very slowly, adding up to 2 mm/yr total shell length (SL) for snails 50-70 mm SL, while snails >80 mm SL typically grew <1 mm/yr, if at all. Comparisons of whelks from recently invaded cool habitats and warmer native habitats suggest there are significant differences in reproductive success, recruitment, and growth.

Testing morphologically-based views of species using molecular phylogenies: a case study using freshwater mollusks

Charles LYDEARD

University of Alabama, Biodiversity & Systematics, Department of Biological Sciences, Box 870345, Tuscaloosa, Alabama 35487 USA, clydeard@bama.ua.edu

Species are natural entities that exist in nature whether humans choose to recognize them or not. Currently recognized molluscan species are a product of years of cumulative research effort by past and present taxonomists. Ideally, a species description should include a detailed description of the shell and anatomy, a diagnosis to distinguish it from other taxa, a distribution map, life history information, and various taxonomic remarks. Regrettably, many freshwater molluscan species descriptions, particularly those written in the 19th or early 20th century provide nothing more than an epithet of unknown value or uncertain validity. Despite the qualitative differences among species descriptions, the underlying concept for delineating new species is a morphologically-based diagnostic species concept. The implicit assumption is that the diagnostic character or character combination is sufficient to warrant the recognition of a distinct species. Although there is little doubt about the validity of many of the described freshwater molluscan taxa, concern has been expressed over the validity of several species described on the basis of ambiguous shell descriptions and/or minor anatomical differences. One way to test the validity of morphologically-based diagnostic species is to use genetic data to construct a molecular phylogeny of the taxa of interest and test their monophyly. Although the value of the Phylogenetic Species Concept based on monophyly has been described in the literature, it has not been utilized often for molluscan taxa. Here I present data from freshwater mollusks illustrating the value and shortcomings of the Phylogenetic Species Concept.

Molecular phylogeny of a circum-global, diverse gastropod superfamily (Cerithioidea: Mollusca: Caenogastropoda): pushing the deepest phylogenetic limits of mitochondrial LSU rDNA sequences

Charles LYDEARD¹, Wallace E. HOLZNAGEL¹, Matthias GLAUBRECHT² and Winston F. PONDER³

¹ Biodiversity and Systematics, Department of Biological Sciences, University of Alabama, Box 870345, Tuscaloosa, AL 35487, USA, clydeard@bama.ua.edu

² Institute für Systematische Zoologie, Museum für Naturkunde, Invalidenstrasse 43, D-10115 Berlin, Germany.

³ Centre for Evolutionary Research, Australian Museum, 6 College St., Sydney, New South Wales 2000, Australia.

The Cerithioidea, is a very diverse group of gastropods with ca. 14 extant families and over 200 genera occupying, and often dominating, marine, estuarine, and freshwater habitats. While the composition of Cerithioidea is now better understood due to recent anatomical and ultrastructural studies, the phylogenetic relationships among families remains chaotic. Morphology-based studies have provided conflicting views of relationships among families. We generated a phylogeny of cerithioideans based on mitochondrial large subunit rRNA and flanking tRNA gene sequences (total aligned data set 1873 bp). Nucleotide evidence and the presence of a unique pair of tRNA genes (*i.e.*, threonine + glycine) between valine-mtLSU and the mtSSU rRNA gene supports conclusions based on ultra-structural data that Vermetidae and Campanilidae are not Cerithioidea, certain anatomical similarities being due to convergent evolution. The molecular phylogeny shows support for the monophyly of the marine families Cerithiidae, Turritellidae, Batillariidae, Potamididae, and Scaliolidae as currently recognized. The phylogenetic data reveals that freshwater taxa evolved on three separate occasions, however, all three recognized freshwater families (Pleuroceridae, Melanopsidae, and Thiaridae) are polyphyletic. Mitochondrial rDNA sequences provide valuable data for testing the monophyly of cerithioidean families and relationships within families, but failed to provide strong evidence for resolving relationships among families.

Evolution of molluscs in Lake Pannon

Imre MAGYAR¹, Dana H. GEARY², Pál MÜLLER³, Miklós SZÓNOKY⁴ and
Sándor GULYÁS⁴

¹MOL Hungarian Oil and Gas Company, Batthyány 45, 1039 Budapest, Hungary,
immagyar@mol.hu

²Department of Geology and Geophysics, University of Wisconsin-Madison, 1215
W. Dayton Street, Madison, WI 53706, USA, dana@geology.wisc.edu

³Geological Institute of Hungary, Stefánia 14, 1143 Budapest, Hungary,
mullerp@mafi.hu

⁴Department of Geology and Paleontology, University of Szeged, Egyetem 2-6, 6722
Szeged, Hungary, gubanc@yahoo.com

The Late Miocene Lake Pannon is one of the few examples of fossil long-lived lakes. It existed in the intermontane basin surrounded by the Alps, Carpathians, and Dinarides approximately 12-4 Ma (Magyar *et al.* 1999). Two features of Lake Pannon and its history appear to have played a role in the generation of the spectacular endemic molluscan fauna (with more than 900 species described). First, the mollusc fauna of the lake had multiple sources of origin. Many lineages, all cardiids and dreissenids, and many hydrobiids, descended from eurytopic survivors of the marginal marine "Sarmatian Sea". Other lineages (unionids, viviparids, lymnaeids, planorbids, melanopsids, some neritids) moved in from surrounding fresh water habitats, such as rivers, ponds, and marshes (Müller *et al.* 1999, Geary *et al.* 2000). Second, geological and paleoecological studies failed to detect signs of extreme physical or chemical changes in Lake Pannon. Although lacustrine species flocks may evolve very rapidly, the long-term stability of an ancient lake system appears fundamental to the development of a diverse fauna because it permits the few eurytopic colonizing species to evolve into increasing numbers of stenotopic descendants. Detailed morphometric studies have revealed a striking number of cases of sustained gradual change among cardiid and dreissenid bivalves, and planorbid and melanopsid gastropods. Changes involve a wide range of shell characters, including size, shape, and ornament, and occasionally result in highly unusual shell forms (*e.g.* *Valenciennius*, *Budmania*).

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Impact of commercial fisheries on the malacological communities inhabiting the continental shelf and slope of the Algarve (Southern Portugal): An assessment of the effect of two different métiers

Manuel António E. MALAQUIAS, Karim ERZINI, Luis BENTES and Teresa C. BORGES

Centro de Ciências do Mar, Universidade do Algarve, Faculdade de Ciências do Mar e do Ambiente, Campus de Gambelas, 8000-117 Faro, Portugal, mmalaqui@ualg.pt

Recent studies on commercial trawling for crustaceans and fish have provided evidence of the impact on the biological communities that inhabit the continental shelf and slope of the Algarve, South of Portugal (Borges *et al.* 1997; Borges *et al.* 2000). However little is known concerning possible ecological changes in the populations, as a result of such fisheries.

According to Borges *et al.* (2000) molluscs represent about twenty per cent of the species discarded. The effects on the malacological communities (except for the Cephalopoda) of these fisheries were studied and compared for the first time. Multivariate analysis using cluster analysis for classification and multidimensional scaling (MDS) for ordination were used to compare the effects of the two métiers (crustacean trawling and fish trawling) in terms of species composition, number of specimens and season.

The sampling effort in this study involved 67 fishing trips (39 in crustacean trawlers and 28 in fish trawlers), over four years, from the winter of 1996 to the winter of 2000. Observers on board collected, random samples of approximately 10 kg of by-catch specimens per fishing operation. Specimens were caught at depths between 50 to 700 meters.

A total of 44 species were identified (1 Polyplacophora, 16 Bivalvia and 27 Gastropoda). From the number of specimens captured, the results show that the species which seem more affected are the bivalves *Venus nux*, *Atrina pectinata*, *Neopycnodonte cochlear*, *Pteria hirundo* and *Acanthocardia echinata* and the gastropods *Galeodea rugosa*, *Scaphander lignarius*, *Calliostoma granulatum*, *Ranella olearia* and *Ampulla priamus*.

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Diet assessment of *Haminoea orbygniana* (Férussac, 1822) (Mollusca: Opisthobranchia: Cephalaspidea): a comparative approach by direct observation, gut content and stable isotopes analysis

Manuel António E. MALAQUIAS, Raquel MACHÁS, Silvia CONDINHO, Rui SANTOS and Martin SPRUNG

Centro de Ciências do Mar, Faculdade de Ciências do Mar e do Ambiente,
Universidade do Algarve, Campus de Gambelas, 8000-117 Faro, Portugal,
mmalaqui@ualg.pt

Previous studies revealed that cephalaspids feed on a variety of food items (molluscs, foraminiferans, diatoms, algae and detritus), but just a few have dealt with the feeding habits in detail (Chester 1993). *Haminoea orbygniana* (Férussac 1822), a common cephalaspid gastropod in the Ria Formosa coastal lagoon (southern Portugal), is often associated with one of the lagoon's principle primary producers, the seagrass *Zostera noltii*. Diet assessment of this species in Ria Formosa was based on direct observation in the field (Sprung 1994). However, this method cannot distinguish the feeding relationships between the different potential food sources of a seagrass meadow (e.g. seagrass, epiphytic algae, microflora and detritus). Gut content analysis can adequately resolve this question. However, the latter may reflect material which is not assimilated, in contrast to the stable isotope approach, which makes use of the principle that "you are what you eat," providing a time integrated estimate of assimilated food sources (Peterson & Fry 1987, Currin *et al.* 1995). On the other hand, stable isotope analysis cannot provide the kind of taxonomic detail given by gut content analysis. In this study we compared the three methods of diet analysis: direct observation in the field, gut content analysis and stable isotope analysis to assess the diet of *Haminoea orbygniana*.

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Paleobiological patterns in Paratethyan pectinids

Oleg MANDIC

Institute of Paleontology, University of Vienna, Geozentrum, Althanstrasse 14, A-1090 Vienna, Austria, oleg.mandic@univie.ac.at

Pectinids are one of the most striking bivalve groups of the Paratethys region. They show high diversity, conspicuous abundance, high speciation and extinction rates and enhanced preservation potential due to calcite shell mineralogy. They are characteristic fossils of the fully marine sequences, being completely absent in phases of decreased water salinity. The regional fossil record covers a time span of about 20 my from the Early Oligocene (Kiscelian) up to the Middle Miocene (Badenian). The regional dispersion pattern displays remarkable disequilibrium. Pectinid diversity maximum is restricted to Western and Central Paratethys whereas in the geographically larger Eastern Paratethys pectinids are less abundant. The present study provides an overview of paleoecologic, paleogeographic, and biostratigraphic patterns of these bivalves in the Central Paratethyan based on their revised taxonomy.

The begin of the Paratethys as a paleogeographic unit is marked by anoxia and enhanced hydrogen sulfide content in bottom water throughout the region. Probably as a consequence of such unfavorable conditions the earliest pectinid record is obscure. Indeed at that time Propeamussiidae rather than Pectinidae characterize the Western and Central Paratethyan Pectinacea. In the latter, pectinids become abundant with the begin of the Late Oligocene stage Egerian. *Aequipecten biarritzensis*, *Costellamussiopecten deletus* and *Costellamussiopecten pasini* ("=*Pecten burdigalensis*") are the most striking elements of that assemblage. The begin of the regional stage Eggenburgian (Lower Miocene) is marked by the first occurrence of *Pecten pseudobeudanti* and *Oopecten gigas*. The range of the latter species defines biostratigraphically the Early Eggenburgian time span, which was characterized by decreased pectinid diversity probably as result of geographic isolation. In contrast the faunal overturn at the base of the Late Eggenburgian apparently marks the renewed installation of the Mediterranean connection. The Central Paratethyan stratigraphic markers like *Macrochlamis holgeri* and "*Flexopecten*" *palmatum* are typical species of the Mediterranean Burdigalian. The prevailing Mediterranean faunal character remains throughout the Lower Miocene where three immigration phases occurred: Early Ottnangian, Late Ottnangian and Karpatian. Further, the Middle Miocene Badenian assemblage is characterized by Mediterranean species like *Costellamussiopecten cristatus* or *Macrochlamis nodosiformis*, although several endemic forms like "*Flexopecten*" *neumayeri* or *Aequipecten elegans* are abundant. Finally, with the beginning salinity crisis around the Badenian/Sarmatian boundary pectinids became extinct in the region.

Some terrestrial snails from Northern Iran

Allahbedasht MANSOORIAN¹ and Karl EDLINGER²

¹ School of Public Health and Institute of Public Health Research Tehran University of Medical Sciences, P.O.Box 6446, Tehran 14155, Iran.

² Naturhistorisches Museum Wien, 3. Zoologische Abteilung, Sammlung Mollusca, Burgring 7, A-1014 Wien, Austria.

Many terrestrial snail-species are known as transmitters of zoonotic parasites. Some of these snails, such as Enids, Helicellids and Succineids, occur in Iran and are very important for public health, veterinary medicine and zoology. Until now the terrestrial malacofauna of Iran is not completely known. For this reason a comprehensive survey has been undertaken which was financially supported by the Tehran University of Medical Sciences and technically in part by the Museum of Natural History Vienna. Dr. Hartwig Schütt (Düsseldorf, Germany) gave helpful counsel. The following taxa were determined:

Assyriella mahanica (Kobelt, 1910); *Buliminus halepensis* (L Pfeiffer, 1841); *Caucasicus atrolabiata* (Krynicky, 1833); *C.atrolabiata r. lencoranea* (Mousson, 1863); *C. atrolabiata r. stauropolitana* (Schmidt, 1855); *C.atrolabiata r. tschalusi* Starmühlner & Edlauer, 1957; *Ceciliooides acicula* (Muller, 1774); *Chondrula tridens* (Muller, 1774); *Cochlicopa lubrica* (Muller, 1774); *Euchondrus didymodus* (Bottger, 1880); *Euomphalia (Harmozica) arpatschiana* (Mousson, 1837); *E.(H.) pisiformis* (L Pfeiffer, 1852); *E.(H.) transcaucasica* (Bayer & Mousson, 1863); *Helicella (Xeropicta) derbentina* (Krynicky, 1836); *H.(X.)krynickyi* (Krynicky, 1833); *Helicopsis spp* (O. F. Müller,1774); *Helix lucorum* L.,1758; *Helix salomonica* Naegele,1836; *Jaminia isseliana* (Issel, 1865); *J. pupoides* (Krynicky, 1833); *Laciniaria (Euxiana) lederi* (Bottger, 1879); *Lamellaxis gracilis* (Hutton, 1834); *Lauria bruguieri* Jaekeli, 1956; *Lauria cylindrica* (Da Costa, 1778); *Monacha obstructa* (L Pfeiffer, 1842); *Orcula dolium* (Draparnaud, 1801); *Oxyloma indica* (L Pfeiffer, 1849); *Pupoides coenopictus* (Hutton, 1834); *Turanena scalaris* (Naegele, 1902); *Zebrina carducha* (Martens, 1874); *Zebrina hohenackeri* (L Pfeiffer, 1848); and *Zootecus insularis* (Ehrenberg, 1831).

Geographic genetic structure of Mediterranean *Cerastoderma glaucum* (Bivalvia, Cardiidae)

Stefano MARIANI and Elvira DE MATTHAEIS

Institute of Zoology, Department of Animal and Human Biology, University of Rome "La Sapienza", Viale dell'Università 32, 00185 Rome, Italy,
Stefano.Mariani@uniroma1.it

Most of benthic marine species, especially bivalves, show high rates of larval dispersal. The presence of planktonic larval stages has been long considered as a life-history strategy for the maintenance of the gene pool homogeneity of a species over its distribution area. Nevertheless, a number of studies have shown that extensive larval dispersal does not necessarily imply wide scale homogeneity of marine species. In fact, in spite of the high potential for dispersal of bivalves and their consequent presumable high gene flow, significant levels of genetic heterogeneities along salinity gradients, consistent with geographic clines, dependent on habitat fragmentation and correspondent to past migration events have been reported so far.

Cerastoderma glaucum is a soft-bottom bivalve which inhabits non-tidal confined coastal ecosystems, such as lagoons, saltmarshes and brackish lakes (Kingston 1974). Its distribution along open coastal waters is limited by an intolerance to air exposure and wave action (Boyden & Russell 1972). It is thus expected to show a well-structured pattern of spatial genetic variation due to its naturally fragmented habitat.

Our population genetic analysis at different geographic scales in the Mediterranean shows that the degree of population structuring is less pronounced in the Mediterranean than in the North-Atlantic *C. glaucum*. Moreover, the spatial structuring of genetic diversity is shown to follow different models, depending on the geographic scale considered: a stepping-stone model proves to fit at wide scale, with gene flow inversely related to geographic distance, whereas at small scale, genetic relationships among samples cannot be interpreted as the effect of sole physical distance among populations. Results are discussed taking into account the intrinsic and extrinsic factors which are most likely to affect the patterns of genetic structuring in coastal marine animals: the modalities of dispersal, the geographic scale considered, the hydrodynamic features of the basin, possible locality-specific selective factors, and past geological events.

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Blue Blood: Structure and evolution of gastropod hemocyanin

Jürgen MARKL, Bernhard LIEB, Ulrich MEISSNER, Wolfgang GEBAUER and J. Robin HARRIS

Johannes Gutenberg University of Mainz, Institute of Zoology, Müllerweg 6,
Germany, markl@mail.uni-mainz.de

Oxygen transport in the hemolymph of most gastropods and many other mollusks is achieved by a giant extracellular oxygen carrier, the blue copper protein hemocyanin. We study *Haliotis tuberculata* hemocyanin (HtH) and keyhole limpet hemocyanin (KLH, from *Megathura crenulata*); the latter is a clinically applied immune stimulant and hapten carrier. We found that both hemocyanins occur as two distinct isoforms, termed HtH1 & HtH2 and KLH1 & KLH2. Each of these molecules is based on a very large polypeptide chain (molecular mass ca 400 kDa, encoded by ca 10.000 base pairs). This subunit is folded into a series of eight globular functional units (molecular mass ca 50 kDa each). Twenty copies of this subunit form a cylindrical quaternary structure (molecular mass ca 8 MDa). Our results on details of the quaternary structure, subunit architecture, amino acid sequence, gene structure and biosynthesis (in rhogocytes) of HtH and KLH will be summarized. A hypothesis of a stepwise evolution of the molluscan hemocyanin molecule in the late Precambrian will be discussed. Possibilities to trace molluscan phylogeny on the basis of hemocyanin sequences, and the potential of recombinant molluscan hemocyanin for research and clinics will be emphasized.

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The molluscs type specimens' preliminary study of the Museu Valencià d'Història Natural (Valencia, Spain)

Alberto MARTÍNEZ-ORTÍ

Museu Valencià d'Història Natural. Passeig de la Petxina, 15. E-46008 Valencia,
Spain, alberto.martinez@uv.es

The cataloging of the Siro de Fez collection deposited in the Museu Valencià d'Història Natural in Valencia (Spain) to date is ongoing. At the moment, type specimens of 48 Gastropoda Molluscan taxa, species and subspecies, have been found. These specimens came from Altimira, Boscá, Brandt, Beier, Clench, Dobat, Fez, Gasull, Ortiz de Zárate, Schuett and Weyrauch collections. Nine of them are considered name-bearing types and correspond to holotypes of four species: *Helix aguilari* Fez, 1947, *Iberus rositae* Fez 1950, *Oestophora (Suboestophora) jeresae* Ortiz de Zárate, 1962 and *Trochoidea (Xerocrassa) roblesi* Martínez-Ortí, 2000, recently deposited; to syntypes of one subspecies: *Helicigona (Chilostoma) desmoulinsi bechi* Altimira, 1959 and three species *Helix jeschawi* Ortiz de Zárate, 1949, *Helicella (Xeroplexa) claudinae* Gasull, 1963; *Helicella (Xeroplexa) ortizi* Gasull, 1963, and to the lectotype of one species: *Helicella (Candidula) camporroblensis* Fez, 1944. In addition, there are paralectotypes of six species, three correspond to terrestrial molluscs: *Candidula camporroblensis*, *Helicella (Candidula) najerensis* Ortiz de Zárate, 1950, *Helicella (Candidula) rocandoi* Ortiz de Zárate, 1950, and another three to freshwater species: *Moitessieria ollerii* Altimira, 1960, *Valvata fezi* Altimira, 1960 and *Pseudoamnicola lagari* Altimira, 1960. All of them correspond to Gastropoda taxa that present a geographic distribution through the Iberian Peninsula or Balearic Islands. Finally, paratypes of 36 species are deposited, of terrestrial molluscs of different geographic distribution, seven from Europe: *Albinaria dobati* Brandt, 1962, *Helicella parabarcinensis* Ortiz de Zárate, 1946, *Helix zapateri* Hidalgo, 1870, *Montenegrina (Beieriella) irmengardis* Klemm, 1962, *Oestophora jeresae*, *Pyrenaearia poncebensis* Ortiz de Zárate, 1956 and *Trochoidea roblesi*, four from Ecuatorial Guinea (genus *Gulella* and *Ptychotrema*), twenty from Libya (mainly genus *Barcania* and *Orcula*), two from Peru (genus *Scutalus* and *Zilchiella*) and three from Caribbean Islands (genus *Cerion*).

Biodiversity and chorology of the snails in the "Comunidad Valenciana" (Spain)

Alberto MARTÍNEZ-ORTÍ¹ and Fernando ROBLES²

¹ Museu Valencià d'Història Natural, Passeig de la Petxina, 15. E-46008 Valencia, Spain, alberto.martinez@uv.es

² Instituto "Cavanilles" de Biodiversidad y Biología Evolutiva c/ Dr. Moliner, 50. E-46100 Burjassot, Valencia, Spain, roblesf@uv.es

The conchological and anatomical study of snails, as much bibliographical as of specimens from the past ten years from the "Comunidad Valenciana", in the East of the Iberian Peninsula, has led to a list of 106 species of molluscs corresponding to 24 families of terrestrial Gastropoda. The general area of distribution in the "Comunidad Valenciana" varies between a large holarctic one and a reduced area for some endemic species. Species of holarctic distribution: 11 spp. (10.4%), e.g. *Oxyloma elegans*. Species of palaeartic distribution: 4 spp. (3.8%), e.g. *Vertigo antivertigo*. Species of large European distribution, that can extend their distribution area through the North of Maghreb and Macaronesian Islands: 9 spp. (8.5%), e.g. *Platyla polita*. Species of a more restricted European distribution: 12 spp. (11.3%), e.g. *Chondrina avenacea avenacea*. Species of Western and Mediterranean European distribution: 12 spp. (11.3%), e.g. *Pomatias elegans*. Species of preferentially Mediterranean distribution: 24 spp. (22.6%), e.g. *Trochoidea pyramidata*. Others are genuine of the Western Mediterranean such as *Pomatias sulcatus*. Some species enlarge their distribution over the Western Atlantic European coast such as *Myosotella myosotis*. Species of Iberic distribution that enlarge their area over Southeast of French and/or over the Maghreb: 10 spp. (9.4%), e.g. *Otala punctata*. Endemic species of the Iberian Peninsula: 24 spp. (22.6%). Some have a large peninsular distribution such as *Iberus gualtieranus*. One group of species lives in the South of the Pyrenees and reaches the "C. Valenciana": *Cochlostoma martorelli*, *Oxychilus courquini*, *Trochoidea ripacurcica* and *T. salvanae*. Two species, *Suboestophora tarraconensis* and *Atenia quadrasi* are extended through the South of Catalonia and the "C. Valenciana". Another two, *Trochoidea derogata* and *T. barceloi*, are extended through the "Comunidad Valenciana" and Murcia. Finally, *Chondrina arigonis*, *C. gasulli*, *Granaria braunii marcusii*, *Oxychilus mercadali*, *Trochoidea molinae*, *T. roblesi*, *Suboestophora altamirai*, *S. boscae*, *S. hispanica* and *S. jeresae* are strictly endemic of the "Comunidad Valenciana".

Do squid lie with Zebra? Comparison of male-male displays in agonistic situations

Jennifer A. MATHER

Department of Psychology and Neuroscience, University of Lethbridge, Lethbridge, Alberta, Canada T1K 3M 4, mather@uleth.ca

The squid *Sepioteuthis sepioidea* (Loliginidae) performs agonistic Zebra skin visual displays in many different situations. Many though not all of these are during conflicts between adult males over the consortship of adult females. A calculation of probable intensity of the Zebra allowed the author to quantify this variable for displays in male-male confrontations and compare intensity with winning or losing the contest. The winning male often but not always displayed more intense Zebra stripes. One common exception was the Zebra display of a subadult male at a courting adult male showing the sexual Flicker display. While the smaller individual was often chased off and Zebra exchanged, it nearly always displayed more intensely than its winning rival. The signal is thus not always an honest indication of agonistic capability, and can be used in situations other than straightforward assessment of reproductive "quality".

Differences among Tanganyikan gastropods as algal consumers and prey for crabs

Peter B. MCINTYRE¹ and Ellinor MICHEL²

¹ Dept. of Ecology and Evolutionary Biology, Corson Hall, Cornell University, Ithaca, NY 14853-2701 USA. pbm3@cornell.edu

² Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, P.O. Box 94766, 1090-GT Amsterdam, The Netherlands.
michel@science.uva.nl

Lake Tanganyika contains a "super flock" of thiarid gastropods. Two factors that may have fueled diversification within the Tanganyikan thiarids are trophic differentiation and intense predation pressure from an endemic crab. Here, we evaluate these hypotheses using preliminary data on ratios of stable isotopes of carbon and nitrogen in muscle tissue. To analyze patterns of trophic segregation among sympatric snails, we collected samples from eleven species of large-bodied thiarids representing all five genera common on rock substrates at three sites. There was substantial trophic differentiation among the genera, and the relative relationships among genera remained similar across depths and sites. Within the most diverse and abundant genus, *Lavigeria*, there was less evidence of trophic segregation at most sites. The isotopic differences among snail genera also allowed us to evaluate the importance of each genus in the diet of a crab species (*Platytelphusa armata*) that is a specialized predator on snails. Two crab samples collected from one site indicate consumption of snails in the genera *Reymondia* and *Spekia*, but not *Lavigeria*. Field data on shell scar frequencies show that crabs often attack *Lavigeria*, hence the preliminary isotopic data suggest that *Lavigeria* have escaped lethal predation by evolving heavily armored shells. Overall, our data indicate that trophic differentiation may have accompanied the divergence of the thiarid genera in Lake Tanganyika, and that selection by predatory crabs may have played a role in the more recent diversification of the *Lavigeria* group.

Freshwater mussels: potential biofilters?

Anna L. MCIVOR and David C. ALDRIDGE

Aquatic Ecology Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK, alm1000@cam.ac.uk

Freshwater mussels (Unionidae) are common in many freshwater ecosystems. They may occur at high densities and filter large volumes of water, removing suspended particulate matter. Invading bivalve species, such as *Dreissena polymorpha* and *Corbicula fluminea*, have had enormous impacts on freshwater ecosystems in the USA. However, the role of native freshwater mussels in ecosystems is largely unknown, but may be of similar magnitude. This raises the possibility of artificially increasing mussel densities in waterways with algal problems, and using the mussels as biofilters. To assess whether this is feasible, we need to know if mussels can survive in eutrophic waterways, how many actively feeding mussels are needed to balance algal growth under different conditions, and whether it is possible to breed mussels in sufficient numbers for their eventual introduction into waterbodies with algal problems. These questions are being addressed using translocation experiments (on the small and large scale), measurements of mussel filtration rates alongside algal growth rates, and breeding experiments.

Human exploitation of the intertidal mussel *Perna perna*: implications of mussel biology

Christopher D. MCQUAID

Dept of Zoology and Entomology Rhodes University, Grahamstown 6140, South Africa, c.mcquaid@ru.ac.za

Exploitation of intertidal animals in South Africa as food has a history dating back to the iron age. However, the development of high density human populations near the coast has resulted in unprecedented and unsustainable levels of pressure. The most widely taken species is the mussel *Perna perna*, which has disappeared from long stretches of coastline as a result of exploitation. *Perna* is economically important to people, but it also has ecological importance as a link between pelagic production and higher consumers and because mussel beds create complex habitats with high biodiversity. Unfortunately, mussels are most heavily collected by people in those areas least capable of withstanding exploitation. This is true on both biogeographic and local scales.

The west coast of South Africa is dominated by the Benguela upwelling system, while the south and east coasts are strongly influenced by the more oligotrophic Agulhas current. The result is that inshore nutrient levels and phytoplankton standing stocks decrease markedly from west to east. Correlated with this is a dramatic decrease in the intensity of mussel recruitment. Densities of mussel recruits drop by four orders of magnitude from west to east. This biogeographic decline in mussel recruitment from west to east coincides with an equally dramatic rise in levels of non-commercial human exploitation to the east.

At local scales, mussel population biology is strongly influenced by the degree of wave action experienced. Mussel growth rates on exposed shores are double those on sheltered shores and low shore recruitment rates are also greater. Although mortality is higher on exposed shores, this is more than compensated for by growth, and exposed shores support larger mussels. Thus, mussel populations on exposed shores show higher turnover rates and are likely to be more resilient to exploitation. Again, the ability of mussel populations to sustain human predation pressure is mismatched with where exploitation pressure is most intense, as people normally collect from more sheltered shores.

Reproductive anatomy defines phylogeny and interprets distribution in the African giant land snails

Albert R. MEAD

University of Arizona, Tucson, AZ 85721-0088, USA, mead@u.arizona.edu

The Achatinidae originated in Cameroon/Gabon of the lower Guinea. From there they spread throughout virtually all of Africa south of the Sahara to form four major faunal districts, each identified by a dominant genus: WESTERN (*Archachatina*), CENTRAL (*Achatina*), EASTERN (*Lissachatina*) and SOUTHERN (*Cochlitoma*), each with a distinctive genital pattern. Comparative anatomical studies over many years have established the fact that the phylogenetically most important changes are found at the base of the male conduit, with complementary and new changes taking place in the female conduit. Anatomical innovations and modifications are the driving forces of phylogeny in this family. Cumulatively they have produced broad speciation. Anatomical characters have proved to be more stable and more dependable, but conchological data are required. Lines of distribution moving into new territories have responded externally to new environmental impacts. Tangibly alike, or dissimilar anatomical features are requiring taxonomic adjustment to reflect the true phylogenetic relationship. Multiple examinations have put into perspective the transient effects produced by age, climate, environment, and method of preservation.

The long promised revision of the family, based on comparative genital anatomy, has been delayed by the anatomical and taxonomic complexities encountered in *Cochlitoma*. The major manuscript currently is in an advanced stage of preparation.

Adult female biased sexual ratio of clam *Anomalocardia brasiliana* (Bivalvia, Veneridae) in a management area of southern Brazilian coast

Carla MEDEIROS Y ARAÚJO¹ and Toshie KAWANO²

¹ Instituto de Ciências Biológicas, Universidade de Brasília, Brasília, Brasil,
yaraújo@unb.br

² Instituto Butantan, São Paulo, Brasil, tkawano@usp.br

During reproductive studies at the Pirajubaé Marine Management Area (REMAPI) in south of Brazil (27°38'00''SE, 48°33'05''W), almost 1000 clams were collected from February 1997 to February 1998. Specimens were submitted to standard histological procedures and sex ratio was calculated. Results showed that shell-length classes of 10.1 - 20 mm and 20.1 - 30 mm had equal sex ratios (1:1). Otherwise, in adult clams, more females (158) than males (85) were present in an almost 2:1 ratio. In general, clams showed a great variety of reproductive strategies, from separate sexes to functional simultaneous hermaphrodites, with intermediate sexual strategies including change of sex. Sex ratio rarely differs from 1:1 in adult marine and estuarine clams, except for deviation correlated to environmental situations (Morton 1991). *Anomalocardia brasiliana* is strictly dioecious; no sex reversal was expected. From 1996 to mid-1997, highway construction in the REMAPI area caused a set of environmental modifications, including intensive dredging. Through the effort of community fishermen, dredging was stopped after the bay area was reduced by 100 hectares. Perhaps more female clams survived these environmental changes, or they lived longer than the males, due to the higher bioenergetic cost of female reproduction (Russell-Hunter & McMahon 1975).

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Clam closed season proposal related to reproductive aspects of *Anomalocardia brasiliana* (Bivalvia, Veneridae) in a management area of southern Brazilian coast

Carla MEDEIROS Y ARAÚJO¹ and Toshie KAWANO²

¹ Instituto de Ciências Biológicas, Universidade de Brasília, Brasília, Brasil,
yaraújo@unb.br

² Instituto Butantan, São Paulo, Brasil, tkawano@usp.br

Since 1988 in The southern Brazilian coast, a sustainable management program has been established with the clam *Anomalocardia brasiliana*. An area located in Florianópolis, Santa Catarina state (27°38'00''SE, 48°33'05''W), has been monitored by a governmental institution and a fishermen's association. To enhance biological information about clam populations, reproductive studies have been carried out that include histological analyses of the sexual cycle. Stereologic and qualitative data revealed synchronous gametogenesis, ripeness and spawning by both sexes during summer to fall (February to May 1997) and spring to summer (October 1997 to February 1998). Both sexes reduced gametic development during winter and early spring (through June to mid-October 1997), a period of great nutritive tissue proliferation, including follicle cells, muscle and connective tissue. Despite a long spawning period, a closed clamming season was proposed to be established for March, April and May because fall spawning could promote the annual larval recruitment, which is only detected to be massive in spring (Pezzuto & Echternacht 1999) in this short-lived tropical clam (Monti *et al.* 1991). A closed fall clam season will not overlap with the activities of commercial fishermen in the summer, which is also a period of gamete ripening and spawning, but characterized by a great increase in bivalve consumption.

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Mitochondrial evolution of crown gastropods: insight from large subunit sequences and gene order data

Mónica MEDINA^{1,2}, Yvonne VALLÈS^{2,3}, Terrence GOSLINER² and Jeffrey BOORE¹

¹ DOE Joint Genome Institute, Walnut Creek CA, USA

² California Academy of Sciences, Golden Gate Park, San Francisco CA, USA

³ San Francisco State University, San Francisco CA, USA
M_Medina@lbl.gov

Crown gastropods exhibit high levels of homoplasy in multiple morphological characters. A well-characterized example is the independent reduction and loss of shell in several lineages with associated detorsion and regain of bilateral symmetry. We are comparing sequences of the RNA genes of the mitochondrial large ribosomal subunit (16S) for the euthyneuran clade (*i.e.* opisthobranchs plus pulmonates). We intend to map traits of interest, both morphological and molecular, onto this phylogeny. The second aspect of our research focuses on the evolution of mitochondrial (mtDNA) gene order within this clade. In the evolution of mitochondrial genomes in mollusks, there is a long period of stasis followed by major rearrangements, which likely occurred some time before the divergence of Euthyneura from a prosobranch ancestor. We are obtaining complete mtDNA sequences from several taxa (*i.e.* caenogastropods, heterobranchs and opisthobranchs) to try to reconstruct the pattern of these rearrangements in gastropod evolution.

The use of a database in paleoecological interpretation of northwest European Pliocene-Quaternary deposits

Tom MEIJER

TNO-NITG National Geological Survey of the Netherlands, P.O.Box 80015, 3508TA
Utrecht, The Netherlands, t.meijer@nitg.tno.nl

For paleoecologic and biostratigraphic interpretations of fossil molluscan assemblages a database of molluscan species was compiled. The content of the database is focussed on the Pliocene and Quaternary marine and non-marine deposits of the North Sea Basin.

Presently, the following fields (characters) are included in the database:

Applicable to all species: *Taxon name*; *Class*; *Main ecological group*.

Only marine species: *Marine faunal province*; *Bathymetry*; *Salinity*; *Mobility of bivalves*; *Feeding mode*.

Only non-marine species: *Environment (based upon the Lozek system)*; *North-South climatic gradient of land-species*; *East-West climatic gradient of land-species*; *Substrate preference of freshwater species*.

These fields contains values (groups) relating to a subdivision of that particular character. Species are assigned to one of these groups based upon their present day preferences in the region. Extinct species are subdivided according to preferences of extant related species and upon the preferences of co-occurring extant species in fossil assemblages.

Value assignment is not yet completed for all species present in the database. This is an ongoing process. Also, the content of the database is regularly updated according to growing knowledge and additional fields are developed as well. Three fields are in an experimental phase. These are:

- Age group (providing information on stability of assemblages).
- Shell shape (providing taphonomic information).
- Shell sculpture (providing taphonomic information).

With help of the database ecologic diagrams are produced which can show trends in faunal development present in a series of samples.

A case study from marine deposits of Early Pleistocene age in which the database has been used is concisely described. The deposits testify to a general trend of a shallowing basin which is caused by accelerated erosion of the hinterland during glacial phases. Superimposed on this trend the diagrams show an oscillating sea level during a series of at least 5 interglacial stages. This number of interglacials is more than has been recognized until now in the regional stratigraphy. Multidisciplinary research is going on to complete and refine these new results.

The feeding process in *Psiloteredo healdi* (Bivalvia: Teredinidae): How it handles two discrete food sources

Georgeana L.C. de MESERANI^{1,2}, and O. DOMANESCHI²

¹ Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, CP 11.461, São Paulo-SP, 05422-970, Brazil, 1georgeanaz@hotmail.com and 2domanesc@usp.br

² Department of Zoology, University of Washington, Box 351800, Seattle, Washington 98195, USA.

Teredinidae is a family of highly specialized bivalves that drill into and make burrows in wood, in marine and brackish water. They feed both on wood collected at the anterior end of the burrow and phytoplankton via the posterior inhalant siphon. We investigated functional anatomy of *Psiloteredo healdi* from submerged logs in brackish to almost fresh water in SE Brazil, to determine how it processes these distinct foods. The anterior portion of the body is mostly involved with the wood capture and selection. Small particles of wood removed by cutting action of the shell are selected and conducted by ciliated tracts of the foot surface to the labial palps to be ingested, or to mantle tracts to be rejected. Alternating areas with and without cilia on the foot surface suggest that expanding or retracting the foot can control the flux of wood particles to the palps or mantle. The body region posterior to the shell, although very elongated, acts as in typical suspension-feeding bivalves. The inhalant current conducts suspended material to the pallial cavity, where it is size-selected by the elongate posterior portion of the ctenidia, excess material being discarded via strong rejection tracts on the mantle surface. The study also revealed that the two siphons have different kinds of ciliated receptors, that a row of prolaterofrontal cilia is present on each side of the gill filaments, and the longitudinal median frontal face lacks cilia. In addition, long ducts, not previously reported in Teredinidae, occur in the excretory system and are probably related to the low salinity environment inhabited by the species.

Diversity of Condyllocardiidae (Bivalvia; Carditoidea) in Australia

Peter U. MIDDELFART

Centre for Evolutionary Research, The Australian Museum, 6 College Street, Sydney 2010, Australia, peterm@austmus.gov.au

Micro-bivalve material from around Australia has been examined and the family Condyllocardiidae revised. Although Australia has been known to have a particularly high diversity of condyllocardiids, the present revision indicates that earlier diversity estimates were too low and that many synonyms exist. The use of SEM has been imperative to the investigation of these bivalves, which comprise the smallest bivalves in Australia, some of which measures less than 0.8 mm in height as adults. The hinge teeth configuration and protoconch morphology has been used extensively to distinguish genera, while shape and external sculpture of the shells have been used for species level distinctions. A total of 50 species level taxa are recognised of which 25 are new and these are contained in 11 genus-group taxa of which five are new.

Making pearls: unraveling the methods of modern perliculture

Paula M. MIKKELSEN¹ and Rüdiger BIELER²

¹ Div. of Invertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024-5192, mikkell@amnh.org

² Department of Zoology, Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, Illinois 60605-2496, bieler@fieldmuseum.org

Pearls have been among the most coveted gemstones since antiquity, but their availability to all but those of wealth or royal blood has been largely restricted to the past 50 years. It was then, after World War II, that the Japanese and most especially Kokichi Mikimoto began producing and marketing affordable cultured pearls. Today, more than 30 countries have pearl farms. The range of modern product includes not only white Akoya pearls, but also larger “black” Tahitian pearls and silver or golden South Sea pearls, as well as eastern Pacific “New World pearls,” abalone pearls, and (most widely and inexpensively) satiny multicolored Chinese freshwater pearls. Modern perliculture techniques are largely Japanese innovations, although its roots predate Mikimoto and his contemporaries. The first cultured pearls were half-pearls in the shapes of small buttons or Buddhas, produced in Chinese freshwater pearl mussels probably as early as the 5th century CE. Studying Chinese examples brought to Europe by travelers, Carl Linné was first to produce spherical free pearls, in European river mussels in the 1750s, receiving the noble “von” in his name for this. Shortly thereafter, scientists in Denmark, France, and Germany began speculating about the formation of natural pearls and conducting experiments to test their theories. They ultimately found that a natural pearl most often forms around a parasite or other organic particle, rather than “a grain of sand.” They deduced that a piece of mantle tissue is the critical inserted element. Perliculture development was transported to European colonies in Tahiti and Australia in the late 1800s, and from there to Japan. The paper trail of Japanese patents reveals a three-sided rivalry to develop cultured pearls at the turn of the 20th century. Mikimoto ultimately won the contest, and his efforts rapidly gained acceptance for cultured pearls. Today’s perliculture methods all use modifications of Mikimoto’s method. Based on recent on-site research, contrasting techniques are reviewed for the major industries. A major exhibit on the history of Pearls can be seen at AMNH from October 2001 to April 2002, and at FMNH from July 2002 to January 2003.

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Gastropod fauna associated with *Thalassia testudinum* beds in Morrocoy National Park, Venezuela

Patricia MILOSLAVICH and Eduardo HUCK

Departamento de Estudios Ambientales and INTECMAR, Universidad Simón Bolívar, P.O. Box 89.000, Caracas, 1080, Venezuela, pmilos@usb.ve; ehuckb@hotmail.com

Morrocoy National Park is located in the central west coast of Venezuela. Given the ecological importance of its marine communities and the fact that several episodes of massive mortalities of plants and invertebrates have occurred due to natural causes in the last five years, a research priority of the communities of this park has been established.

The gastropod fauna associated with *Thalassia testudinum* beds in four protected bays (Las Luisas, Caño Capuchinos, Playa Sur and Tumba Cuatro) was collected by means of cylinders (infauna and epifauna) and by aspiration (epifauna) during the months of February and May 2000. A total of 32 species were identified. Las Luisas is characterized by a very dense seagrass bed with high content of organic matter in its sediments. In this bay, we found a mean gastropod density of 31262 ind. / m² in February and 42812 ind. / m² in May. Of these, 93% of the February sample were *Bittium varium* and 90% of the May sample were *Vitrinella* sp. In Caño Capuchinos, the mean density of gastropods was 8586 ind. / m² in February and 4552 in May, with *Bittium varium* dominating the community with more than 65% in both months. Playa Sur and Tumba Cuatro had lower gastropods densities and the communities were dominated by *Caecum pulchellum* and *Albania* sp. The highest density found at these sites was 3572 ind. / m² and the lowest was 199 ind. / m². Other species found in high densities at all bays were *Crepidula navicula*, *Caecum cornucopiae*, *Zebina browniana*, *Assimineia succinea* and *Cerithiopsis greene*.

Reproduction of *Crepidula aphysioides* Reeve (Caenogastropoda) from La Restinga Lagoon, Venezuela

Patricia MILOSLAVICH¹ and Pablo E. PENCHASZADEH^{1,2}

¹ Departamento de Estudios Ambientales, Universidad Simón Bolívar, P.O. Box 89.000, Caracas, 1080, Venezuela, pmilos@usb.ve.

² Laboratorio de Invertebrados, Departamento de Biología, Facultad de Ciencias Exactas y naturales, Universidad d Buenos Aires, Argentina, penchas@bg.fcen.uba.ar.

Brooding specimens of *Crepidula aphysioides* were collected at La Restinga Lagoon, Margarita Island, Venezuela between 0.5 and 1m depth. Individuals were attached to the roots of the mangrove *Rhizophora mangle*. A total of 72 females of *C. aphysioides* were collected. The shells of brooding females measured between 9.4 and 18.2 mm in length, between 7.1 and 1.2 mm in width and between 2.8 and 3.9 mm in height. Each female brooded 23.4 ± 4.5 egg capsules. The egg capsules had a triangular shape, with one corner extending to form a stalk by which all of the egg capsules were attached to the substrate at a common point. The capsule walls were thin and transparent. Egg capsules measured 1.1 ± 0.4 mm lengthwise (without the stalk) and about 1.4 ± 0.4 wide. The number of eggs per capsule varied from 3 to 12. The uncleaved eggs measured about 300 μ m and all eggs developed. Nurse eggs were not observed. However, the possibility of cannibalism among sibling embryos exists given that the number of hatchlings was significantly lower (by one individual) than the number of eggs. Hatchlings were crawling juveniles measuring about 600 μ m in shell length.

Survival of the freshwater pearl mussel *Margaritifera margaritifera* after opening with mussel tongs

Evelyn A. MOORKENS¹ and Mark J. COSTELLO²

¹ 40, Templeroan Avenue, Dublin 16, Ireland, evelynmoorkens@eircom.net

² Huntsman Marine Science Centre, 1 Lower Campus Road, St. Andrews, New Brunswick, Canada, Costello@huntsmanmarine.ca

Margaritifera margaritifera L. is a large freshwater bivalve with a holarctic distribution. Habitat destruction, pollution and over-exploitation have led to a decline in mussel populations throughout its range, and its extinction from some rivers (Wells *et al.* 1983).

This study tested the survival of pearl mussels after prising them open with tongs. Each of six mussels were opened to either 0 mm, 5 mm, 10 mm or 15 mm for 15 seconds using pearl fishing tongs, and were kept out of water for a total of one minute in the process. Mussels were checked for life signs and weighed at intervals over the following 50 days.

Eight of the 24 mussels tested died during the 50 days after the experiment, including all six of those opened by 15 mm.

The main conclusion of the study was that opening mussels with tongs could be fatal if the aperture of opening is too wide for that mussel. It would be difficult to remove a pearl without opening the mussel more than 1 cm. Considering the practical difficulties involved in regulating the use of tongs, and the results above, a total ban on pearl fishing is considered to be more appropriate for the conservation of this species than any licenced system of pearl fishing involving tongs.

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The genus *Bankia* Gray, 1842 (Bivalvia, Teredinidae) of the Brazilian coast: taxonomical and anatomical approaches

Daniela T. DE MORAES and Sônia G. B. C. LOPES

Institute of Biosciences, University of São Paulo, Rua do Matão, travessa 14, nº. 101, 05508-900 - São Paulo – SP, Brazil, dtmoraes@ib.usp.br, sonialop@uol.com.br

Teredinidae are bivalves adapted to bore into wood and digest cellulose. The pallets are the main structure used in the identification of species but, especially in the genus *Bankia* Gray, 1842, it shows great intraspecific variation that has led to a number of synonyms for each species (Turner, 1966). On the Brazilian coast there are eight reported species of *Bankia*: *B. gouldi* Bartsch, 1908; *B. fimbriatula* Moll & Roch, 1931; *B. rochi* Moll, 1931; *B. carinata* (Gray, 1827); *B. campanellata* Moll & Roch, 1931; *B. cieba* Clench & Turner, 1946; *B. destructa* Clench & Turner, 1946 and *B. bagidaensis* Roch, 1929; but these records must be reviewed. The characters of the pallet aren't always enough to correctly identify some of these species, especially in the case of *B. rochi* and *B. fimbriatula*.

The objective of this work is to redescribe the species of the genus *Bankia* that occur on the Brazilian coast, considering not only the pallets, but also the anatomy of the soft parts. The anatomies of *B. gouldi* and *B. fimbriatula* are already known from the studies of Sigerfoos (1908) and Martins-Silva (1997), respectively.

Animals collected in several localities in Brazilian, as well as type species and specimens deposited in the Museum of Comparative Zoology (MCZ, USA) have been analyzed. Preliminary results show that the pallet and the anatomy of *B. gouldi* collected in Brazil are similar to those described by Sigerfoos (1908). Nevertheless, specimens that have been identified as *B. rochi* differ in their pallet and in their anatomy from the specimen deposited in the MCZ (170838), considered by Turner (1966) as *B. rochi*. Specimens collected in Brazil that have been identified as *B. rochi* and *B. fimbriatula* are not different in their general disposition of the organs in the pallial cavity. Furthermore, their pallets show so many variations that it is difficult to separate them into different species. Type analysis and anatomical studies of the remaining species have been done to complete the review of the Brazilian species of the genus *Bankia*.

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Relationships of the orthurethran land snails

Peter MORDAN and Christopher WADE

Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, pbm@nhm.ac.uk, chriw@nhm.ac.uk

The name Orthurethra was first coined by Pilsbry (1900) for one of his three primary divisions of the stylommatophoran pulmonate land snails and slugs. These groups were defined primarily on the anatomy of their excretory systems. Pilsbry considered the orthurethran kidney to be primitive, and the Orthurethra as a whole to be both ancient and ancestral to the rest of the Stylommatophora. These views have been broadly accepted ever since, although it has been pointed out that the supposed plesiomorphic nature of the orthurethran kidney suggests that the group would be paraphyletic.

The Orthurethra comprise mainly Palaearctic taxa but also include Oriental and Afrotropical forms, as well as a number of Pacific families such as the Partulidae and Achatinellidae which are of considerable conservation interest. The composition of the Orthurethra has varied little in the last hundred years, the number of families recognised varying largely as a result of the lumping or splitting of component groups. Only the inclusion of the Partulidae has been seriously questioned in recent classifications.

A molecular phylogeny of the Stylommatophora (Wade *et al.* 2001) based on the rRNA gene cluster, including almost a hundred genera in fifty families, shows the Orthurethra to be a relatively advanced monophyletic clade, broadly equivalent to superfamilial groups such as the Helicoidea and Limacoidea. Its sister group is, however, unclear. The molecular tree highlights a number of interesting patterns of relationship between orthurethran families.

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Vertical distribution of the Mollusca at two contrasting subtidal soft-bottoms at Ensenada de Baiona (Galicia, NW Spain)

Juan MOREIRA, Loreto GESTOSO and Jesús S. TRONCOSO

Departamento de Ecología e Bioloxía Animal. Facultade de Ciencias, Univ. de Vigo, Vigo, E-36200. Spain, moreira@uvigo.es

Between the years 1995 to 1997 a study on the benthic communities of Ensenada de Baiona (NW Spain) was carried out, including the cartography, population dynamics and vertical distribution of these communities. This inlet is located at the mouth of Ria de Vigo, one of the largest of the galician rias. In this communication, results on the vertical distribution of the malacofauna are presented.

Two different bottoms were chosen for this study: a sandy bottom with the seagrass *Zostera marina* L. scattered over it and a muddy bottom at the harbor of Baiona, influenced by human activity. Samples were taken between May 1996 and February 1997 with a quarterly periodicity using a corer of PVC operated by two divers. The corer penetrates 30-40 cm into the sediment. The samples were divided in layers of 5 cm to study mollusk distribution at different sediment depths. The use of this corer has proved to be appropriate for this kind of studies (Troncoso & Urgorri 1992, 1993) A sediment core for granulometric analyses was also taken.

At the *Zostera* station, diversity was higher than in the harbor station during the period of study and animals penetrated deeper into the sediment, due mainly to the presence of the bivalve *Ensis arcuatus*. At the harbor station, mollusks were mainly collected in the first 10 cm and in low numbers, only the bivalves *Thyasira flexuosa* and *Mysella bidentata* reached high abundances in May and February.

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Reproductive cycle of *Eurhomalea exalbida* (Bivalvia, Veneridae) from Ushuaia Bay (54° 50'S), Beagle Channel (Argentina)

Elba MORRICONI^{1a}, Betina J. LOMOVASKY¹, Jorge CALVO¹ and Thomas BREY²

¹ Centro Austral de Investigaciones Científicas (CADIC). C.C 92 Ushuaia, Tierra del Fuego, Argentina, ^a jcem@arnet.com.ar

² Alfred Wegener Institute for Polar and Marine Research (AWI). Bremerhaven, Germany

The reproductive cycle of *Eurhomalea exalbida* from Ushuaia Bay, Beagle Channel, was studied from October 1998 to December 1999. Clams were collected monthly by SCUBA diving at 3 to 5 m water depth.

The degree of sexual maturity was determined histologically (n=318). Sex ratio was 1:1 (χ^2 p>0.05). First sexual maturity occurred at 41-43 mm valve length (*i.e.* 4 y age) in both sexes. Five distinct histological stages of sexual maturity could be established in males: (1) Early Active, (2) Late Active, (3) Ripe, (4) Partial Spawning and (5) Spent. Females had both immature small oocytes and large developed oocytes in their ovaries throughout the year, hence we could not classify reproductive stages based on a qualitative histological scale of sexual maturity. Therefore quantitative measures using an image analyzer were used.

In males, the percentage of ripe individuals was high all year round except in November when 75% had spawned. In females, the mean number of developed oocytes number per gonadal area, the mean diameter of oocytes per gonadal area, the percentage of gonadal area occupied by oocytes, and the Relative Condition Index (RCI) were lowest in November indicating a previous spawning peak. These results indicate synchronous gonadal development and spawning in males and females. The more intensive spawning activity in November coincides with the higher phytoplankton biomass and production in spring.

The arms race that wasn't: Ecological and evolutionary stability in a Pliocene rift lake (Lusso, Congo)

Paul J. MORRIS

Malacology, The Academy of Natural Sciences, 1900 Franklin Parkway,
Philadelphia, PA 19103, USA, mole@morris.net

The Upper Pliocene lacustrine deposits along the Upper Semliki River record the late stages of a large rift lake with a rich endemic molluscan fauna. Other deposits on the western border of Uganda record a longer Mio-Pliocene history of this paleo-lake. In addition to the endemic mollusks, this fauna is also unusually rich in mollusk-eating fish. The gastropods in this fauna show evidence of crushing predation. A high proportion of gastropod shells have breakage and repair scars consistent with failed predation attempts. Potentially predation resistant shell sculpture, particularly heavy keels, spines, and nodules are common morphological features on gastropod species in this fauna.

Throughout the Pliocene history of this paleo-lake, the gastropods show a general qualitative trend towards increased sculptural complexity - an apparent increase in the presence and size of potentially predation resistant shell sculpture. On the large scale, the history of the molluscan fauna appears as one of increase in defenses in response to fish predation.

The Upper Pliocene deposits on the Upper Semliki record the late stages of this history at a relatively high level of resolution. Contrary to expectations, changes in the morphology of the gastropods are neither gradual nor randomly distributed over time. The overwhelming bulk of morphological change in the gastropod lineages occurs over a brief stratigraphic interval, coincident with major changes in the diversity of the fauna. In the lower portion of the deposits along the Upper Semliki, the gastropod fauna is uniformly rich and diverse, containing several lineages with moderate development of keels and similar putative anti-predatory shell sculptures. Near the top of the section, diversity rapidly declines and a formerly rare lineage becomes the dominant representative of a depauperate fauna. This decline in diversity occurs over about one meter in section and correlates tightly with substantial morphological change in all gastropod lineages observed, change that reflects an increase in size of keels, spines, and nodules. Thus, the fine structure of the evolution of potentially anti-predatory shell structures in the fauna of the Upper Semliki is concentrated in an interval of ecological change. This suggests that stable ecological systems may act to limit the evolutionary change of species within them, and that changes in the ecological structure of communities may allow more rapid evolutionary change.

The evolution of the Clavagelloidea (Anomalodesmata)

Brian MORTON

The Swire Institute of Marine Science and Department of Ecology and Biodiversity,
The University of Hong Kong, Hong Kong, China, bmorton@hkucc.hku.hk

It is generally thought that the anomalodesmatan Clavagelloidea comprises two functional groups: the nestling/boring *Clavagella* (including *Bryopa* and *Dacosta*) and the infaunal *Brechites* (including *Aspergillum*, *Foegia*, *Penicillus*, *Pseudobrechites* and *Nipponoclava*) and *Stirpulina*. Recently, *Bryopa* has been proposed as a third group and a unique extension of the clavagellid line of evolution, in which the anterior region of the shell is dissolved as the animal bores deeper. It has also recently been shown how the cemented *Humphreyia* can be derived from an infaunal *Brechites*-like ancestor, making a fourth functional entity. These recent studies, in broadening our understanding of the range functional diversity, however, raise questions with regard to the, as currently defined, taxonomic composition of the Clavagelloidea.

Clavagella has an internal ligament (but no lithodesma) located between chondrophores, both adductor muscles, a pallial line with a pallial sinus, no pedal disc and although it cements the left valve to its burrow wall, the right is free, inside the tube, or crypt. This is also true of the infaunal *Stirpulina*. Cementation is a feature of some other modern anomalodesmatans, e.g. *Myochama* and *Cleidothaerus*, so that the adoption of this habit by *Clavagella* and *Brechites* and *Humphreyia*, is not a reason for their affiliation per se. It is known that the true juvenile shell valves of *Brechites* and *Humphreyia* are not cemented to anything: they become surrounded by and marginally united with an adventitious tube to which they are then fused by an internal calcareous secretion of the underlying mantle. Both *Brechites* and *Humphreyia* have an external ligament (the latter with a lithodesma), are amyarian as adults, have no pallial sinus and develop a watering pot anteriorly internal to which is a pedal disc. *Humphreyia* (and it is suspected *Brechites*) has a distinct post-planktonic life history stage in which a free-living, typical bivalve juvenile metamorphoses into a tube-dwelling adult. This does not occur in *Clavagella*.

This paper thus argues that the Clavagelloidea, as currently defined, probably contains two families with *Clavagella s. s.* and *s. l.*, and *Stirpulina*, belonging to the Mesozoic Clavagellidae and *Brechites* and *Humphreyia* belonging, with the allies of the former, to the Caenozoic Penicillidae. Both families seem to have radiated into a wide range of marine habitats involving a considerable degree of convergent and parallel evolution, e.g. the infaunal tube-dwelling *Stirpulina* (Clavagellidae) and *Brechites* (Penicillidae). The extant Anomalodesmata comprises one-sixth of all bivalve familial diversity: but it is probably actually much more diverse than that.

Anatomical, histological and immuno-cytochemical studies on the central nervous system in the African mussel, *Perna perna* (Linnaeus, 1758)

Abdellatif MOUKRIM¹, M. MATHIEU², S. BENOMAR¹ and K. KELLNER-
COUSIN²

¹ Biology Department, Sciences Faculty of Agadir, Ibn Zohr University, B.P. 28/S,
Agadir, Morocco, moukrim@nomade.fr

² Marine Biology and Biotechnology Laboratory, Caen University, France,
mathieu@ibba.unicaen.fr

The central nervous system of mytilid mussels is involved in the regulation of growth and reproductive cycles. This has been demonstrated for the European mussel, *Mytilus edulis*, but few data are available for the African mussel, *Perna perna*. The aim of our work is to contribute to the knowledge of the central nervous system of this bivalve which is widely distributed along the African coasts and plays an important socio-economical role. The anatomical study shows that the central nervous system of *Perna perna* consists of three pairs of ganglia: cerebro-pleural, visceral and pedal. Histological studies using Thionine paraldehyde and Romeis AZAN staining for light microscopy reveal that these ganglia have the same structural organization showing three distinct areas: perineurium, cortex and neuropile. Selective staining for neurosecretory activity allowed identification of four different types of neurosecretory cells, a1 to a4. These cells are all located in the cortex. They are characterised by their neurosecretory products which stain red with AZAN and green-blue with Thionine. Relative to the other cell types, the a1 type is most abundant. The immuno-cytochemical study using GnRH, insulin, glucagon and FMRF amide, reveals that the immuno-reactive sites in the cerebral and pedal ganglia are located primarily in the anterior and posterior area and in the lateral region of the two ganglia. The a1 and a2 are the more cells concerned by immuno-reactivity.

The Asian clam, *Corbicula fluminea*, in Britain

Stephan J. MÜLLER and David C. ALDRIDGE

Aquatic Ecology Group, Department of Zoology, University of Cambridge, Downing
Street, Cambridge CB2 3EJ, UK, sjm50@cam.ac.uk

The Asian clam, *Corbicula fluminea*, arrived in Britain approximately five years ago and has rapidly gained a foothold in the Norfolk Broads, one of Europe's largest and most important wetland areas. Over the last five decades *C. fluminea* has had extensive economic and ecological effects in North America, and its influence on aquatic ecosystems the world over is set to increase following a further rapid range expansion in recent years. In this study, the source of the British *C. fluminea* population is being determined using molecular genetic techniques. Studies are being carried out to determine how *C. fluminea* is spreading through the Norfolk Broads and beyond, and to assess the effectiveness of dredging as a control measure. *C. fluminea* has been shown to interact strongly with native predator communities. Therefore, wildfowl and fish stomach-content analyses are being used to assess the role of *C. fluminea* as a novel food source, and exclusion studies are being used to assess the ability of native predator communities to control *C. fluminea* density and biomass.

***Berthella patagonica* (d'Orbigny, 1837) (Gastropoda, Opisthobranchia): a poorly known pleurobranch from the Patagonian coasts (southwestern Atlantic)**

Claudia MUNIAIN¹ and Juan Lucas CERVERA²

¹ Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Angel Gallardo 470 (C1405DJR) Buenos Aires, Argentina, claudiamuniain@velocom.com.ar

² Dpto. Biología Animal, Vegetal y Ecología, Fac. Ciencias del Mar, Universidad de Cádiz, Apdo. 40, 11510 Puerto Real, Cádiz, Spain, lucas.cervera@uca.es

Two species of the genus *Berthella* Blainville, 1825 have been recorded from the South Atlantic: *Berthella patagonica* (d'Orbigny, 1837) and *Berthella platei* (Bergh, 1898) (both as *Pleurobranchus*). *Berthella patagonica* was described based on a specimen collected in intertidal rocks at Ensenada de Ros (41° S, Río Negro, Argentina) by Alcide d'Orbigny in 1837. The original description, very brief, provides only an external description with a colour drawing, and the type material is missing. Recent contributions on magellanic species of *Berthella* is given by Muniain (1997) and Schrödl (1999).

In this contribution, *Berthella patagonica* is redescribed on the basis of new material collected from different localities from Patagonia. Information on living specimens and internal anatomy. These studies include internal anatomy SEM of the radula and shell and anatomy of the medial buccal gland and reproductive system, as well as ecological aspects of the diet, defence and geographical range. A discussion of Brazilian and West-Pacific species of the genus will be included.

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A comparison of two surveys of the land snails of Jamaica

Lauren L. MUNROE

Department of Zoology, University of the West Indies, Mona, Jamaica,
pemps79@yahoo.com

In 1933, H.B Baker conducted a survey of the Jamaican fauna, collecting land snails at about 40 sites. Over the last three years, Drs. Gary Rosenberg and Igor Muratov and accompanying scientists have sampled 550 sites in all geographic regions of Jamaica. Since the island has undergone considerable development in the time between the two studies, a comparison was made.

The major objectives of the study were to see whether differences in species diversity and composition exist between sites sampled by both Baker and Rosenberg & Muratov and to seek explanations for any observed differences. Map analysis and coordinate comparisons were used to determine exact site locations from Baker's publications. These were then compared to sites sampled by Rosenberg and Muratov. Eleven sites were identified that definitely or probably overlapped geographically. Species lists for these sites were generated by examination of Baker's publications, and by study of collections, catalogues and databases at the Academy of Natural Sciences in Philadelphia, where materials from both surveys are housed.

Site-by-site comparison showed on average little variation in diversity within sites over time. However, when diversity is summed across the sites, it turns out that Rosenberg and Muratov collected 97 species across all sites, whereas Baker collected 124 species. Thus while site diversity did not decrease, overall diversity did decrease. This decrease is due possibly to increased levels of disturbance that have occurred in the areas sampled. This is indicated by Baker's having collected more species alive than did Rosenberg and Muratov. Some species that are tolerant of disturbance apparently have become more widespread. For example, *Pleurodonte sloaneana*, which is often found at disturbed sites, was found at five of the sites by Rosenberg and Muratov, but at only one by Baker.

Comparison of the sites is made difficult by lack of knowledge of Baker's sampling methods. It is not known how long he spent at a site, whether he preferentially collected live material, or if he in some cases did not bother to collect common or introduced species. He apparently did not collect leaf litter samples, and therefore Rosenberg and Muratov obtained a higher diversity of microfauna at several sites. Clustering techniques showed that Baker's stations were more similar to each other than they were to Rosenberg and Muratov's stations. This might reflect homogenization of the fauna, but it also suggests that differences in collecting procedures significantly affected the results.

Jamaican land snails: zoogeography and the origin of the fauna

Igor V. MURATOV

The Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, Philadelphia,
Pennsylvania 19103-1195, USA, muratov@acnatsci.org

Although Jamaica emerged as an island off the southern coast of Mexico probably as early as Paleocene, it was almost completely submerged from the late-middle Eocene to early Miocene (Buskirk 1985). Therefore the colonisation of Jamaica by terrestrial animals occurred much later than of Cuba, northern portion of Hispaniola and Puerto Rico. This partially explains the disproportionately smaller diversity of Jamaican terrestrial arthropods (Buskirk 1985, and personal observations).

The high relative diversity (over 250 species of pulmonates and over 250 operculate species) of Jamaican terrestrial snails can be explained in large part by the high level of local endemism and by the abundance of limestone, especially the White Limestone Formation, which provides not only calcium carbonate but a good water regime and abundant shelter as well.

Rapid sea level changes during the Pliocene-Pleistocene produced a number of isolation-connection events between areas of limestone that had been already partially or completely isolated by sedimentary, igneous and metamorphic rocks. Each of these areas has a more or less distinct terrestrial malacofauna. Examples including some common local endemics are: Negril Hills and the hills east of Great Morass with *Thelidomus cognata* (Camaenidae) and *Sagda occidentalis* (Sagdidae), Northern Coastal Terrace with *Excavata costata* (Helicinidae) and *Dentellaria bronni* (Camaenidae), John Crow Mountains with *Annularia pisum* (Annularidae), *Meiophysema lamelliferum* (Sagdidae) and *Pleurodonte ingens* (Camaenidae).

In addition the Blue Mountains (non-limestone) fauna can be clearly recognized with three distinct indicator species of *Pleurodonte* (Camaenidae): *P. carmelita*, *P. chemnitziana* and *P. subacuta*.

A large limestone area in the north-central Jamaica including the Cockpit Country contains number of often highly variable species (*Pleurodonte lucerna* for example) indicating rapid adaptive radiation and ecophenotypical variation of many groups of land snails.

Finally agricultural and urban development (primarily on alluvial formations) have been amplifying natural isolation, as well as adding exotic species to the Jamaican malacofauna.

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Life cycle strategies of land snails in central and southern Greece

Moysis MYLONAS and Katerina VARDINOYANNIS

Natural History Museum of Crete, University of Crete, PO Box 2208, 71409 Irakleio,
Crete, Greece, director@nhmc.uoc.gr, mollusca@nhmc.uoc.gr

Central and southern Greece is characterized by its Mediterranean climate of dry to semi-humid type. The wet season is between late October to early April while the dry from May to October. Land snails follow these periods. They "obligatory" aestivate during the dry period and on the other hand they "have" to complete all their activities - feeding, growth, reproductive cycle - during the short wet period.

Although our knowledge for the life-cycle of the Greek species is not complete there are a lot of data which mainly appear as part of recent theses, or from field studies for the conservation of protected areas or from studies dealing with the function and structure of certain ecosystems.

All these data allow us to distinguish three life-cycle strategies in the area. This distinction is based on the time of the year that land snails reproduce in relation to feeding and other activities.

In the first strategy species wake up after the first rains and they immediately reproduce. All their other activities follow reproduction. The second strategy type is almost the reverse of the first. Land snails are activated after the first rains but reproduce during the last month of the wet season. The third is an intermediate strategy where the species are activated after the first rains and reproduction takes place in the middle of the wet period (late December - January) and they remain active till the end of the wet period.

The majority of land snails follow the first strategy - autumnal type. These are species that are the most common and have dense populations in the area. In the second type - vernal type - belong species that are either paleoendemics or relicts. The third strategy - hibernal type - belong species that aestivate deep in the soil, wake up and feed a fortnight to one month after the first rains, and seek for the most favourable conditions in order to reproduce. These species are the least thermophilous species in the area.

Distributional and feeding relationships of snails (Gastropoda, Mollusca) and leeches (Hirudinea, Annelida) in an English hard-water river

Nelson NAGEFELA¹ and Georges DUSSART²

¹ Durrell Institute of Conservation & Ecology, University of Kent, England.

² Canterbury Christ Church University College, Kent CT1 1QU, England, gbd1@cant.ac.uk, corresponding author.

Water snails are an important prey item for leeches in freshwater in Britain (Young & Proctor 1986) but relatively little is known about their predator-prey relationships. The distribution of snails and leeches in the River Stour in South East England was investigated to determine the extent of localised ecological relationships between the two taxa. The objectives were to determine the distributional relationships between snail and leech species, prey species preference, the effect of starvation level on foraging time, and size preference for snail prey. The habitat comprised two sites which had been classified into marginal/central and vegetated/non-vegetated areas. At the slow flowing downstream site (0.35 m.s⁻¹), there was a significant regression relationship between *Erpobdella octoculata* (L.) and *Lymnaea peregra* (Müller) in vegetated margins ($E_o = 1.39 + 0.168 L_p$ $F_{1,34} \sim 4.4$, $P < 0.04$). At the faster flowing upstream site (0.50 m s⁻¹), there was a significant regression relationship between *E. octoculata* and *Bithynia tentaculata* (L.) in the non-vegetated margins ($E_o = 0.506 + 0.172 B_t$ $F_{1,34} \sim 5.3$, $P < 0.02$).

More snails and leeches were found at the site with the slower flow. *Bithynia tentaculata* density was found to be related to both site and sample area, confirming prior observations that its distribution is strongly affected by habitat conditions (Dussart 1979). Since field investigation had identified *E. octoculata* as an abundant predator, this species was used in associated laboratory experiments of feeding behaviour. The time taken by *E. octoculata* to locate prey decreased with increased starvation time up to about six days, after which further starvation did not result in a significant change in foraging time. Food preference order for *E. octoculata* was *L. peregra* > *Baetis* > *B. tentaculata* > *Gammarus pulex* (L.) ($F_{3,19} = 13.6$, $P < 0.0001$) and the leech showed a preference for feeding on smaller individuals ($F_{2,19} \sim 18.1$, $P < 0.001$). *Erpobdella octoculata* foraged actively, whereas *Glossiphonia complanata* (L.) tended to use an ambush strategy.

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Land snail diversity in Sri Lanka

Fred NAGGS, Dinarzarde RAHEEM and Peter MORDAN

The Natural History Museum, London SW7 5BD, UK, fren@nhm.ac.uk

The Convention on Biological Diversity, which was launched at the Rio de Janeiro "Earth Summit" in 1992, raised the political profile of biological conservation and sustainable development. One of the responses of the British Government was to set up a fund called the Darwin Initiative. The purpose of the Darwin Initiative is to support projects that use British expertise and resources to help countries rich in biodiversity but poor in resources to meet their obligations under the Convention on Biological Diversity.

The Natural History Museum in London is a rich resource of biological reference collections and library facilities and is well placed to respond to the Darwin Initiative's objectives. Using the criteria of high diversity, high levels of endemism, a threatened environment, a strong local interest and close historical ties, reflected in the Natural History Museum's resources, Sri Lanka was identified as an obvious choice for a Darwin project on land snails. Sri Lanka possesses an extensive system of higher education and a high level of environmental awareness but its capacity to carry out systematic work on a group such as land snails is greatly hindered by a lack of appropriate literature resources and adequate specimen reference collections. The current project addresses these problems and, by means of a survey programme, is establishing specimen reference collections and a Geographical Information System database on land snails. In addition to funding work and providing equipment in Sri Lanka through the Darwin Initiative, the Natural History Museum is making its resources available through printed and computerised media and is providing a programme of training and postgraduate supervision. Seven Sri Lankan undergraduate and three postgraduate students are grouped into two research teams based at the National Museum in Colombo and Peradeniya University and the Postgraduate Institute of Science at Peradeniya. In addition to basic taxonomic studies, work is being carried out on patterns of diversity, life history studies and pest species.

After initial surveys aimed at a wide geographical coverage the National Museum team is concentrating on the high-diversity rain forests in the South-west and the Peradeniya-based team is working in the Central Highlands, particularly the Knuckles Region north of Kandy. In addition to the scientific programmes there is an ongoing public awareness project with activities ranging from village outreach sessions to an exhibition that was launched at the Natural History Museum in Colombo and which will be presented at a number of venues throughout Sri Lanka.

**Non-marine mollusks from the outskirts of Santiago Papasquiario,
Durango, Mexico**

Edna NARANJO-GARCÍA

Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 70-153, México, D.F. 04510, naranjo@servidor.unam.mx

The non-marine mollusks from 20 sites (including six freshwater sites) around Santiago Papasquiario, Durango were collected between June 1994 to August 1996. Santiago Papasquiario is located in central Durango (Northwestern Mexico); vegetation in the area goes from Chihuahuan desert to pine-oak forest. Samples were taken from suitable snail habitats such as beneath logs, leaf litter, crevices in rocks or bark and were either hand-picked or sorted later in the laboratory from leaf litter or humus samples stored in ziplock bags. Freshwater mollusks were mainly collected manually from aquatic vegetation or on rocks.

Forty species were found, 26 are terrestrial and 14 are freshwater. It seems that three records are new for Mexico: *Punctum randolphi* (Dall, 1895), *Gastrocopta pilsbryana amissidens* Pilsbry, 1934 and *Columella alticola* (Ingersoll, 1875). Interestingly the ranges of six species are increased from New Mexico or/and Arizona or states further north (for example from Oregon, Idaho, Illinois, etc.) in the United States or from Mexico proper to this area in west-central Mexico. Regarding freshwater species *Menetus sp.* and *Neoplanorbis cf. umbilicatus* appear to be new records for Mexico. Until this collection was made, very little was known about the molluscan fauna of Durango State.

**Relationship among biodiversity and ecosystem of marine benthic
mollusks from Parque Nacional Morrocoy and Refugio de Fauna
Silvestre Cuare, Venezuela**

Samuel NARCISO

FUDENA. Av. Ppal. Los Cortijos de Lourdes con 2^{da} Transversal, Edif. Centro Empresarial Senderos Piso 6, Ofic. 611 Caracas-Venezuela, spondylus@uole.com.ve

Parque Nacional Morrocoy is a marine area on the western central coast of Venezuela. This area contains a diversity of habitats: mangrove, seagrass meadows, coral reef, etc. The National Park has 43,943 ha total area that is down to 30 m deep. The main objective of this study was to determine the relationship between the biodiversity and abundance of marine benthic mollusks in each habitat. The biological material studied came from collections made *in situ* between January 1996 and May 2001 using various methods including scuba and dredging. The organisms with the highest species diversity were gastropods (175 species), bivalves (122 species), cephalopods (33) and scaphopods (1 species). The coral reef ecosystem had higher species diversity (65%), while *Thalassia* beds had 20%, mangrove 10% and other ecosystems 5%.

The expression patterns of twist and snail homologues in *Patella vulgata* (Gastropoda) point to conserved and divergent aspects of mesoderm development

Alexander J. NEDERBRAGT¹, Olivier LESPINET², Wim J.A.G. DICTUS¹,
André E VAN LOON¹, André ADOUTTE² and Jo A.M. VAN DEN BIGGELAAR¹

¹ Department of Developmental Biology, Utrecht University, The Netherlands.

² Centre de Genetique Moleculaire, CNRS, Gif-sur-Yvette, France.

In contrast to deuterostomes and ecdysozoans, data about genes involved in mesoderm formation in lophotrochozoans are limited. Therefore, we decided to compare genes known to be involved in mesoderm formation in non-lophotrochozoans with orthologs of these genes in lophotrochozoans, in particular in mollusks.

As the *twist-snail* gene network is known to specify mesoderm in a number of non-lophotrochozoan animals, it is interesting to know whether this gene network is also present in mollusks and if so, whether its function is conserved. As a starting point we chose the primitive gastropod mollusk, *Patella vulgata*. We have cloned two *Patella* orthologues of *snail*, and one fragment of the orthologue of *twist*. The results of *in situ* hybridization experiments for *snail* are very intriguing, as no distinct mesodermal expression for either of the *snail* orthologues has been observed. The expression pattern indicates gene expression inside the future head region, in the developing mantle folds, and in the developing anterior central nervous system. *In situ* hybridizations for *twist* show expression in a subset of the mesoderm, in particular the ectomesoderm.

We conclude that in molluscs, and possibly in all Spiralia, *twist* genes play a role in differentiation of a subset of the mesoderm. From this, it can be inferred that members of the *twist* gene family are involved in mesodermal differentiation and myogenesis in all major clades of the bilaterians. Furthermore, the ancestral role of the *snail* gene family involves epithelial-mesenchymal transitions and nervous system development.

Terrestrial molluscs from the Soqotran Archipelago – a hot spot of evolution in Northeast Africa

Eike NEUBERT

Wiesenstr. 2, D-79410 Badenweiler, Germany, eike.neubert@t-online.de; c/o
Forschungsinstitut Senckenberg, Senckenberganlage 25, D-60325 Frankfurt/Main,
Germany, enebert@sng.uni-frankfurt.de

The Soqotran archipelago forms the southern boundary of the Gulf of Aden. It consists of 4 islands, whose biota still are insufficiently known. The description of terrestrial and freshwater molluscs of the islands followed a short but fruitful period of expeditions at the end of the 19th century, and the last comprehensive article was published by Smith in 1903. The knowledge of the archipelago's malacofauna could essentially be improved by the expedition from 1999. Endemism on species level surpasses 90% and approx. 75% on generic level. Meanwhile, more than 100 species are known from the islands, many of them new to science. Faunistic relationships between the islands are few, each island has more or less its own characteristic malacofauna specified on species as well as on generic level. Exact locality data revealed that on the main island Soqotra two centres of microendemism could be identified, at least.

Currently, the author revises the complete malacofauna to update the taxonomic concepts still originating from the last century. These concepts stressed relationships with other islands from the Eastafrican Island Arc, in particular with Madagascar. Revisions and analyses of the malacofaunas of adjacent areas (Neubert 1998) contradict this hypotheses. The unique conditions of an arid tropical region formed a specialised malacofauna to be found in south-western Arabia and the neighbouring Eastafrican areas. The terrestrial molluscs of the Soqotran archipelago exhibit the rare case of a continental fauna forced to adapt to island conditions with a subsequent endemic radiation.

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***Placostylus* revisited – unravelling the puzzle of the big bulimes of New Caledonia**

Eike NEUBERT

Wiesenstr. 2, D-79410 Badenweiler, Germany, eike.neubert@t-online.de; c/o
Forschungsinstitut Senckenberg, Senckenberganlage 25, D-60325 Frankfurt/Main,
Germany, enebert@sng.uni-frankfurt.de

New Caledonia and the opposite Loyalty Islands harbour a rich fauna of huge "bulimoid" terrestrial snails. The first shells were brought to Europe by Captain Cook and his party, and the big shells attracted collectors very soon. The colonisation of New Caledonia by France in 1853 gave rise to an immense flow of shells. Subsequently, an impenetrable taxonomical and nomenclatural jungle was created by those, who had access to the material. About 140 valid species names could be traced.

Today, many *Placostylus* populations are under pressure or already on the verge of extinction caused by extensive deforestation, mining activities and other reasons. To identify the most endangered populations and obtain data to develop conservation strategies, Philippe Bouchet and colleagues from the MNHN started to collect in a dense grid all over New Caledonia. First results were published by Chérel-Mora (1983), the investigation was continued by the author. Analysis of morphological characters of the genital organs clearly showed that we have to deal with 6 species with approx. 20 geographic subspecies. The degree of variation in shell morphology is puzzling, while anatomy of the genitals are surprisingly characteristic and stable. Parallely, the investigation showed that the anatomical characters of the group have been widely misinterpreted, and consequences on higher taxonomical levels will follow. Only extensive shell collections with exact locality data and well preserved animals could resolve the problems and thus describe the guideline for the future investigation of the other Pacific bulimes.

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Propagation of endangered freshwater mollusks in North America

Richard J. NEVES

Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, VA 24061-0321, USA, mussel@vt.edu

The extremely diverse molluscan fauna in North America has experienced a significant decline in recent decades, particularly in the United States. Of the nearly 300 taxa of freshwater mussels (Unionoida), 69 (23%) are listed as endangered or threatened, and another 40 species (14%) are candidates for possible listing. The status of our 660 species of gastropods has been evaluated, unfortunately with disheartening results. Although only 15 species are federally protected, at least 42 species have become extinct in the 20th century, and dozens of species are in precipitous decline. Canada's freshwater mollusks have fared better; of 180 species of bivalves and gastropods, only 3 of 51 mussel species and 2 of the 90 snail species are nationally protected.

To address this urgent need to maintain and restore populations of these protected mussels and snails in North America, a surge of recovery activities was initiated in the last decade to prevent further extinctions through habitat protection and propagation. Propagation efforts were initiated in the upper Tennessee River system, home to 34 endangered mussel species, and have subsequently spread to other rivers with aggregations of rare mollusks. Freshwater mussel propagation work is underway at facilities in Virginia, Tennessee, Georgia, Missouri, Arkansas, Ohio, Wisconsin, and North Carolina in efforts to augment populations in reproductive decline and to expand the ranges of extant populations. A cadre of biologists, affiliated with federal, state, and university organizations, have dedicated space in research laboratories, fish hatcheries and makeshift mussel culture facilities in attempts to halt further extinctions. Similar work is underway at the University of Guelph in Ontario, focused on restoring nationally protected and other species occurring only in the Sydenham River, Canada.

As of early this year, more than 300,000 juveniles of 10 endangered species were released into U.S. rivers in Tennessee, Virginia, Georgia, and Kansas. Most (82%) of these were produced at the Freshwater Mollusk Conservation Center at Virginia Tech, Virginia and released into tributaries of the upper Tennessee River. Research continues at these facilities to identify host fishes for other endangered mussels and to improve culture techniques, particularly the rearing of juvenile mussels during the first 6 months of life. Development of a suitable diet is now critical for facilitating the transition from the pedal-feeding to filter-feeding stage. With the high level of research underway, we soon will be able to prepare a manual for mussel propagation, to assist with species conservation at an international scale.

Cardiid evolution of in closed and hemiclosed Paratethys basins

Lidia A. NEVESSKAYA, Nina P. PARAMONOVA and Sergej V. POPOV
Paleontological Institute RAS, Profsojuznaja 123, Moscow 117868, Russia,
serg.pop@cityline.ru

A phylogenetic analysis of the subfamily Limnocyprinae (Cardiidae, Bivalvia) in the closed and hemiclosed epicontinental basins of the Paratethys is most needed to unravel the history of repeated explosive radiations. These radiations resulted in numerous homeomorphic taxa due to low competition when most of the marine biota went extinct and a few progressive eurybionts diversified to occupy the numerous vacant niches.

Seven events of intensive diversification are revealed from the Oligocene (Solenovian time) to Eopleistocene. Each radiation started from a *Cerastoderma* or *Parvicardium* species and produced homeomorphically similar forms. Many structures were transformed through fetalization: adult limnocyprines retain ornamentation, hinge and rib structure, and shell microstructure characteristic of early ontogenetic stages of their ancestors. In closed brackish basins with episodic connections to the open sea, the rates and patterns of evolution differed considerably from those in the hemiclosed Paratethys basins. Beside the characters formed through fetalization, some new features not characteristic of marine cardiiids were acquired here: disproportional development or hypertrophy of some hinge elements, alatform shell, and formation of a pallial sinus.

The wealth of material, including complete phyletic series and transitional forms, allows tracing the phyletic lineages quite reliably in many cases. At the same time it obstructs limnocyprine systematics, because many taxa prove to be polyphyletic, or diagnoses overlap. The proposed systematic scheme is a compromise between the morphological and phylogenetic approach, each of them being unacceptable if taken separately.

The Limnocyprinae contains 73 genera with more than 700 species. The genera are separated into 18 tribes, in which we tried to extract the individual phyletic lineages of limnocyprines (Neveeskaja *et al.* 2001). Evolution in the closed basins finally comes to extinction as result of subsequent environmental changes. However, it is explainable by ephemeral character of the brackish basins themselves rather than by peculiarities of the evolution.

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Geography, climate and pathways in Miocene Southeast Pacific - what the gastropods tell

Sven NIELSEN and Klaus BANDEL

Geologisch-Paläontologisches Institut und Museum, Universität Hamburg, Bundesstr.
55, 22146 Hamburg, Germany, Nielsen@geowiss.uni-hamburg.de

Apart from earliest representatives of endemic Southeast Pacific gastropods, such as *Acanthina* and *Chorus*, a number of genera occur in the Miocene Navidad Formation of Chile which indicate a close relationship with New Zealand (*Magnatica*, *Bedevea*, *Aeneator*, *Lamprodomina*). Similarities between mollusk faunas of New Zealand and Argentina (*Penion*, *Nassarius* (*Hima*)) have been shown by Beu *et al.* (1997) but connections of Chilean faunas with those from Argentina require migration pathways other than Drake Passage. We have now found a strait admitting migration through the young Andes near Valdivia, explaining the close relationship of *e.g.* *Valdesia*, *Struthiochenopus*, *Struthiolarella*, *Austrocominella*, *Proscaphella* and *Olivancillaria* with Argentinean species.

Opening of Drake Passage during the Late Oligocene has led to models initializing the Circum Antarctic Current (CAC) and Humboldt Current (HC) during that period. However, subtropical to tropical Foraminifera and gastropods (*Heminerita*, *Xenophora*, *Sinum*, *Zonaria*, *Echinophoria*, *Distorsio*, *Ficus*, *Conus*, *Terebra*, *Architectonica*) cannot be explained with such models. It seems more likely that initialization of the CAC-driven HC took place during the Late Miocene or even Early Pliocene.

Other groups demonstrate adaptation to changing climates - *Fissurella*, *Bathybembix*, *Monilea*, *Trochita* and *Ptychosyrinx* live since the warm Miocene in the Central Chilean region which today is dominated by the cold HC.

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Spatial and temporal distribution of fossil "*Calypptogena*" communities in the Plio-Pleistocene fore-arc basin in central Japan, NW Pacific

Takami NOBUHARA

Science Education (Geology), Faculty of Education, Shizuoka University, 836 Ohya,
Shizuoka 422-8529, Japan, etnobuh@ipc.shizuoka.ac.jp

Fossil chemosynthetic communities dominated by "*Calypptogena*" species have been discovered from more than 10 localities in the Plio-Pleistocene Sagara-Kakegawa basin, central Japan. The fossil communities occur from the low-permeable, massive siltstone deposited on the upper to middle slope (300 - 1000 m in depth) of the fore-arc basin. In contrast, the living "*Calypptogena*" communities around the Japanese Islands have been discovered from the cold-seepage sites on high-permeable coarse substrates in relative deeper-water settings such as trenches and accretionary prisms. These fossil communities offer the key to an understanding of habitat nature of shallower bathyal "*Calypptogena*" communities.

The fossil localities are concentrated near two horizons and form a cluster, less than 1 km in diameter, in each horizon. The fossil "*Calypptogena*" assemblage occurs in shell beds or limestone blocks (ca. 1 to 10 m in diameter), scattered through the massive siltstone, and commonly associated with *Lucinoma*, *Conchocele*, and *Solemya*. The limestone blocks consist of brecciated siltstone cemented by carbonate and contain abundant articulated "*Calypptogena*" shells. Cracks, burrows, and mould cavities of dissolved shells in the limestone blocks are filled or encrusted by authigenic carbonate. These indicate that the "*Calypptogena*" communities on slope muddy sediments depended on a methane-seepage system associated with gas eruption.

It remains unclear what is the origin and process of the seepage on the slope muddy facies. Majima (1999) suggested that the fossil chemosynthetic communities in bathyal muddy facies may have depended on a decomposition of methane-hydrate caused by water temperature rises or sea-level falls. However, both scenarios are inconsistent with the paleoclimatological data and their distributions in the sequence stratigraphic framework. The hydrate decomposition may have been related to some tectonic events such as seismic pumping.

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Gastropod phylogeny and diversity at the Palaeozoic/Mesozoic transition

Alexander NÜTZEL

Paläontologisches Institut, Loewenichstr. 28, D-91054 Erlangen, Germany,
nuetzel@pal.uni-erlangen.de

Gastropods are (at least from the Mesozoic onward) one of the most diverse and successful invertebrate groups. The destruction of Palaeozoic biotas and ecosystems at the end-Permian and the late Triassic mass extinctions is probably one reason for the success of the gastropods. Even within the Gastropoda, some groups seem to have benefited more than others from the destruction of Palaeozoic ecosystems. As an example, modern-looking cerithiid-like gastropods are a more or less marginal group in the Late Paleozoic to the early Late Triassic (Carnian). But since the latest Triassic (Norian/Rhaetian), modern-looking cerithioids have become more abundant and, for the first time, they dominate faunas in that period. Another example for this pattern are the shell-bearing Opisthobranchia (Cephalaspidea, Cylindobullinoidea). There are no certain and only a few putative cephalaspideans in the Late Palaeozoic. But in the Early Triassic (Scythian, Olenekian) Moenkopi Formation of North America, small shell bearing opisthobranchs are most abundant. Obviously, modern gastropod faunas were shaped to a high degree by the reorganization of gastropod faunas during recovery periods after major mass-extinctions.

A database with more than 2000 Triassic gastropod species shows a characteristic diversity pattern. An Early Triassic minimum is followed by a steady and rapid increase with a peak in the Carnian. Subsequently, diversity drops considerably in the Norian and remains low in the Rhaetian. The exceptionally rich gastropod fauna of the Carnian Cassian Formation (Italian Alps) possibly biases this diversity pattern to a certain degree. On the other hand, every stage has an exceptionally rich fauna and, therefore, the Carnian peak seems to reflect a real phenomenon. Only a few databases on the species level in diverse groups have been compiled so far. The present database suggests that diversity patterns on a higher taxonomic level reflect species level data only to a limited degree.

QUALITIGHT - a new specimen jar

Christoph OBERER

Working Group on Malacology, Basle Natural History Museum, Augustinergasse 2,
CH-4001 Basle, Switzerland

The maintenance of wet specimen collections is time-consuming, labour-intensive and expensive. The collections are therefore often in a poor state, and the specimens are partly or completely dry or have been destroyed by mould or drying out and have therefore become useless for scientific purposes. In addition, the specimens suffer as a result of the changing quality of the preservation liquid during the storage period.

Another problem of present-day collections is associated with the large number of different vessels and closure systems, which are not compatible with one another. This gives rise to high cost and makes it impossible to manage a collection in an efficient manner – especially with the use of computers.

A major problem is the poor tolerance of defects. Since the sealing compounds of closures used today have been developed for only short storage times, they become brittle after only a few years and liquid escapes. In addition, the seals tend to stick to the glass. Metal parts and internal coatings of the closures are susceptible to corrosion. Often, replacement closures are no longer available. Small defects, such as cracks in brittle seals, have a cumulative effect and lead to complete loss. This insufficient tolerance of defects makes it essential to monitor the state of each individual vessel continuously. Losses of preservation liquid are compensated, seals are replaced and the specimens are maintained. Each glass jar must be checked once or twice per year; however, the maintenance intervals differ from museum to museum. Political, economic and social influences (for example wars, economic depressions, declining importance of taxonomy, the lack of trained preparators) can hinder or delay this monitoring of the ageing process – which may lead to major losses of material in collections.

QUALITIGHT, a highly tight, reclosable specimen jar, was specially developed for the storage of wet specimens. It consists of a closure of stainless steel and elastomer which, in combination with a glass vessel tailored to it, forms an overall system which is tight in the long term and permits substantially more economical maintenance of a collection.

A description of the problems associated with the storage systems to date and detailed technical information on the new glass jar are to be found in Oberer (2001).

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Invasion of the clonal clams: *Corbicula* in the New World

Diarmaid Ó FOIGHIL, Taehwan LEE and Sirirat SIRIPATRAWAN

Museum of Zoology, University of Michigan, Ann Arbor, MI 48109-1079.
diarmaid@umich.edu

The exotic freshwater clam *Corbicula* has established itself throughout much of the Americas. Although relatively well-studied, there has been little consensus on the systematic status of New World populations. We have genetically characterized replicate samples of New World *Corbicula* morphotypes and representatives from the Old World generic range of *Corbicula* for a mitochondrial gene fragment. Three groupings of New World genotypes were encountered and all three produce biflagellate sperm, a convenient marker for clonality in freshwater *Corbicula*. Two of the three occurred in both North and South America samples and were identical to, or were minor variants of, haplotypes encountered in the Japanese triploid androgenetic *C. leana* and a Korean sample of triploid ameiotic *C. fluminea*. The *C. leana* haplotype predominated in both North and South American samples. Although our results are provisional in that they are based solely on mt genotypes, the *C. leana* clonal lineage has apparently undergone an enormous New World range extension over the past 80 years which may be underpinned by a surprisingly narrow genetic base. A third New World *Corbicula* genotype, detected only in South America, was nested within the Australasian clade but was distinct from our limited sampling of Old World *Corbicula* mitochondrial diversity. Our results show that New World *Corbicula* lineages are genetically heterogeneous clones and caution against a blanket application of clonal lineage-specific ecophysiological datasets.

Distribution and diversity of the Achatinidae (Gastropoda) in Nigeria

O. Chris OKE and F. I. ALOHAN

Zoology Dept., University of Benin, Benin City, Edo State, Nigeria.

The distribution of the land snails of the family Achatinidae in Nigeria has been studied. It includes two climatic areas: the savanna in the north and the rainforest in the south. Twelve species in 5 genera were collected. One species, *Limicolaria kambuel*, is restricted to the savanna. Ten species are restricted to the south. One species is common to both climatic areas. The distributions of varieties of the giant African land snail *Archachatina marginata* in the south follow distinct climatic and geographic patterns.

Embryogenesis and development of *Epimenia babai* (Aplacophora)

Akiko OKUSU

Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138,
USA, aokusu@oeb.harvard.edu

The pericalymma larva is a free-swimming lecithotrophic larva with a ciliated test, and neomenioid aplacophorans and protobranch bivalves share the larval form. The larvae of the neomenioid aplacophoran *Epimenia babai* from Amakusa, Japan, has been considered unusual in lacking a cellular test and the developing definitive adult body is entirely exposed. All the definitive adult structures of neomenioid aplacophorans and protobranch bivalves, except for *E. babai*, develop within the overgrowth of the test and are not apparent until later stages or metamorphosis. The ontogeny and fate of the larval test of *E. babai* were ascertained using scanning electron and light micrographs, semi-thin sections, and programmed cell death (PCD) staining. *Epimenia babai* embryos (~250 μ m in diameter) are lecithotrophic and cleavage is spiral, unequal, and holoblastic. Two polar lobes are formed, one each at the first and second cleavage stages. The "molluscan cross" is apparent at the 64-cell stage. Neither the molluscan protonephridium nor any trace of metameric iteration was visible at any stage. The ontogeny of hollow spicules is described: growth begins as a solid tip, continues to an open-ended hollow spicule, and finally to a close-ended hollow spicule. Re-examination of early and late development of *E. babai* larvae reveals that the entire pre-oral sphere of *E. babai* larva is homologous to the pericalymma test of the other neomenioids despite their superficial differences. Homology between protobranch and neomenioid test-cell larvae remains undetermined.

The marine Bivalvia of the Rodrigues Lagoon

Graham OLIVER and Anna HOLMES

Department of Biodiversity & Systematic Biology, National Museum & Gallery
Cardiff, Cathays Park, Cardiff, CF10 3NP, UK, Graham.Oliver@nmgw.ac.uk,
Anna.Holmes@nmgw.ac.uk

Rodrigues lies 650 km east of Mauritius and is surrounded by a coral reef that encircles the island with a lagoon up to 8 km wide at some points. Although this is the largest reef surrounded lagoon in the Indian Ocean, up until now it had surprisingly been ill-researched in terms of its marine fauna.

In 1998 the Shoals of Capricorn Programme (organised by the Royal Geographical Society) began its marine science and education programme and with that came taxonomic interest. A research trip to the island in November 2000 produced an abundance of information on molluscan taxonomy, zonation and commensalism. Specimens were shore-collected (by handpicking and weed and rock washing), snorkel-collected up to 2 m and SCUBA dive-collected for larger depths. Many live collected animals were observed *in situ* before their removal.

An annotated checklist of bivalves is currently being produced which will include descriptions and photos of each species and locality data. The biotopes of the lagoon fall into four major categories: coral reef, consolidated reed limestone, lagoon sand & rubble and lagoon mud. A biotope map will be produced and molluscan species added.

Due to the success of this and previous expeditions, a marine workshop organised by Shoals of Capricorn will be held on Rodrigues in September 2001.

The Thyasiridae of the North Sea

Graham OLIVER and Ian KILLEEN

Department of Biodiversity & Systematic Biology, National Museum & Gallery
Cardiff, Cathays Park, Cardiff, CF10 3NP, UK, Graham.Oliver@nmgw.ac.uk,
Ian@malacserv.demon.co.uk

A critical review of the Thyasiridae of the shelf waters of the North Sea has been completed. A taxonomic guide has been prepared with illustrations of growth series and variations. Eleven species are included, *Thyasira flexuosa*, including *T. flexuosa polygona*, *T. gouldi*, *T. sarsi*, *T. obsoleta*, *T. succisa*, *T. equalis*, *T. granulosa*, *T. eumyaria*, *T. croulinensis*, *T. pygmaea* & *T. ferruginea*. The subgenera *Thyasira*, *Parathyasira*, *Mendicula*, *Axinulus* and *Genaxinus* are discussed. *T. gouldi* is shown to be more widely distributed in Scottish waters than previously expected. Of the eleven species seven are amph-Atlantic. One species, *T. sarsi*, has a distribution pattern highly correlated with oil-wells.

**Molecular vs. ecological variation in the polyphagous coralliophiline
Coralliophila meyendorffii (Muricidae, Coralliophilinae)**

Marco OLIVERIO¹ and Paolo MARIOTTINI²

¹ Dipartimento di Biologia Animale e dell'Uomo, "La Sapienza" Rome University,
Italy, marco.oliverio@uniroma1.it

² Dipartimento di Biologia, "Roma Tre" University, Italy, mariotpa@bio.uniroma3.it

The coral eating neogastropods of the genera *Coralliophila*, *Babelomurex*, *Hirtomurex*, *Latiaxis*, *Quoyula* etc., have been recently demonstrated to be included in a subfamily Coralliophilinae of the Muricidae, based on molecular data and supported by morphological affinities with the Rapaninae *s.l.*

Coralliophila meyendorffii (Calcare, 1845) is a coralliophiline commonly occurring in the Northeastern Atlantic (including the Mediterranean Sea) that feeds upon a wide range of cnidarian prey. At least 10 different cnidarians have been scored as host for *C. meyendorffii*. Two main size classes are encountered that show discrete differences in ecology (cnidarian prey) and reproductive biology (shell length at sex-change). A large sized form (adult females 8 - 40 mm length; sex-change at about 8 - 10 mm) is found associated with sea anemones, feeding by boring into the stalk wall. A small form (adult females 4 - 9 mm length; sex change at 4 - 5 mm), is found on scleractinians (solitary such as *Balanophyllia europaea*, or colonial such as *Cladocora coespitosa*), feeding by sucking out the predigested content from the stomodeum.

We have analysed the sequence variation at the two internal transcribed spacer regions (ITS-1 and ITS-2) of the nuclear rDNA (over 1000 bp) from sympatric individuals of the two forms sampled at several different localities and from different cnidarian hosts. Variation displayed a clearly geographic pattern, with the sympatric specimens plotting together regardless of their size. There was no significant difference in the variation within the two size classes.

This result clearly demonstrated that individuals with the two shell forms are conspecific sharing the same gene pool, with a geographically congruent variation. An intriguing hypothesis to test is that energy input from the cnidarian host can regulate the biological processes that affect size, ecology and biology in the two forms.

**Population genetics and evolutionary processes of the polymorphic
marine gastropods of the genera *Umbonium* and *Suchium*
(Vetigastropoda, Trochidae) in the Indo-Western Pacific**

Tomowo OZAWA

Department of Earth and Planetary Sciences, Graduate School of Environmental
Studies, Nagoya University, Chikusa-ku, Nagoya 464-8602, Japan,
ozawa@eps.nagoya-u.ac.jp

The gastropods of the Trochid genera *Umbonium* and *Suchium* in the Indo-Western Pacific contains a number of species that exhibit conspicuous polymorphism in shell color, banding and pattern (striping). In Japan, five species of *Suchium* form well-defined populations in embayments and open coastal sandy shores discontinuously distributed along the Japanese Islands, each with a characteristic frequency of the polymorphic forms. In these species there are four distinct shell color types; buff, black, ochreous orange and white. The theoretical consideration of the frequency of the colour types in natural populations reveals that these color polymorphism are controlled by a series of alleles (3 alleles system or 4 alleles system), being close similar to the genetical system of ABO blood types in human populations. The buff color phenotype is the wild (normal) type but is genetically the condition of recessive homozygote. It is cryptic to the background of sandy substratum. and is more advantageous than the color mutant morphs in the selection by molluscivorous predators such as the decapod crustaceans and teleosti.

The ratios of color types observed between the parents and the recruit (offspring) show that the heterozygotes are more viable than the corresponding homozygotes. In general the frequency of color mutants (black, orange and white morph) in the natural populations increases towards the north along the Japanese sea coast where cold sea-water prevails in the winter season. The color polymorphism in the species of *Suchium* is considered to be maintained mainly by heterosis and also by selection pressure by visual predators. The color and color patterns of shells are well preserved for a long geologic time. In the Pleistocene populations, all the color and color pattern polymorphism that occur in the modern populations are recognized. Thus the species of *Suchium* provide evolutionary biology of Mollusca with excellent material for following the process of evolution at population genetical level.

Phylogenetic relationships of buccinid gastropods of the genera *Buccinum* and *Neptunea* inferred from mitochondrial DNA sequences

Tomowo OZAWA and Mamoru ENDO

Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, Chikusa-ku, Nagoya 464-8602, Japan, ozawa@eps.nagoya-u.ac.jp

Whelks of the buccinid genera *Buccinum* and *Neptunea* are two of the largest taxonomic groups within the Caenogastropoda and commonly inhabit neritic to abyssal muddy substrates in the Northern Pacific, the Arctic and the Northern Atlantic. Using data from the direct sequencing of entire mitochondrial 16S ribosomal RNA gene and a partial 12S ribosomal RNA gene (total length 1500 bp), we have reconstructed the molecular phylogeny for 44 *Buccinum* species and 11 *Neptunea* species living in Japanese, Arctic and Northern Atlantic waters. Our phylogenetic analysis reveals the monophyly of *Buccinum* and *Neptunea*, with high bootstrap probabilities (100% in all trees). In the phylogenetic trees, the first branch within the monomorphic clade of *Buccinum* is *Buccinum felis*, followed by almost simultaneous divergence of three monomorphic clades; namely, the *Buccinum osagawai* species-group, the *Buccinum inclytum* species-group and the *Buccinum undatum* species-group, respectively. Subsequently, several additional subclades (species-groups of *Buccinum kinukatsugi*, *B. undatum*, *B. middendorfi*, *B. ochotense* and *B. maehirai*) also diverged within the *Buccinum undatum* species-group. Within each species-group, the members share their common morphological characteristics, indicating that the molecular phylogeny is consistent with morphological classification. In the molecular phylogenetic trees of *Neptunea*, both of the subgenera *Neptunea* and *Barbitonia* form distinct monomorphic clades. In addition, the timing of divergence of the clades within *Buccinum* and *Neptunea* could be estimated using molecular clock analysis. The estimated timing of initial divergence of the three species-groups of *Buccinum* and two subgenera of *Neptunea* is nearly identical with the first fossil occurrence of the ancestral species of each of the species-group in the Lower Oligocene in the Northwestern Pacific region comprising Northeastern Japan and Sakhalin. The lineages of the Atlantic *Buccinum* and *Neptunea* diverged in the Oligocene when a cold marine climate prevailed in the Northern Pacific, but their migration to the Atlantic did not take place until the Bering Strait opened in the latest Miocene to earliest Pliocene.

Consequences of form and function of radular teeth of herbivorous gastropods

Dianna K. PADILLA

Department of Ecology and Evolution, State University of New York, Stony Brook, NY 11794-5245, USA, padilla@life.bio.sunysb.edu

For most herbivorous gastropods, the radula is the main structure used for feeding. Historically the radula has been used primarily as a means of species identification. Most attention to the morphology of the radula and radular teeth has been from a systematic or taxonomic perspective. However, many species do not have a fixed tooth morphology throughout their life, and may have phenotypically plastic tooth morphology. The effectiveness of the radula as a tool for feeding will depend on the sizes, shapes and material properties of teeth, how they are used, how they interact with each other, and the properties of the food material consumed. Although many of these factors were pointed out by Hickman in 1980, very little research has been done to understand not only how radular teeth function and how their form influences this function, but also how function has influenced the evolution of tooth form. In particular, the shapes and positions of teeth, how they interact with each other, and how they interact with different types of potential food sources can have a large impact on feeding efficiency, and may provide important cues about the potential adaptive value of tooth morphologies and the evolution of phenotypically plastic morphologies.

Developmental novelty facilitating foregut evolution in predatory Caenogastropods

Louise R. PAGE

Department of Biology, University of Victoria, Victoria, British Columbia, Canada
V8W 3N5, lpage@uvvm.uvic.ca

Evolution of complex structures has been an enduring enigma because hypotheses about functional intermediates can be difficult to reconstruct and difficult to test. Adult specialization among organisms that evolved within the context of a complex life cycle adds a second layer to the conceptual difficulty because interdependence of larval and post-metamorphic systems might be expected to constrain specialization in the two life history stages. Evolution of predatory feeding systems in caenogastropods is a potentially useful system for studying the constraints and opportunities that have interacted within developmental programs during the emergence of specialized adult anatomical systems. Caenogastropods display a wide spread in degree of feeding specialization. Therefore, some members of the extant fauna may preserve developmental programs that generated highly derived morphologies in other lineages. Comparative developmental studies mapped on a phylogenetic hypothesis hold the potential for reconstructing the key developmental novelties that have facilitated the explosive diversification of predatory gastropods from herbivorous ancestors. Initial results show that the specialized foregut of at least some predatory gastropods is constructed in partial or complete isolation from the larval foregut. The adult system is functionally incompatible with the feeding process of the planktotrophic larval stage. At metamorphosis, the larval system is destroyed and the adult system either creates a new mouth opening to the exterior or becomes connected to the pre-existing larval mouth. This developmental novelty may have facilitated the evolutionary emergence of an elongate proboscis among at least some groups of predatory caenogastropods. However, I propose that the performance advantage that originally selected this novel developmental pattern relates to providing youngest juvenile stages with serrated jaws. Further developmental studies and a resolved phylogeny for caenogastropods will test these hypotheses.

A comparative ultrastructural study on oogenesis and vitellogenesis in two sympatric species of siphonariid limpets (Gastropoda: Mollusca)

Purba PAL and Alan N. HODGSON

Department of Zoology and Entomology, Rhodes University, Grahamstown, 6140,
South Africa, g99p0003@campus.ru.ac.za

A comparative ultrastructural study on oogenesis and mechanisms of vitellogenesis has been done on two sympatric species of *Siphonaria*, a marine intertidal pulmonate limpet. In both *S. serrata* and *S. capensis* the ovotestis is composed of numerous sac like acini with no separate compartments for male and female gametes although Sertoli cells separate developing oocytes from spermatids. Oogenesis is intraovarian and follicular, where a few follicle cells surround early oocytes. Pre-vitellogenic oocytes have large nucleus with often more than one nucleolus and a cytoplasm with few organelles. Early vitellogenic oocytes show a marked increase in rough endoplasmic reticulum and the number of mitochondria and Golgi bodies, which produce a large number of small vesicles, which fuse to form nascent yolk granules. During the later period of vitellogenesis the follicle cells move away from the oocytes. The follicle cells have single large nucleus and their cytoplasm is full of extensive arrays of rough endoplasmic reticulum, as well as a few lysosomes. The abundance of proteosynthetic organelles suggests that they may play a role in providing nutrition to the developing egg during vitellogenesis. In *S. capensis* yolk is formed autotynthetically and only one type of membrane bound yolk granule is found. This consists of two distinct zones, an electron-dense non-crystalline core whereas the outer zone is more electron-lucent. Both the rough endoplasmic reticulum and Golgi complex are involved in yolk synthesis. By contrast, *S. serrata* forms two types of yolk granule by auto and heterosynthesis. Type I yolk granules, which have an electron-dense crystalline core, are formed autotynthetically by the RER and Golgi complex whereas Type II yolk granules are formed heterosynthetically during later stages of vitellogenesis by incorporation of extra-oocytic material. Type II yolk bodies are more granular in appearance although they have a small electron-dense area. The presence of coated pits along the oolemma of *S. serrata* indicates endocytotic uptake of yolk precursors. In both species lipid droplets and glycogen granules are also deposited in the mid- to late oocytes. It is suggested that mixed synthesis of yolk may be necessary in *S. serrata* to produce its larger eggs, which develop directly into juvenile adults.

Morphogeography of an endemic tree snail genus *Amphidromus* of Thailand (Pulmonata, Camaenidae)

Somsak PANHA^{1,2}, Chirasak SUTCHARIT¹, Piyoros TONGKERD¹ and John B. BURCH^{2,3}

¹ Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand, somsakp@sc.chula.ac.th

² Museum of Zoology and Department of Biology, ³ School of Natural Resources and Environment, University of Michigan, Ann Arbor, Michigan 48109, U.S.A., jbburch@umich.edu

The unique, attractive and colorful tree snail genus *Amphidromus* Alber, 1850 is an endemic taxon of southeast Asian forests. The geographic distribution is from Assam, north of India, throughout Southeast Asia and the Northern Territory of Australia. We have analyzed cladistic morphology by using Hennig86 with unweighted, non-additive characters, mostly for species in Thailand. Sixteen characters have been employed and *Chloritis siamensis* was selected as an outgroup. The cladogram indicated subgenus discrimination; however, it is still complicated at the specific level. *Amphidromus atricallosus* underwent a morphological transformation or morphocline in color pattern, chirality and radular characteristics along the Thai-Burmese border to the Malay Peninsula. The length of the flagellum, shape of the vagina and penial complex seem to be significant characters for classification at both subgeneric and specific levels. *Amphidromus* (*Amphidromus*) and *Amphidromus* (*Syndromus*) shared their niches in mainland southeast Asia and larger islands such as Sumatra, Java and Borneo, while smaller or very small islands such as Timor, Aru, Alor, Tachai and Kra are occupied only by *Amphidromus* (*Syndromus*). The Philippine group has specific characters which differ from the others. Wallace's Line and Huxley's modifications of Wallace's Line are distinct barriers for the three amphidromids.

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Homology in sculptured shell morphology: An example from a clade of the *Lavigeria* (Thiaridae) species flock of Lake Tanganyika

Leonard N. PAPADOPOULOS¹, Ellinor MICHEL¹ and Jonathan A. TODD²

¹ Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, P.O. Box 90766, 1090 GT Amsterdam, The Netherlands, leonard_papadopoulos@hotmail.com, michel@science.uva.nl

² Department of Palaeontology, The Natural History Museum, London, SW7 5BD, UK., J.Todd@nhm.ac.uk

Although their phylogenetic signal and homoplasy is a subject of dispute (*e.g.* Wagner 1999), shell characters still largely form the basis of gastropod systematics and phylogenetics. All of the approximately thirty species of the *Lavigeria* species flock develop characteristic axial and spiral micro- and macrosulpture with species-specific variations, making this a model group for studying the significance of shell morphology in alpha-level taxonomy and the reconstruction of early stages of cladogenetic events.

We present a shell-based phylogeny of one of the three supraspecific clades recognized within the genus, using characters of microsculpture, macrosulpture, whorl shape, color patterns and adult modifications (see Papadopoulos & Todd, this volume). Although we find important systematic characters in many aspects of shell morphology (*e.g.* color, ribs), spiral cords can be homologized individually, show abrupt changes in their evolution and in other groups have been connected to heterochronic patterns (*e.g.* Allmon 1994). We show how alternative schemes for homologizing these sculptural elements require different kinds and numbers of assumptions to describe the evolution of sculptural characters. Specifically, we contrast a homologizing method that takes into account solely the positioning of spiral cords within the whorl from the top to bottom sutures against a method that combines this positional criterion with ontogeny and whorl morphology (a more stringent hypothesis of similarity). The two methods are compared based on topology, resolution and support measures of the trees constructed. We show that during the evolution of the clade morphological change includes changes in the relative timing of appearance, the relative strength, and in some cases, the number of sculptural elements (*i.e.* number of spiral cords).

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How to recognise adulthood and homology: Defining cladistic characters in a clade of the *Lavigeria* (Thiaridae) species flock of Lake Tanganyika

Leonard N. PAPAPOULOS¹ and Jonathan A. TODD²

¹ Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, P.O. Box 90766, 1090 GT Amsterdam, The Netherlands, leonard_papadopoulos@hotmail.com

² Department of Palaeontology, The Natural History Museum, London, SW7 5BD. UK, J.Todd@nhm.ac.uk

In gastropods with determinate growth, size-increase ceases at, or a specific period after, reproductive maturation. The slowing down and cessation of growth is connected with the appearance of adult modifications, *i.e.* alterations in the shell morphology of the adults as compared to the juveniles. Such alterations may be drastic and largely provide the shell with its "characteristic" form in some well-known taxa (*e.g.*, stromboids, cypraeids). Despite numerous reports of determinate growth expressed through adult modifications in gastropods, there has been only limited discussion of its occurrence across high taxonomic levels and surprisingly little consideration of its homology and variation in occurrence at the species level (Vermeij & Signor 1992).

We define eight characters as adult modifications in a supraspecific clade of the *Lavigeria* species flock from Lake Tanganyika. Two are characters of shell sculpture, five of the aperture and one of the suture. We scored the presence/absence of these characters in samples of the species studied and at the same time collected multivariate size measurements as well as protoconch and teleoconch whorl numbers. Frequency of character occurrence varies greatly among species with some adult modifications always occurring in some species and not at all in others. Sculpture and suture modifications occur in more comparable frequencies across species. We tested for correlations between the occurrence of each character and size and found that an overall pattern is not present. The same character might appear highly correlated with size in one species and poorly correlated in another.

Our results show that different adult modifications may appear quite independently from each other. Their independence and their variation in frequency of occurrence among species suggests their utility as cladistic characters. We discuss ways of coding the presence of these adult modifications and their potential phylogenetic signal.

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Molecular phylogeny of the genus *Mastus* (Gastropoda, Pulmonata, Buliminidae)

Aristeidis PARMAKELIS and Moysis MYLONAS

Natural History Museum of Crete, University of Crete, P.O. Box 2208, 71409, Irakleio Crete, Greece, parmakel@nhmc.uoc.gr, director@nhmc.uoc.gr

The land snail genus *Mastus* with a circum Mediterranean distribution comprises 33 nominal species. An extreme degree of morphological differentiation both in the shell and the morphology of the genitalia is evident in the taxa of the Aegean area, where 24 species have been reported by various authors. Sixteen of these occur only on Crete and its surrounding islets, one is endemic to mainland Greece and four of them are endemic to islands of the Cyclades region.

In an effort to expand our understanding of evolutionary relationships of the Aegean *Mastus* taxa, we examined a large portion of the large rRNA subunit gene from 20 Aegean populations. Another population from Italy was also included in the study representing the most widespread species. In order to avoid misidentifications of dubious taxa most of the individuals (populations from Greece) sequenced were collected from the type locality of their species. A molecular phylogeny was constructed after utilising a variety of algorithms and the revealed phylogenetic relationships were compared to the current taxonomy of the genus. This study also serves as an important foundation for future studies and the conservation of endemic *Mastus* taxa under threat.

**Spawn of the patagonian gastropod *Pareuthria plumbea* (Philippi, 1844)
(Mollusca: Buccinidae)**

Guido PASTORINO¹ and Pablo E. PENCHASZADEH²

^{1,2} CONICET-² FCEyN-UBA. ^{1,2} Museo Argentino de Ciencias Naturales, Av. A.,
Gallardo 470 3° piso lab 57, C1405 DJR Buenos Aires, Argentina,
rvpastor@criba.edu.ar

Pareuthria plumbea (Philippi, 1844) is the oldest name of a very polymorphic species endemic to the Magellanic malacological province. It ranges from southern Chubut province (~45°S), Argentina in the Atlantic to 49°S in the Chilean Pacific. It is usually found intertidally during low tide under rocks and tide pools. As most buccinids this is an active scavenger species.

The spawn of *P. plumbea* is composed of 4-19 egg capsules. Each egg-capsule is transparent, yellowish subcircular and bulliform; they are placed aggregated, partially overlapping each other, attached to the substrate by a circular basal membrane, measuring 4.2-5.2 mm (X=4.96, SD=0.22, n=10). Each capsule has its own basal membrane which do not merge with the others. The capsules measure 3.2-3.8 mm in diameter (X=3.6, SD=0.18, n=10). There is a suture line that splits the capsule in two halves. There is no pre-formed apical plate or escape aperture as a plug, nor an escape slit.

The uncleaved eggs, numbering 1 to 4 per capsule, measured about 300 microns. *Pareuthria plumbea* has direct development without nurse eggs, hatching at a crawling stage. Extra-vitelline substances in the intracapsular liquid are the most important food available for the embryos. Hatching occurs generally by rupture or dissolution of the capsule wall in an indeterminate place of the thin basal membrane. The number of hatchlings varied between 1 to 4 within the same spawn. Hatchling number and shell size are correlated. The maximum length decreases when the number of embryos grows.

**Water molluscs in two different types of lakes in the alpine foreland of
Salzburg, Austria**

Robert A. PATZNER and Daniela ZICK

Institute of Zoology, University of Salzburg, Hellbrunnerstr. 34, A-5020 Salzburg,
Austria, robert.patzner@sbg.ac.at

Lake Fuschlsee is situated in an altitude of 663 m. It covers 2.66 km² and has a maximum depth of 67.3 m (medium depth: 37.4 m). It is an oligotrophic lake with clear water (max. visibility 13 m) and relatively low summer temperatures. Sediment are stones, gravel and mud. As macrophytes one can find large areas of *Chara* and few *Potamogeton* and *Myriophyllum*. Lake Mattsee is situated in an altitude of 503 m. It covers 3.6 km² and has a maximum depth of 42 m (medium depth: 17.1 m). It is a mesotrophic lake with relatively turbid water (max. visibility 6 m) and high summer temperatures. Sediment is mud, and underwater plants are mostly *Potamogeton* and *Myriophyllum* in large quantities.

In lake Fuschlsee, 34 species of freshwater molluscs were found (two of them already extinct): Hydrobiidae: 1, Bithyniidae: 1, Valvatidae: 2 + (1); Lymnaeidae: 6, Planorbidae: 5, Ancyliidae: 1; Unionidae: 1+(1), Sphaeriidae: 14, Dreissenidae: 1. In lake Mattsee, 39 species: Viviparidae: 1, Hydrobiidae: 2, Bithyniidae: 1, Valvatidae: 2; Acroloxidae: 1, Lymnaeidae: 9, Planorbidae: 12, Physidae: 1; Unionidae: 3, Sphaeriidae: 6, Dreissenidae: 1. Remarkable differences between the two lakes in species composition are the families Planorbidae and Sphaeriidae. Highly significant are the differences in the abundances. In lake Mattsee nearly all species are found in higher abundances than in lake Fuschlsee, some of them are very abundant. Beside *Dreissena polymorpha* all species in lake Fuschlsee are found in low abundances. Notable is a decline of all unionid species in both lakes during the last decades.

Distribution of land gastropods on the Delmarva Peninsula, eastern USA: Conservation implications

Timothy A. PEARCE

Delaware Museum of Natural History, Box 3937, Wilmington, Delaware, 19807-
0937, USA, tpearce@delmnh.org

The observation that species are not evenly distributed on a geographic scale suggests that certain habitats might be more suitable to certain species. Correlations of habitats with land gastropod distribution records on the Delmarva Peninsula, eastern USA, suggest which species may be habitat generalists and which may be habitat specialists. One goal of conservation biology is preserving habitats that contain rare species. If all rare species co-occurred, species conservation efforts would be simplified because preserving the habitat of one species would preserve that of many species. I will discuss whether rare gastropods on the Delmarva Peninsula are habitat specific, and whether they tend to specialize in the same specific habitats. Another issue in conservation biology is the potentially negative effect of habitat fragmentation. To address the importance of habitat fragmentation to land gastropods, I will discuss the relationship between forest patch size on the Delmarva Peninsula and land gastropod diversity.

Age and growth of Noah's Ark shell, *Arca noae* L., in the Croatian Adriatic Sea

Melita PEHARDA¹, Christopher RICHARDSON², Vladimir ONOFRI¹, Ana
BRATOS³ and Marija CRNCEVIC³

¹ Institute of Oceanography and Fisheries, Kneza Damjana Jude 12, 20000
Dubrovnik, Croatia, melita@labdu.izor.hr, onofri@labdu.izor.hr

² School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Anglesey
LL59 5EY, UK, c.a.richardson@bangor.ac.uk

³ Collegium Ragusinum, Cira Carica 4, 20000 Dubrovnik, Croatia, abratos@vdu.hr,
marijacrn@hotmail.com

The Noah's Ark shell (*Arca noae*) is widely distributed in the coastal waters of the eastern Adriatic and is one of four commercially exploited bivalves in the region. Little is known about its population structure and there are no data on its growth and longevity. The age of *A. noae* collected at three sites in the Croatian Adriatic was estimated using 1) external surface growth rings, 2) scars on the internal shell surface, and 3) growth lines in acetate peel replicas of the umbo region and prismatic shell layer. All methods gave similar estimates of the age of *A. noae*, although the age determined from the prismatic growth lines was less variable, using this more expensive and time-consuming method, than estimates determined by the other methods. In future population studies a combination of internal shell surface growth lines and external growth rings is desirable for estimating the age of *A. noae*. *Arca noae* is a slow-growing species which reaches a length of 70 mm and can attain an age of up to 16 years in the Adriatic and is vulnerable to over-exploitation.

Imposex in coastal marine gastropods from Argentina (South-Western Atlantic)

Pablo E. PENCHASZADEH, Andrés AVERBUJ, Maximiliano CLEDÓN and Victoria ZAVATTIERI

Departamento de Biología, Facultad de Ciencias Exactas y Naturales de la Universidad de Buenos Aires, Ciudad Universitaria, Pabellón II. C.P. 1428, Capital Federal, Argentina, penchas@bg.fcen.uba.ar, mcledon@bg.fcen.uba.ar, andresbuj@bg.fcen.uba.ar

Imposex is a widespread phenomenon in marine molluscs, having been documented in more than 118 gastropod species. Its occurrence is explained as a result of an anti-fouling paint compound called TBT (tributyltin), whose presence is related to high marine traffic. The grade of TBT presence in the water or sediment causes a directly related response on non-target gastropods, consisting in the masculinization of females of dioecious molluscan species. This mutation can be observed by the appearance of a vas deferens and a penis in females. Concentrations lower than 0.5 ng/l can induce imposex in meso- and neogastropods.

The phenomenon of imposex was demonstrated for three endemic species of the south-western Atlantic coast, two in the vicinity of Mar del Plata harbour and one in Puerto Madryn harbour in Patagonia, Argentina.

Two shallow water (5 to 15 m depth) species, *Buccinanops monilifer* and *Adelomelon brasiliense* were studied in two localities in Mar del Plata and a control area in Mar Chiquita restricted reserve. Imposex in this second locality was null. In Mar del Plata, *B. monilifer* reaches an imposex percentage of 85.7 and *A. brasiliense* 50. *Buccinanops globulosus*, also a Patagonian shallow-water species, was studied in the locality of Puerto Madryn, where 100% of imposex was recorded. All observations for this work were controlled by means of histological studies.

An analysis of genetic and morphometric variation in the landsnail *Euglandina* (Gastropoda: Pulmonata) from Texas and northern Mexico

Kathryn E. PEREZ

Department of Biology, Angelo State University, San Angelo, Texas 76909,
Kathryn_Perez@excite.com

This study examined genetic and morphological variation and systematic relationships of naturally occurring populations of the land snail *Euglandina* in Texas and northern Mexico. Genetic variation was determined between specimens of *Euglandina singleyana* and *E. texasiana* using cellulose acetate electrophoresis and a segment of the 16S rRNA mtDNA coding region. The results of all three analyses support the validity of traditional classification separating *E. texasiana* and *E. singleyana*. Also significant is the conclusion based on allozyme and sequence data that there is continuous gene flow in *E. singleyana* throughout the extremes of its range. The morphometric analysis indicates that there is a significant change in size and shape of *E. singleyana* that is correlated with geographic location (east to west). The morphometric evidence also shows that *E. immemorata* is distinct from all examined Texas *Euglandina* species. This study seeks to establish a framework for future systematic work with this problematic genus.

Chemosymbiosis, fossil lucinid bioturbations and the *Chondrites* enigma

Peter PERVESLER¹, Martin ZUSCHIN¹, Oleg MANDIC¹ and Mathias HARZHAUSER²

¹ Institute of Palaeontology, University of Vienna, Althanstrasse 14, 1090 Wien, Austria, peter.pervesler@univie.ac.at, martin.zuschin@univie.ac.at, oleg.mandic@univie.ac.at,

² Museum of Natural History, Burgring 7, BOX 417, A-1014 Wien, Austria, mathias.harzhauser@nhm-wien.ac.at

The trace fossil *Chondrites*, although widespread in different trace fossil assemblages, is used as an indicator of low-oxygen (dysaerobic) conditions if occurring as single feature. Sediment-ingesting polychaetes, sipunculids, or even detritus-feeding arthropods had been regarded as potential constructors of *Chondrites*-like structures, yet solid proof is missing. Here, we present the unique *in situ* preservation of the burrowing bivalve *Thyasira michelottii* (R. Hörnes, 1875) together with its *Chondrites*-like bioturbations and provide evidence for chemosymbiotic life strategies under dysaerobic conditions.

Thyasira michelottii from shallow marine sediments in a channel facies of the Austrian Miocene (Grund Formation, Badenian) produced not only the inhalent tube but also a system of ramifications below their life position. The circular to blade-shaped and weakly to densely branching shafts have diameters up to 3 mm and reach down to 10 cm into the sediment below the ventral shell margin. The *Chondrites*-like postero-ventral tunnel branchings reflect the search of the burrowing, worm-shaped foot for short-lived pockets of sulfidic material in an otherwise low-sulfide environment.

Chemosymbiotic strategies are responsible for the morphological similarity between recent *Thyasira* burrows and *Chondrites* trace fossils. In chemoautotrophic symbioses, bacteria provide the host with some form of chemosynthetically fixed carbon obtained through the oxidation of reduced sulfur; the bacteria benefit from a protected environment. Among the Lucinoidea, special anatomical and morphological features like thick gills, reduced palps, short simple gut, and an elongated burrowing foot are interpreted as an adaptation to oxygen- and nutrient-poor habitats. The *Chondrites*-like branching burrow systems are formed when the clams use their extendable feet to obtain hydrogen sulfide from interstitial water in the underlying sediments.

The bivalves from the Belpbergschichten near Bern, Switzerland (middle Burdigalian, Upper Marine Molasse)

Thérèse PFISTER¹ and Urs WEGMÜLLER²

¹ Naturhistorisches Museum Bern, Bernastr. 5, CH-3005 Bern, Switzerland.

² Im Gerbelacker 12, CH-3063 Ittigen, Switzerland.

Our project is to study the whole marine macrofauna of the Belpbergschichten. The Natural History Museum of Bern made 2 excavations in 1982 and 1983. The fauna consists mostly of mollusks, followed by shark teeth, trace fossils and other fossil groups. The taxonomy of the bivalves is completed and that of the gastropods in progress. Paleoecological, taphonomical, stratigraphical and other investigations will follow, perhaps in collaboration with other colleagues.

Ninety species of Bivalvia were revised, described and figured in five publications between 1994 and 2001.

13 species and 1 variation were new, e.g. *Megacardita guenterti*, *Acanthocardia steiningeri*, *Maetra ruescheggensis*, *Spisula hohburgensis*, *S. belpbergensis*, *Pitar haasi*, *P. kehrensis*, *P. moesigrabensis*, *Lutraria acutifrons*, *Ensis bernensis*, *Solecortus brevis*, *Pharus jansseni* and other species. The most common species are *Paphia deshayesi*, then *Pitar islandicoides* and in certain layers *Lutraria sanna*, followed by *Acanthocardia steiningeri*, *Spisula hohburgensis*, *Gastrana fragilis*, *Pandora granum* and other species. *Crassostrea gryphoides* and *Ostrea granensis* form local oyster banks.

The fauna of the bivalves reflects the position of the Belpbergschichten at the transition of the Western to the Central Paratethys: Following our own list of synonyms 39 species are common with Austria, 44 with France (mostly Loire basin and Aquitaine), 36 with Italy (Northern and Central Italy), 17 with Germany (Oberbayern). 3 are common with Austria only, 8 with France only and 2 with Italy only. 29 occur in France, Switzerland and Austria (37%). 18 species and 1 variety are found only in Switzerland (24%).

Occurrence in time corresponding to our list of synonyms: 5 species began in the Oligocene, 51 are restricted to the Miocene, 25 existed also in the Pliocene/Pleistocene and 15 are still living today.

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Distribution and population dynamics of *Bulinus globosus* and *B. nyassanus* in Lake Malawi at the Nankumba Peninsula, Mangochi district, Malawi

Happy PHIRI¹, Paul BLOCH², Henry MADSEN³, Peter FURU³ and Cornell DUDLEY¹

¹ University of Malawi, Chancellor College, Zomba, Malawi.

² GoM/Danida/DBL Bilharzia Control Project, Mangochi, Malawi.

³ Danish Bilharziasis Laboratory, Charlottenlund, Denmark.

Schistosomiasis is an important public health problem for communities on the Nankumba Peninsula. Little information is available on the transmission of schistosomiasis in and around Lake Malawi such as the geographical distribution, density and infection rates of the intermediate hosts. *Bulinus globosus* is a known intermediate host for *Schistosoma haematobium* in Malawi, but recently it was shown that the endemic species *Bulinus nyassanus* also acts as intermediate host for *S. haematobium*. However, the relationship between these two species in terms of habitat preferences, coexistence and contribution to transmission remains to be investigated. The studies reported were carried out as part of the GoM/Danida/DBL Bilharzia Control Project (BCP). Longitudinal quantitative and semi-quantitative sampling of freshwater snails were carried out in three villages, namely Malembo on the western side, Nkope on the eastern side and Chembe on the tip (called Cape Maclear) of Nankumba Peninsula.

Bulinus globosus was only found in protected backwaters and at stream inlets at Malembo and Nkope, while *B. nyassanus* was found in the lake along exposed shorelines with a substrate of sand/gravel at all three villages. However, *B. nyassanus* was much more common at Chembe village than at the other two. Both species are important for transmission of *Schistosoma haematobium* in their respective habitats. Density of *B. globosus* is low from December to March and increases from April to reach a peak during September/October. Infected *B. globosus* were found from April to November. Overall, the density of *B. nyassanus* is low from January to April when it starts to increase to peak density during August to November. However, this pattern varies somewhat with depth. Infected *B. nyassanus* were found from June to October. The implications of these findings for control of schistosomiasis are discussed.

The response of *Lavigeria nassa* shell armoring characters to crab attack

Megan PHIFER¹, Peter B. MCINTYRE² and Ellinor MICHEL³

¹ Dept. of Biology, Duke University, Durham, NC 27708, USA,
megphif@hotmail.com

² Dept. of Ecology and Evolutionary Biology, Corson Hall, Cornell University,
Ithaca, NY 14853-2701 USA, pbm3@cornell.edu

³ Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, PO.
Box 90766, 1090-GT Amsterdam, The Netherlands, michel@science.uva.nl

The morphological similarity between marine gastropods and the gastropods of Lake Tanganyika has recently been attributed in part to a coevolutionary relationship with the lake's crabs (West *et al.* 1991, West & Cohen 1996). Laboratory experiments have shown that snails in species characterized by heavy "armor" - thicker lips, larger size, and heavy sculpturing - are more likely to avoid and/or survive attack by a crab than individuals of less well armored species. However, it has not yet been shown in field studies whether more "armored" individuals within a species are more likely to survive a crab attack than less armored individuals. Additionally, recent work has shown that, in some snail species, more predator resistant phenotypes can be induced by chemical cues from predators. This phenomenon has not been explored in Lake Tanganyika gastropods. We hypothesized that individuals having thicker, heavier, and more sculptured shells or smaller apertures would be more likely to survive an attack by a crab and that changes in morphological phenotype could not be induced. Shell morphology and mass were measured in a population of *Lavigeria nassa* (Woodward) near Kigoma, Tanzania. Logistic regression was used to determine whether morphological characters were useful as predictors of whether a snail had been attacked by a crab. We used a Student's t-test to determine the direction of the association between a character and predation. A general linear model was employed to determine whether the measured morphological characters were induced or fixed. Though most morphological characters designated as likely to affect survival of predation were significant predictors of predation survival, the direction of the association was not always in the direction expected. Additionally, results suggest that the shell characters assumed to be affected by predation are fixed, and not inducible, in this species.

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Gastropods of some affluents of the upper Lualaba and Luapula Rivers in Congo

Andrzej PIECHOCKI

Department of Invertebrate Zoology and Hydrobiology, University of Łódź, Banacha Street 12/16, 90-237 Łódź, Poland, piech@biol.uni.lodz.pl

The study reports the freshwater gastropod fauna of the upper Congo River Basin, based on materials collected in 1988 from 13 streams and rivers. The following affluents of the Luapula River and Lualaba River were investigated: Lubumbashi, Kafubu, Kifumanzi, Luiswishi, Kiseru, Luamisamba, Mwati; Kafila, Mwena, Lukafu, Lufira, Luafi and Kalule Nord.

A total of 14 species are reported and the commonest were: *Melanoides anomala* (Dautzenberg & Germain), *Lymnaea natalensis* Krauss, *Bulinus truncatus* (Audouin) and *Biomphalaria pfeifferi* (Krauss). The most interesting and rare species were *Lobogenes spiralis* Pilsbry & Bequaert (Hydrobiidae) and *Burnupia alta* Pilsbry & Bequaert (Ancyliidae).

It should be stressed that the gastropod fauna of the affluents of the Luapula and Lualaba rivers is comparatively poor. That poverty is probably effected by growing contamination of a natural river ecosystem. High water pollution and eutrophication were observed, especially in the rivers of the Lubumbashi Agglomeration and in river sections situated below the bigger villages.

Preliminary SSCP data confirm the existence of two evolutionary lineages in *Arion subfuscus* (Pulmonata, Arionidae)

Jan PINCEEL¹, Natalie VAN HOUTTE¹, Kurt JORDAENS¹ and Thierry BACKELJAU^{1,2}

¹ Department of Biology, University of Antwerp (RUCA), Groenenborgerlaan 171, B-2020 Antwerp, Belgium, jpinceel@ruca.ua.ac.be

² Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

Arion subfuscus (Draparnaud) is a highly polymorphic terrestrial slug with a wide distribution in Europe and North America. Therefore the species is often considered as a complex of different taxa. Allozyme data have provided strong support for this hypothesis, yet need independent confirmation before reliable and consistent taxonomic decisions can be implemented. In this context we screened DNA sequence variation in *A. subfuscus* via PCR-SSCP analysis. To this end we developed specific SSCP primers, two sets of which amplify two fragments of the nuclear ribosomal Internal Transcribed Spacer 1 (ITS1), while two other sets amplify respectively a fragment of the mitochondrial 16S rRNA (16S) and a fragment of the mitochondrial cytochrome c oxidase subunit 1 (COI). Approximately 300 individuals of 12 *A. subfuscus* populations were analyzed in this way. This revealed low variation within, but high variation among populations. Two major evolutionary lineages were distinguished consistently by three markers (COI, 16S, 2nd ITS1 fragment). The first ITS1 fragment also discriminated between the two lineages, but did not assign all of the populations correctly. These results are congruent with allozyme data and support the idea that *A. subfuscus* is a complex of at least two different taxa.

Abundance of *Theodoxus prevostianus* (Gastropoda, Neritidae) in the drainage of a thermal spring near Vienna (Austria)

Barbara PIRINGER

Institute of Zoology, University of Vienna, Althanstraße 14, A-1090 Vienna, Austria.

Although *Theodoxus prevostianus* has long been known to science, there is hardly any biological information available. It is considered as a thermophilic relict species and is exclusively known from thermal springs and waters in Austria, Hungary and the Balkan Peninsula.

From 1987 to 1988 monthly samples were taken at the thermal waters of Bad Vöslau (Lower Austria). Samples of the substrate were sieved in the laboratory; all individuals found were counted. Water temperature, surface water current, water level, and quality of the substrate were recorded.

The mean values of the temperature, the surface current, the water level and the abundance are described; the characteristics of the sediment from several stations are compared. Water temperature continuously declines downstream (one exception), but never falls below air temperature. Also, the fraction of coarse gravel decreases downstream. Surface velocity is negatively correlated to the water level. The abundance of *Th. prevostianus* increases from the upper to the middle section to maximum values of 6800 ind. / m²; n=30) and drops subsequently.

The abundance values are approximately corresponding with the course of the afternoon's temperature, since the middle section of the brook is heated from solar radiation during the day. The individuals cannot be found in waters, which are not influenced by the thermal spring. This fact indicates, that the dispersion is strongly influenced by temperature and, perhaps, water chemistry. *Theodoxus prevostianus* is generally considered rheophil, preferring hard substrate. The decrease in current velocity and in the quantity of coarse gravel may also be a reason for the drop in abundance in the lower sections, but can hardly explain the low abundance at the beginning of the brook. Instead, the high density (up to 3660 ind. / m²; n=30) of another gastropod, *Fagotia acicularis audebartii* (Melanopsidae), in the upper section accounts for the low abundance of *Th. prevostianus* there.

***Pupilla muscorum* L. - a case against ovoviviparity**

Beata M. POKRYSZKO

Museum of Natural History, Wrocław University, Sienkiewicza 21, 50-335 Wrocław, Poland, bepok@culex.biol.uni.wroc.pl

One of the disadvantages of ovoviviparity, accounting for its relative rarity among land pulmonates, is the limited number of embryos that can be incubated at a time, resulting in a lower fertility compared to oviparous snails of corresponding size. Besides the mere size of the adult snail, combined with the minimum incubation time, another limiting factor may be a reduced fitness of individuals incubating numerous embryos. This hypothesis has been approached from a purely mechanistic viewpoint. One hundred adult *Pupilla muscorum* L., collected during a period of maximum variation of the number of embryos per adult, were dried to cause maximum retraction into the shell, alcohol-preserved and examined for the degree of retraction and the number of incubated embryos. There was a strong negative correlation between the number of incubated embryos and the degree of retraction. One of the roles of a land snail's shell is protection against a variety of physical and ecological adversities. The surface area of the snail's body available for evaporation depends directly on the size of the whorl cross-section at the level to which the snail has retracted; a more deeply retracted snail is better protected by a longer "humid chamber" provided by the vacated whorls. Retraction also provides protection against small invertebrate predators. The incubated embryos constitute a mechanical obstacle precluding deep retraction and thus their maximum number should be lower than that expected on the basis of the snail's size.

The research vs conservation dilemma - how much data do we need for adequate management?

Winston F. PONDER

Australian Museum, 6 College Street, Sydney, NSW 2010, Australia,
Winstonp@austmus.gov.au

When do we have enough data to have a useful input into conservation planning? In the absence of the detailed information required for species (or taxon)-based conservation, is a habitat-based approach involving conservation of a set of representative habitats - and, de facto, the suites of species they contain, a viable alternative for mollusc conservation? Because the threatened species approach to conservation requires detailed knowledge about individual taxa (distribution, declines, threatening processes, biological attributes, etc.) it is addressing only the tip of the biodiversity iceberg. The first step in knowledge acquisition required for the taxon-based approach is the discovery and documentation of at least the major components of the fauna. In Australia, a country generally accredited with having a reasonable knowledge of its fauna and flora, well over half of the non-marine molluscs have been discovered in the last 20 years and at least half of the species are yet to be named. Habitat-based conservation enables action in the absence of comprehensive data. It seeks to prevent degradation and biodiversity loss in contrast to the reactive expenditure of resources on a relatively small number of (usually large, charismatic) species that have already suffered possibly irreversible declines. Weaknesses of the habitat-based approach include: difficulties in definition and delineation; site-based - so many narrow-range taxa potentially excluded; doubtful assumption that "habitat" is a meaningful surrogate for a particular suite of molluscs (and other invertebrates); and, if threatening processes continue to operate, site-based protection is insufficient. We used a modified approach in which suites of invertebrate taxa were used to define areas for conservation selected and these were prioritised on the basis of attributes such as species richness or endemism. Available data (mainly from museum records) was enhanced using modelling techniques incorporated in a GIS system and was used to identify hotspots of diversity and endemism. Tools to further prioritise these areas include the concepts of complementarity and replaceability.

In some circumstances distributional data is not available due to lack of sampling, but in many cases there is adequate data for such analyses, particularly on a state, national or regional scale. This can be obtained with minimal additional fieldwork by using authenticated museum collection records. An important goal in the next decade is to get targeted collection data networked nationally and internationally so this invaluable source of biodiversity information can be accessed for conservation and planning purposes.

Diversity of Badenian small gastropods from Transylvanian Basin and Pannonian Basin, Romania

Mirela POPA and Carmen CHIRA

Babes-Bolyai University, Faculty of Biology and Geology, Palaeontology-Stratigraphy Museum, 1 Kogalniceanu Street, 3400 Cluj Napoca, Romania,
popamir@bioge.ubbcluj.ro, mcchira@bioge.ubbcluj.ro

The small size gastropods from Badenian faunal assemblages located in Transylvanian Basin and in the Romanian sector of the Pannonian Basin were analyzed in detail. This study concerns only those gastropods belonging to families with small and very small size representatives.

In the Transylvanian Basin, the Badenian deposits outcrop in marginal zones, on larger areas in its northern and western part. Small gastropods were noticed only sporadically in the northern part and the rest of the basin, being more frequent in the south-western part - at Buitur and in Hateg Depression (Popa & Ianoliu 2000). In Romanian sector of the Pannonian Basin, the Badenian deposits crop out in its eastern extensions, this meaning the western basins (Caransebes, Faget, Zarand, Beius, Borod, and Simleu basins).

The richest faunal assemblages containing a big number of small gastropods species, can be found in the Mures passageway, a link between Pannonian Basin and Transylvanian Basin. At Lapugiu de Sus, Costei and Nemesesti (famous fossiliferous sites), species belonging to more than 20 families were signalized (Suraru & Papp 1993). The small gastropods are well represented in the Caransebes basin, Beius basin, Borod basin and Simleu basin as well (Popa & Chira 2000).

Alvania, *Rissoina*, *Turboella*, *Triphora*, *Melanella*, *Odostomia*, *Turbonilla* and *Ringicula* are the genera containing the largest number of species. The best represented by their number are the species belonging to genera: *Alvania*, *Turboella*, *Caecum*, *Turbonilla*, *Melanella*, *Bittium* and *Eulimella*. The great diversity of small gastropods represents result of inter-species relationships from Badenian paleobiotopes, and of influences of abiotic factors as well.

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Paratethyan brackish and euryhaline mollusc endemics and their importance for stratigraphy

Sergej V. POPOV, Lidia A. NEVESSKAYA, Lubov B. ILYINA, Irina A. GONTSCHAROVA, and Nina P. PARAMONOVA

Paleontological Institute RAS, Profsojuznaja 123, Moscow 117868, Russia,
serg.pop@cityline.ru

The first appearance of specific euryhaline and brackish genera and species, the spread of endemic groups and their short-term existence in the unstable environments of semi-closed basins provide important information for Paratethyan stratigraphy. Explosive evolution of ancestral marine euryhaline forms is observed among mollusks, ostracods, diatoms and dinoflagellates. The best-studied group is mollusks. We see six levels that are important for inter-Paratethyan correlations:

1. Solenovian brackishness during the mid-Rupelian - first appearance of *Ergenica*, *Urbnisia*, *Korobkoviella*, *Merklinocardium* among bivalves, endemic ostracods (*Disopontocypris oligocaenica* association), nanoplankton (blooming of *Reticulofenesta ornata*, *Transversopontis fibula*), diatoms and dinocysts.
2. Upper Ottnangian – Kozakhurian event – appearance and invasion of *Rzehakia dubiosa*, *Limnopageta*, *Eoprosodacna*. Transitional forms from euryhaline ancestral *Cerastoderma* to endemic *Limnopageta* and *Limnopappia* in the Bavarian material (Schlicum and Steininger collections).
3. Lower Sarmatian - appearing more than 25 endemic species appear. *Inaequicostata* (3 sp.), *Gibbula* (2 sp.), *Cerithium rubiginosum*, *Mohrensternia inflata*, *Obsoletiforma lithopodolica*, *Mactra eichwaldi* were widespread in the Paratethys.
4. Middle Sarmatian *s.l.* - appearance and spreading of endemic species among mollusks, ostracods, foraminifers. The bivalves *Barbotella*, *Sinzovia mactra vitaliana*, *Obsoletiforma praefischeriana*, *Venerupis ponderosa*, *Inaequicostata barboti* became widespread in the Bessarabian.
5. Pontian - Upper Messinian - new appearance of short-lived, widespread endemics (genera *Lymnocardium*, *Pseudocatillus*, *Eupatorina*, *Valenciennius* among mollusks, *Loxoconcha djaffarovi* ostracod association, endemic species among dinocysts). There was an ancestral association for the Pontian mollusk fauna in the late Messinia.
6. Base of Upper Pontian – Portaferian. Invasion and spreading of the Pontian endemic genera: from the Central (Pannonian Basin) to Eastern Paratethys – *Arpadicardium*, *Tauricardium*, *Phyllocardium*, *Plagiodacna*; from the Eastern to Central Paratethys – *Euxinocardium* and *Pontalmyra*.

Sessility, suspension-feeding, and uncoiling: Exploring the evolutionary radiation of vermetid gastropods

Timothy A. RAWLINGS¹, Rüdiger BIELER² and Timothy M. COLLINS³

¹Department of Palaeontology, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK, T.Rawlings@nhm.ac.uk

²Department of Zoology, Field Museum of Natural History, 1400 S. Lake Shore Drive, Chicago, IL 60605-2496, USA, bieler@fieldmuseum.

³Department of Biological Sciences, Florida International University, University Park, Miami, FL 33199, USA, collinst@fiu.edu

Wormsnails are a grade of sessile, irregularly uncoiled, suspension-feeding gastropods comprising members of the families Vermetidae, Siliquariidae, and Turritellidae (genus *Vermicularia*). The irregular coiling patterns, notoriously plastic habitat-influenced shell morphology, and highly derived anatomical features of wormsnails have so far confounded attempts to determine the relationships of these taxa to one another, as well as to understand the evolutionary context in which this unusual body form and lifestyle have evolved. As part of a larger study examining the evolution of wormsnail taxa within the Caenogastropoda, here we employ molecular tools for the first time to explore the radiation of one family, the Vermetidae, and to examine patterns of character evolution associated with a sessile, benthic, suspension-feeding lifestyle. Vermetids are a diverse group (>100 extant species) of marine gastropods found in shallow waters in warm temperate to tropical environments, believed to have radiated from a basal caenogastropod stock sometime in the early Cenozoic. Our molecular phylogeny, based on 25 vermetid species and using both nuclear (28S rRNA) and mitochondrial (12S, 16S rRNA) genes, supports a monophyletic origin of the Vermetidae and also provides strong evidence for four main radiations of vermetid gastropods. However, our data provide only weak support for relationships among these four clades. Our molecular data also reveal that the systematics of vermetid gastropods, is currently in a state of disarray. Our results challenge the current generic arrangement of taxa within the Vermetidae, indicating that four of five genera recognized by Keen (1961) do not represent monophyletic groups. We present our revised molecular-based phylogeny of the Vermetidae, discuss how morphological characters may provide a misleading impression of vermetid relationships, and describe our initial explorations into the evolution of specific morphological, ecological, and life-history characters within this family.

***Nodilittorina* (Gastropoda, Littorinidae) - a model for Indo-Pacific biogeography: Introduction and morphological systematics**

David G. REID, Suzanne T. WILLIAMS and D. Tim J. LITTLEWOOD

Department of Zoology, The Natural History Museum, London SW7 5BD, UK,
dgr@nhm.ac.uk

The Indo-West Pacific (IWP) marine region is characterised by two striking biogeographic patterns: the very wide distribution of some species and the focus of highest diversity in Indo-Malaya. This has prompted two interrelated questions: how does speciation occur in widely-dispersed invertebrates and what has caused the diversity gradient? The numerous theoretical explanations of the IWP diversity gradient can be grouped in several categories, such as centre-of-origin, centre-of-accumulation, centre-of-survival and centre-of-overlap.

To examine these questions, and to test the theoretical predictions, the genus *Nodilittorina* is a suitable model. These littorinid snails occur on rocky shores throughout the tropics and have been intensively sampled. Their systematics are being revised and, although shell characters are highly plastic, anatomical data suggest 57 species worldwide, of which 26 occur in the IWP. Protoconch and oviduct morphology indicate that all species have planktotrophic development. Their geographical distributions are relatively well known, ranging from narrowly endemic to widespread throughout the IWP.

Morphological characters have been used to reconstruct a phylogeny for the genus, but the resulting trees are poorly resolved, suggesting widespread homoplasy. Molecular data are now being sought to address this problem (see presentation by S.T. Williams *et al.*).

Systematics and population genetic structure in a complex of sibling *Deroceras* species - an allozyme study (Mollusca: Pulmonata: Agriolimacidae)

Heike REISE¹, Thierry BACKELJAU² and B. ZIMDARS¹

¹ Staatliches Museum für Naturkunde Görlitz, PF 300 154, D-02806 Görlitz, Germany, smng.reise@t-online.de

² Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, and Department of Biology, University of Antwerp (RUCA), Groenenborgerlaan 171, B-2020 Antwerp, Belgium, TBackeljau@kbinirsnb.be

The sibling species *Deroceras* (*Plathystimulus*) *rodnae* and *D. (P.) praecox* are terrestrial slugs with a non-overlapping distribution. The only consistent distinguishing morphological character is the penial appendix of *D. praecox* which is lacking in the otherwise morphologically variable *D. rodnae*. Two other poorly known taxa with local distributions also belong to this species complex: *D. (P.) fatrense* and *D. (P.) juranum*. To assess their taxonomic status, 322 specimens of these four taxa from 19 localities were surveyed at 12 putative allozyme loci. For comparison, 143 specimens of six further congeneric species were also considered: *D. (Agriolimax) turcicum*, *D. (A.) reticulatum*, *D. (A.) agreste*, *D. (Malino) panormitanum*, *D. (D.) laeve*, *D. (D.) sturanyi*.

The allozymes clearly separated three species groups: the *D. rodnae*-complex, a group consisting of *D. turcicum*, *D. reticulatum* and *D. agreste*, and a group with the remaining three species. The allozymes also separated the reference species (except for the completely monomorphic *D. agreste* from *D. reticulatum*). However, they failed to differentiate the four *Plathystimulus* taxa, and confirmed *D. juranum* as a colour morph of *D. rodnae*. Instead, genetic distances between *Plathystimulus* populations suggested a geographical pattern, with a western and an eastern group. *D. rodnae*, the taxon with the widest range, occurred in both groups, and showed the highest interpopulation genetic variation (but little intrapopulation diversity). In this taxon, the fixation indices varied from 0 to 1 indicating that its populations vary in reproductive mode. The characters supposed to differentiate *D. rodnae*, *D. praecox* and *D. fatrense* are discussed with reference to the allozyme results. We suggest that these taxa form a complex of populations that have differentiated to different degrees as a result of geographical isolation and self-fertilization. Currently, the data provide no clear evidence for a specific status of *D. praecox* and *D. fatrense*.

Sexual conflict in a mutually fertilising hermaphrodite: manipulation after sperm exchange?

Heike REISE¹ and John M.C. HUTCHINSON²

¹ Staatliches Museum für Naturkunde Görlitz, PF 300 154, D-02806 Görlitz, Germany, smng.reise@t-online.de

² Max-Planck-Institut für Bildungsforschung, Lentzeallee 94, D-14195 Berlin, Germany, hutch@mpib-berlin.mpg.de

Terrestrial slugs of the genus *Deroceras* are simultaneous hermaphrodites with a mating system which differentiates them from many other hermaphrodite groups: sperm is exchanged mutually and simultaneously in a single package. The transfer is external via the everted penes which tightly entwine with each other. Copulation (penis eversion and sperm transfer) starts suddenly and is usually brief (varying interspecifically from a few seconds to a few minutes). This is preceded by a long and complex courtship dance (20 minutes to several hours). Most species have finger-like appendages on the penis, which are everted immediately after sperm transfer. At least in some species, these appendages spread over the partner's body before the partners separate.

Sexual conflict can arise in hermaphrodites because (1) they need not use received sperm (using their own or another partner's instead) or (2) they may try not to donate sperm. Once copulation has started, a *Deroceras* seems to have little chance to stop donating sperm, even if it realises that the partner does not donate sperm. This is in contrast to hermaphrodites with alternation of male and female roles, or with slow sperm exchange with adjustable amounts of sperm. The long and complex courtship might serve several functions: synchronisation, gathering information about the partner, and manipulation of the partner through the transfer of secretions (as has been demonstrated with the love dart of some snails: Koene & Chase 1998). But the use of the penial appendages after sperm exchange seems difficult to interpret as anything other than a manipulation to ensure that donated sperm is used for fertilisation.

The poster gives further details of courtship and copulation in the example of *D. panormitanum*, discussing how they relate to sexual conflict.

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Latitudinal species diversity and range-size gradients in the Scaphopoda

Patrick D. REYNOLDS, Nathan GRAY and Luke P. HILPERT

Biology Department, Hamilton College, Clinton, NY 13323 USA,
preynold@hamilton.edu

A latitudinal gradient of species diversity, increasing from poles to the tropics, is well known for terrestrial fauna and flora and to a lesser extent from marine environments. In the oceans, these gradients are more widely established for nektonic and epilithic biotas than for soft-substrate infauna, and for coastal rather than open oceanic zones. Among molluscan studies, such a gradient has been recently demonstrated in bivalves and gastropods.

We examined patterns of latitudinal diversity of the Scaphopoda, an entirely infaunal class of molluscs, by compiling a data set of latitudinal range records for 355 species (~70% of nominal species diversity within the class). Species counts for each 1° band in each hemisphere of Atlantic and Pacific oceans showed a pronounced latitudinal diversity gradient in both hemispheres of each ocean. In the northern hemisphere, species diversity reached a peak of ~50 species in both oceans, although in the northern Atlantic this peak was reached short of the equator, at 18-19°N. In the southern hemisphere, diversity gradients peaked near the equator in both oceans, but with a much lower maximum diversity in the southern Atlantic. This contributes to a global pole-pole pattern where amplitude of diversity gradients is similar in both oceans, but peaks near the equator in the Pacific, and at ~20°N in the Atlantic. While the gradients were generally gradual, sharp discontinuities occurred in the northern Atlantic between 29-31°N, in the northern Pacific between 34-36°N, and in the southern Pacific between 8-10°S, and may reflect coastal geographic features that limit distribution or areas of particularly high diversification.

Among several hypotheses proposed to explain such gradients is "Rapoport's Rule": that increasing diversity towards the tropics reflects a decreasing gradient in latitudinal range-size. This has been tested in several taxa and ecosystems, with mixed support. For scaphopods, we compiled median range-sizes for all species for each 5° latitudinal band in each hemisphere and ocean. Based upon congruence between diversity and range-size gradient patterns, support for Rapoport's Rule varied markedly. The expected inverse relationship between diversity and range size was consistent through all latitudes in the Atlantic, but did not hold in the Pacific. As has been found elsewhere, a variety of factors impact latitudinal diversity, and their relative influence and expression in latitudinal range-size gradients is likely to vary among ocean basins.

Age and growth determination of *Pinna nobilis* L. from the Croatian Adriatic Sea using Mg/Ca, Sr/Ca ratios and stable oxygen isotopes

Christopher RICHARDSON¹, Melita PEHARDA², Paul KENNEDY¹, Hilary KENNEDY¹ and Vladimir ONOFRI²

¹ School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Anglesey LL59 5EY, UK, c.a.richardson@bangor.ac.uk, d.p.kennedy@bangor.ac.uk, h.a.kennedy@bangor.ac.uk

² Institute of Oceanography and Fisheries, Kneza Damjana Jude 12, 20000 Dubrovnik, Croatia, melita@labdu.izor.hr, onofri@labdu.izor.hr

The fan mussel *Pinna nobilis* L. is the largest Mediterranean bivalve and has been protected in the Croatian Adriatic Sea since 1977. However, little is known about its population structure, age and growth rate in different locations. Adductor muscle scar growth rings were used to estimate the age of *P. nobilis* from three localities in the Croatian Adriatic Sea; Mali Ston Bay, and Veliko jezero and Malo jezero on Mljet Island. The potential use of shell Mg/Ca and Sr/Ca ratios and stable oxygen isotopes ($\delta^{18}\text{O}$) for determining seasonal patterns in elemental shell chemistry and seawater temperature were investigated. Seasonal cycles in Mg/Ca and Sr/Ca ratios closely correlated with changes in $\delta^{18}\text{O}$ reflecting seasonal variations in shell growth rates and were used to identify the number of winter-summer growth cycles. Growth rings on the adductor-muscle scar formed during the winter and early spring as a result of slow shell growth. The first clearly visible ring on the adductor muscle scar forms when fan mussels reach a length of 20-30 cm and probably represents the second winter of growth. The oldest *Pinna nobilis* collected was 9 years old.

Structural differences in the reproductive system of selected Helicinidae (Gastropoda, Neritopsina)

Ira RICHLING

Institute of Zoology, University of Kiel, Olshausenstr. 40-60, 24098 Kiel, Germany, ira@richling.de

The reproductive system of female Helicinidae is generally described as consisting of a V-shaped oviduct with a small accessory sperm sac that leads into a reception chamber and ends as an elongated pallial oviduct near the mantle edge. Besides the pedicel of the primary oviduct the reception chamber also receives a bursa copulatrix, a provaginal sac and a provaginal duct that opens into the mantle cavity.

However, when the reproductive system of Costa Rican representatives (*e.g. Helicina funcki*) was investigated in dissections and in serial sections under the light microscope, the provaginal complex revealed a different structure. Against this background, the "considerable uniformity" (Baker 1926) of the reproductive system of the Helicinidae as well as functional aspects are discussed.

Studying species that belong to different genera of both paleotropic and neotropic origin (*e.g. Schasicheila, Emoda, Aphanoconia, Palaeohelicina*) a much greater variety of structures was observed for the reproductive system than had formerly been expected. Especially, the occurrence of different types of seminal receptacles is remarkable. Additionally a new structure was discovered and is described.

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The molluscs of the Chinese Bosten Hu, a possible member of the ancient lakes community

Frank RIEDEL, Jürgen KLUTE and Steffen MISCHKE

Institut für Geologische Wissenschaften, Freie Universität Berlin, Malteserstr.74-100,
Haus D, D-12249 Berlin, Germany, paleobio@zedat.fu-berlin.de

The Bosten Hu fills a tectonic depression on the edge of the southeastern Tien Shan, the lake surface (about 1045 m asl) covering an area of around 1000 km². Actually the Bosten Hu represents the largest extant freshwater lake in the Central Asian deserts. The lake level is mainly controlled by the inflow of the Kaidu River which has its catchment in the glaciated Tien Shan and enters the Bosten Hu from the West. The water flows out from the southwest of the lake, cutting through a foothill barrier and making its way to the northeastern Tarim Basin or Taklamakan desert respectively. With a maximum depth of 15 m the lake is comparatively shallow. Deep drilling and subsequent examination of core sediments by Chinese colleagues has shown that the lake exists longer than 1 my and thus can be termed long-lived or ancient.

In September 1999 the Bosten Hu was examined by us in some detail. With regard to molluscs it became evident that there existed almost no living individuals in the lake, probably due to the influx of agricultural fertilizers. Consequently sediment samples from about 60 different sites, near shore and off shore, were taken by diving, grabbing and drilling (30-60 cm deep). Apart from the upper few centimetres of the lake bottom, (subrecent) shells were abundant in the sediments. The shells were examined in detail under the scanning electron microscope. Altogether 12 molluscan species could be identified and attributed to the genera *Bithynia* (Caenogastropoda, Rissooidea), *Valvata* (Heterobranchia, Allogastropoda), *Gyraulus*, *Radix* (both Heterobranchia, Basommatophora) and *Pisidium* (Autolamellibranchiata, Veneroidea). None of the species was endemic, which contrasts somehow the idea that the Bosten Hu represents an ancient lake. On the other hand sedimentological results from drilling and hydrographical observations of the last decades suggest that the lake level varied strongly even from year to year. It is proposed here that the low molluscan diversity reflects unstable conditions of an ecosystem and does not indicate a short-lived character of the Bosten Hu. In the future sediments obtained by deep drilling will be examined in order to find out possible changes in the faunal composition during the last 0.5 my.

Gastropods from the Volga delta: a systematic and biogeographic review

Frank RIEDEL¹, Peter RÖPSTORF¹, Jürgen KLUTE¹, Klaus BANDEL² and Nikolai ALADIN³

¹ Institut für Geologische Wissenschaften, Freie Universität Berlin, Malteserstr.74-100, Haus D, D-12249 Berlin, Germany, paleobio@zedat.fu-berlin.de

² Geologisch-Paläontologisches Institut, Universität Hamburg, Bundesstr.55, D-20146 Hamburg, Germany, bandel@geowiss.uni-hamburg.de

³ Zoological Institute of the Russian Academy of Sciences, Universitetskaya nab.1, St. Petersburg, 199034, Russian Federation, aral@zin.ru

The Volga represents the longest European river, rising from the Valdai Hills northwest of Moscow, flowing almost 3700 km through the Russian lowlands and flowing into the Caspian Sea, the largest lake on Earth, a relic of the Neogene Paratethys, inhabited by a large number of endemic organisms. The water level and thus also the salinity of the Caspian Sea is mainly controlled by the inflow of the Volga which penetrates into the endorheic lake via a 200 km wide delta. From the biogeographical viewpoint not only the Caspian Sea proper but also the Volga delta is of special interest because here palaeartic faunal elements may directly face their Caspian counterparts or different faunal complexes may mix to some degree, respectively.

During an expedition in September 2000 the northwestern Caspian Sea and Volga delta were examined with view to molluscan inhabitants. Teleoconchs, protoconchs and radulae of 14 species were documented which belong to the gastropod genera *Theodoxus* (Neritimorpha), *Bithynia*, *Lithoglyphus*, *Viviparus* (all Caenogastropoda), *Valvata* (Allogastropoda), *Acroloxus*, *Ferrissia*, *Gyraulus*, *Lymnaea*, *Physa*, *Radix* (all Basommatophora) and *Oxyloma* (Stylommatophora). *Theodoxus pallasii* represents the only Caspian element found in the delta. With the possible exception of *Lithoglyphus "caspius"* all other species can be attributed to the palaeartic faunal complex. The only species which was not found at the transition to the Caspian Sea proper but further upstream in the delta is *Bithynia tentaculata*. The occurrence of *Ferrissia* in the Volga was not known to date. This ancyliid was found sympatrically with *Acroloxus*, both gastropods living on the same leaves of lotus, particularly on the undersides. None of the 72 species of Caspian *Pyrgulidae* (Rissooidea) described in the literature could be detected in the Volga delta although at least *Turricaspia astrachanica* is thought to settle in this area. Shells were found in the northwestern Caspian Sea, but no living animals. The re-investigation of Caspian pyrgulids has been started.

Patterns of genetic and morphological differentiation in a viviparous gastropod species flock in the ancient lakes on Sulawesi, Indonesia

Thomas von RINTELEN and Matthias GLAUBRECHT

Institut für Systematische Zoologie, Museum für Naturkunde, Invalidenstr. 43, 10115 Berlin, Germany, thomas.rintelen@rz.hu-berlin.de

The ancient lakes of central Sulawesi, Indonesia contain approximately 20 endemic species of viviparous freshwater gastropods in the genera *Brotia* and *Tylomelania* (Caenogastropoda: Cerithioidea: Pachychilidae). Since their discovery in the late 19th century, these snails have not been studied in detail. Nevertheless, this putative species flock was cited as an example of adaptive radiation in ancient lakes. Geological data on the age of the lakes are equally scarce and rather vague, ranging from 1-2 to as old as 5 Myr. New collections of snails in 1993 by Philippe Bouchet (NHNM, Paris) and the authors in 1999/2000 provided the opportunity to study this system in detail for the first time.

We constructed a phylogeny for 25 taxa based on partial COI and 16S mitochondrial DNA sequences. This phylogeny strongly supports the view that the lakes were colonized independently several times from one or several widespread ancestral riverine species. The uncertainty about the age of the lakes makes it difficult to get a precise idea of the number of colonization events; it is likely, however, that at least four independent colonizations occurred. The independent origin of the species in the isolated northernmost Lake Poso was not unexpected, but surprisingly a threefold independent origin must be assumed even for the species in the five interconnected lakes in the Malili System. The data also indicate a pattern of inter-lacustrine migration in the Malili lakes.

Generally, the pattern of molecular and morphological differentiation was found to be remarkably incongruent. The lake species display shell morphologies that are not only very different from that of the riverine species, but vary considerably between and among lake lineages as well. Particularly striking is the genetic similarity of species with uniquely dissimilar morphologies, e.g. of the shell and radula, within certain lake clades. In contrast, the populations of the riverine species are genetically very divergent, but display a rather uniform morphology, especially of the radula and embryonic shells.

These results support the conclusion that upon colonization of the lakes, morphology was subject to dramatic environmentally driven changes. In addition, in at least two clades there was a more recent increase in morphological change in some species. Possible environmental factors involved are briefly discussed.

Report on some new opisthobranchs from Parque Nacional Morrocoy, Venezuela

Nelsy RIVERO PAREDES

Universidad Simón Bolívar, Departamento de Estudios Ambientales, Apartado Postal 89000, Caracas 1080, Sartenejas Baruta, Edo, Miranda, Venezuela, nelsyrivero@cantv.net

As part of a long-term review of the opisthobranch fauna of Parque Nacional Morrocoy (10° 52'N- 69° 16'W), Venezuela, this study includes 10 species never reported before in the area. Individuals of these species (Aplysiidae: *Aplysia dactylomela*, *Aplysia brasiliana*, *Bursatella leachi*, *Dolabrifera dolabrifera*, *Stylocheilus longicauda*; Bornellidae: *Bornella calcarata*; Bullidae: *Bulla striata*; Chromodoridae: *Hypselodoris bayeri*; Discodoridae: *Discodoris evelinae*; Plakobranchidae: *Tridachia crispata*) were collected in the following localities: Varadero, Cayo Sal, Punta Mayorquina, Cayo Muerto, and Cayo Sombrero. Individuals from all these species were found living on different substrata, ranging from coral reefs and rock platforms to algae and beds of *Thalassia testudinum*. At this moment, the collection of mollusks from Parque Nacional Morrocoy and the results of this long term project reflect a remarkably diverse fauna of opisthobranchs living in the western and central coasts of Venezuela.

Dart receipt promotes sperm storage in the garden snail *Helix aspersa* (Gastropoda, Pulmonata)

David W. ROGERS and Ronald CHASE

Department of Biology, McGill University, 1205 Dr. Penfield Ave., Montreal,
Quebec, H3A 1B1, Canada, david.rogers@mcgill.ca, ronald.chase@mcgill.ca

During courtship, many helicid snails attempt to pierce the body walls of their mating partners with mucus-coated calcareous 'love darts'. The adaptive significance of this behaviour has long been the subject of speculation. Proposed roles for the dart include behavioural synchronization, donation of nuptial gifts of calcium, indication of willingness to donate sperm, and avoidance of hybridisation. Little evidence exists to support any of these hypotheses. Our experiments are predicated on the assumption that snails are prone to high levels of sperm competition because they mate promiscuously and they store sperm for long periods prior to oviposition. As an initial test of whether the dart could influence reproductive success through an effect on sperm storage, we measured the effect of dart receipt on the number of sperm stored by once-mated snails (*Helix aspersa*). In general, irrespective of dart receipt, roughly 99.98% of transferred sperm is immediately digested in the female reproductive tract.

Snails that were hit by darts stored significantly more sperm than did snails that were missed. Adjusting for the body size of the recipient snail, which was negatively related to the number of sperm stored, 'hit' snails stored 116% more sperm than did 'missed' snails. Additionally, the effect of the dart was stronger in smaller animals, likely due to the weaker dilution of a chemical factor transferred by the dart, as previously hypothesized. Because dart shooting success was not related to the number of sperm transferred, our evidence does not support the idea that dart shooting signals a snail's willingness to assume the role of sperm donor and thereby stimulates the hit partner to reciprocate in kind. Furthermore, we found that 83 of 84 copulating snails fulfilled the male role. Therefore, it seems that neither dart shooting nor dart receipt influences a snail's willingness to donate sperm. Rather, the results provide strong support for the role of dart shooting in sperm competition. If sperm from rival donors mix within the recipient's storage organ, a greater proportion of these sperm will belong to successful shooters. The numerical advantage enjoyed by successful shooters should translate into higher reproductive success for these individuals. We describe a test of this prediction in the accompanying paper (Chase & Landolfa, this volume).

New molecular data on cocculiniform relationships

Elisa ROLDÁN¹, Thierry BACKELJAU², Karin BREUGELMANS² and Ángel LUQUE¹

¹ Dpto. de Biología, Universidad Autónoma de Madrid, 28049 Madrid. Spain.
² Institut Royal des Sciences Naturelles, Vautierstraat 29, B-1000 Brussels. Belgium.

The order Cocculiniformia comprises about 130 species of marine gastropods mainly restricted to deep water biogenic substrata, grouped into two superfamilies: Cocculinoidea and Lepetelloidea. The phylogenetic relationships of Cocculiniformia have been recently debated.

Building upon the study of Harasewych & McArthur (2000) using 18S rDNA sequences, a wider range of cocculiniform species is included here to increase robustness and to provide a better representation of the two superfamilies. The main scopes are to test the presumed monophyly of Cocculiniformia and to determine cocculiniform relationships with other gastropod taxa. Partial 18S rDNA sequences of five cocculiniform limpets (*Addisonia excentrica*, *Lepetella sierrai*, *Copulabyssia corrugata*, *Coccapigya viminensis* and *Coccapigya spinigera*) were determined and aligned against previously published sequences from two cocculiniform gastropods (*Cocculina messingi* and *Notocrater houbrieki*), 22 other gastropods (Patellogastropoda, Neritopsina, Vetigastropoda, Caenogastropoda and Heterobranchia) and two polyplacophorans. The sequences were aligned with CLUSTALX. Phylogenetic analyses have been performed using Neighbor-Joining, maximum parsimony and maximum likelihood.

The monophyly of Cocculiniformia, weakly supported in Harasewych & McArthur (2000), is not supported. Morphology-based phylogenetic analyses (Ponder & Lindberg 1997, Sasaki 1998) placed Lepetelloidea with the Vetigastropoda, while Cocculinoidea appeared either very close to Neritopsina or close to Vetigastropoda. Here, Lepetelloidea and Cocculinoidea emerge as two independent groups joining the Patellogastropoda in a well supported clade. This is in agreement with the results of Harasewych & McArthur (2000).

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The interest of four types of food for the breeding of experimentally-infected *Lymnaea truncatula* (Gastropoda, Lymnaeidae) under laboratory conditions

Daniel RONDELAUD, Mouna ABROUS and Gilles DREYFUSS

UPRES-EA n° 3174, Facultés de Médecine et de Pharmacie, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud@pharma.unilim.fr

Some authors had already reported that the use of microalgae and/or mixed diets as food for intermediate host snails resulted in a significant increase of the production of cercariae. To enhance the number of cercariae released from infected snails in our laboratory, it was interesting to select a source of food (other than lettuce) among those proposed by these authors and to obtain the highest production of cercariae for the lowest cost of maintenance. Bimiracidial infections of *Lymnaea truncatula* with a digenean species (*Fasciola gigantica*, *F. hepatica*, or *Paramphistomum daubneyi*) were thus performed under laboratory conditions to study the effect of four types of food (microalgae, romaine lettuce, wheat germs, or modified Boray's diet) on snail growth and cercarial production, and to determine the most profitable source by its quality-price ratio. When infected snails were bred using a food other than lettuce, the growth of their shells was significantly greater compared to the groups reared on lettuce, whereas there was no significant variation between the sizes recorded in the former snail groups. Generally, the mean number of shed *F. hepatica* cercariae was significantly greater when snail food was microalgae or Boray's diet (up to a mean of 213 per snail), and the production of individual *L. truncatula* exceeded 1000 cercariae. The results obtained with *F. gigantica* or *P. daubneyi* infections showed no significant differences between the numbers of cercariae found in lettuce- and Boray's diet-reared groups. The lowest cost prices for 100 metacercariae of *F. hepatica* (8.5-9.5 US \$) were noted when algae of Boray's diet were used as food for snails. In contrast, the highest prices were found with lettuce-reared snails (15.7-16.1 \$). If the production of *F. hepatica* metacercariae for commercial purposes is going to be developed, the choice of food for breeding snails, the mode of collecting metacercariae, and the commercial demand for these metacercariae will have to be accounted for and will depend on the strategy that the producer wishes to develop.

New data on feeding, reproduction, and growth of endemic Baikalian gastropods

Peter RÖPSTORF

Institut für Geologische Wissenschaften – Paläontologie, Freie Universität Berlin, Malteserstrasse 74-100, 12249 Berlin, Germany, rpeter@zedat.fu-berlin.de

The Baikalian endemic gastropods representing several species flocks are extraordinary diverse. Although they are well investigated, there are only a few data on their ecological niches. At three different sites of the littoral of Lake Baikal and the River-Angara outflow, the gastropods were collected and stomach-contents of the different taxa were analyzed and compared. The production of egg-capsules was studied *in vivo* and *in vitro*. Juvenile snails were kept in rearing cages under natural conditions and they were monthly measured to estimate the growth rate. Feeding: The stomachs of Baicaliidae contain bacteria, cyanobacteria, diatoms, chrysophyceae, flagellates, yeast, pollen, and rotifers. Within the diatoms, the planktic species dominate (80-90%). In autumn the main source is *Cyclotella minuta*, in spring/ early summer *Alaucoseira baicalensis*. The investigated Baicaliidae probably filtrate particles from the water. Benedictiidae are found to be grazers living on dead sculpins and gammarids, macrophytes, juvenil *Choanomphalus*, detritus, diatoms. A higher amount of benthic diatoms was found in *Choanomphalus* (30-50%) and especially in the acroloxid species (>90%). Clear differences in the composition of food were found only between the higher taxa, but not between the closely related sympatrically living species. This suggests that interspecific competition between closely related species is not prevented by food choice. Reproduction: the Baicaliidae produce egg capsules throughout the year, but in early summer the production increases. At the same time the juvenile snails hatch out of eggs produced in last summer/autumn. Embryogenesis takes several months (Sitnikova *et al.* 2001). A tendency to produce larger eggs and protoconchs was found in Baikalian valvatids, baicaliids and benedictiids. The different species prefer different places to attach the egg-capsules. Growth: The juvenile snails grew slowly. In the term from November to May growth could not observed in the investigated Baicaliidae, from Mai-August the snails grew about 0.2 whorls per month, from September - October 0.4 whorls. Hatchlings with 1.6 whorls reach maximal 3.2 in autumn, so maturity is not reached in one year. In River Angara the growth rate is higher. The studies were supported by Deutsche Forschungsgemeinschaft (DFG) Project RO 2236/1-1/1-2.

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Status report on the terrestrial mollusks of Jamaica

Gary ROSENBERG and Igor V. MURATOV

Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, Philadelphia,
Pennsylvania 19103, USA, rosenberg@ansp.org, muratov@ansp.org

Over the last three years we have collected terrestrial mollusks at 550 sites in all geographic regions of Jamaica. This has led to the discovery of a number of undescribed species and several overlooked introduced species. Some endemic species have undergone considerable contraction in range due to deforestation, whereas others that are tolerant of disturbance have expanded their ranges. Currently 556 species of terrestrial snails and slugs are known from Jamaica and the total will probably exceed 600 species.

Of particular interest are two new *Corneosagda* species (Sagdidae) widespread in the John Crow and Blue Mountains that have previously been overlooked because of their strong resemblance to juvenile *Pleurodonte* (Camaenidae). A new species of *Priotrochatella* (Helicinidae) occurs in karst areas of north central Jamaica; the two new Jamaican species are restricted to the northwest and southeast, the genus appears to have a relict distribution.

Previously unreported introduced species include *Bulimulus* cf. *B. diaphanus* (Bulimulidae), widespread in areas with cattle; *Drymaeus multilineatus* (Bulimulidae) at one site in southwest Jamaica; *Helicodiscus parallelus* (Helicodiscidae) at one site in the Blue Mountains; and *Zachrysia* species (Camaenidae) in the Rio Cobre Gorge.

Long dead shells of *Eurycratera jamaicensis* (Camaenidae), the largest of the Jamaican endemics, are found in limestone areas throughout central and western Jamaica, but living specimens have been found only in and near primary forest, with population centers in the Cockpit Country and the Dolphin Head and Mount Diablo regions. Among some 20 species of *Anoma* (Urocoptidae), we have found only three alive, and a few others in fresh dead condition. These tree snails prefer primary forest, although are not restricted to it, and may show levels of extinction and endangerment similar to those of the Hawaiian *Achatinella*. Other tree snails, such as *Helicina* and *Lucidella* (Helicinidae) seem to survive well in secondary forest.

Endemic species such as *Colobostylus bronni* (Annulariidae) and *Dentellaria sloaneana* (Camaenidae), which are tolerant of drier conditions, have expanded their ranges in disturbed areas. Introduced species are also common in disturbed areas, but rarely seen in primary forest.

Existing and proposed national parks in the Blue and John Crow Mountains, the Cockpit Country and Dolphin Head will safeguard some Jamaican species, but others are threatened with extinction, if not already gone.

Threats to populations of the freshwater pearl mussel, *Margaritifera margaritifera* L., and their conservation strategy in Latvia

Mudite RUDZITE

Museum of Zoology, University of Latvia, Kronvalda bulv. 4, LV - 1586 Riga,
Latvia, mudite@lanet.lv

The freshwater pearl mussel is a species approaching extinction, now in a critical condition, decreasing populations exist not only in Latvia but throughout its range (Bauer 1988, Valovirta 1998). In Latvia, the protection of this species is ensured by inclusion in the List of Threatened Species since 1957, as well as in the 1st category of Latvia's Red Data Book since 1985.

The action plan for the conservation of this species in Latvia was prepared in 1999. Main goal of the action plan: to halt the decline of the freshwater pearl mussel population, establish conditions for its normal regeneration by improving and stabilizing appropriate habitats in oligotrophic river ecosystems (Rudzite 1999).

There are only 7 populations in Latvia with about 12000 individuals. Populations of pearl mussels are restricted to river basins, which include large forest tracts. In river basins where land amelioration and field cultivation dominates, populations are extinct. All the populations are in the stage of obsolescence, the old individuals dominating. It means that the disappearance of this species in Latvia can be expected for the next 20-30 years, in case there are no activities undertaken to stimulate its resurgence (Rudzite, in press).

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Which is the most frequent species of gastropods in the Canton of Aargau (northern Switzerland)? New discoveries with a new sampling method

Jörg RÜETSCHI

Weidweg 42, 3032 Hinterkappelen/Bern, Switzerland, joerg.ruetschi@bluewin.ch

As a consequence of the Rio-Convention, the Canton of Aargau in northern Switzerland (1404 km²) has lanced a project to control the changes in species-richness in a representative sample of the landscape. For this purpose 436 randomly distributed assessment sites have been sampled for gastropods by analysing samples of litter and soil (10 dm², 5 dm³).

The 436 sites include 244 agricultural, 128 forest and 64 construction areas reflecting the proportion by area of different land use in this canton.

This sampling method, mechanically applied by a botanist, yielded mainly small and middle-sized snails which live in litter and soil. Large species and slugs are underestimated. The most frequently found species are *Carychium tridentatum* and *Discus rotundatus* (138 sites), *Aegopinella nitens* and *Vallonia excentrica* (132 sites) and *Cochlicopa lubrica* (125 sites). At 17 sites more than 20 species have been found with two sites showing a maximum of 31 species. 87 sites could not be sampled or did not yield any species. This was the case at 52% of the construction areas, at 21% of the agricultural areas and only at 2% of the forest areas.

This unusual method revealed some new results on the distribution of several species. *Helicodiscus singleyanus* was found three times in three different habitats: In a forest, in a garden and in a road-side area in an agricultural area. Before, this species had been recorded only once in the North of the Alps in Switzerland (Turner *et al.* 1998). *Daudebardia rufa*, which was known in Switzerland only in the Rhine valley, was found three times in the Aare valley at distances of up to 50 km from the Rhine valley. *Columella aspera* was recorded for the second time in Switzerland. This sampling will be repeated in the next five years.

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Distributional patterns of freshwater Gastropoda in Argentina

Alejandra RUMI, Mónica P. TASSARA, Diego E. GUTIÉRREZ GREGORIC, M. Andrea ROCHE, Stella M. MARTÍN, Verónica NÚÑEZ, Inés I. CÉSAR and María F. LÓPEZ ARMENGOL

Invertebrate Zoology Div., Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/nº, 1900 La Plata, Buenos Aires, Argentina, alerumi@museo.fcnym.unlp.edu.ar

At present there are few general works about the distributions of freshwater and mixohaline snails in Argentina (Parodiz 1969, Castellanos 1991). The aim of this work was to study the species richness and geographical taxonomic diversity patterns throughout areographical methods (Rabinovich & Rapoport 1975). The number of species and families of snails were presented in the form of isoline maps. The specific distribution trends related to hydrographic subregions following Bonetto (1994) were analysed. The isorichness lines, throughout latitudinal and longitudinal gradients (five W-E longitudinal and eight N-S latitudinal transects), were described. The record areas were plotted on a reticular map. Each surveyed squared area (N= 336) comprised 10,000 km², using a 100 x 100 km grid. The material examined belongs to the most important collections of Argentina. The taxonomic diversity of Gastropoda was estimated by the Shannon & Weaver formula.

For Argentina, 94 species which belong to 9 families were described, 3 of these species were introduced. The Hydrobiidae had the highest number of species (36). The highest specific richness was recorded in the Guayano-Brasilic subregion (Del Plata basin), at the east of Río de la Plata river, where the Uruguay river and the Paraná-Paraguay system flow out. The richness decreased to the NW, W and S. The north of the Chileno-Patagonian subregion (Atlantic flowing) showed the highest species richness of the region, in the Desaguadero system and the Colorado, Neuquén and Limay river basins. In Patagonia, the richness decreased quickly in the NW-SE direction and slowly in the NW-SW direction because it is supported by the large lakes and the Andean headwaters of the rivers. The endorreic Córdoba province basins and the headwaters of the rivers which originate at the subandean region and the Somuncurá system are endemic areas with specific increments.

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Comparative aspects of the apical area of molluscan larvae

Bernhard RUTHENSTEINER¹, Andreas WANNINGER¹, Kurt SCHAEFER² and
Gerhard HASZPRUNAR¹

¹ Zoologische Staatssammlung München, Münchhausenstrasse 21, D-81247 Munich,
Germany.

² Institut für Zoologie, Universität Wien, Althanstraße 14, A-1090 Vienna, Austria.

The apical or pretrochal area of larvae of selected members of various molluscan classes has been investigated by light and electron microscopy. Larvae of gastropods exhibited two completely different organisations. The pelagic trochophore stage of the presumably primitive Patellogastropoda (*Patella caerulea*, *P. vulgata*) bears a conspicuous central ciliary tuft originating from three cells. During pretorsional development this apical tuft becomes surrounded by three sensory cilia bearing tubercles and additional ciliated sensory cells. The other type of apical area organisation is represented by the so-called cephalic sensory organ of gastropods that hatch as early veliger larvae. This organ usually consists of an inconspicuous ciliary tuft originating from two cells and several sensory cell types, the most noticeable of which are the ampullary cells with an internal cilia-filled lumen. Previously reported in caenogastropods and opisthobranchs our studies confirm the presence of the organ also in neritimorphs (*Smaragdia bryanae*) and pulmonates (*Laemodonta octanfracta*, *Onchidium cf. branchifrum*). The pretrochal area of polyplacophoran larvae (*Chiton olivaceus*, *Mopalia muscosa*) is densely covered by short cilia with a conspicuous apical tuft that originates from three to five cells. Next to the apical tuft lies the opening of a voluminous gland with a triangular duct in *M. muscosa*. The ampullary cells with an internal cilia-filled lumen, which are located posterior to the apical tuft, form a distinct sensory system. The larval apical pole of the scaphopod *Antalis entalis* has a most peculiar organisation. It bears five to eight dumb-bell shaped appendages formed by apical cells. These appendages become gradually reduced in size during larval life and disappear prior to metamorphosis. They give rise to few cilia which are part of the apical tuft, the main portion of which originates from the common base of the appendages. The organisations of the apical area of different molluscs exhibit extremely heterogeneous conditions that hardly allows to homologise individual components between classes. It is not even clear if the only element in common, the ciliary tuft, is homologous or a repeatedly evolved as swimming stabiliser in the trochophore-like larvae.

Brazilian Bulimuloidea: *Leiostracus* Albers, 1850 and *Pseudoxychona* Pilsbry, 1930 as bulimuloid genera (Gastropoda, Stylommatophora)

Norma Campos SALGADO and Arnaldo Campos dos Santos COELHO

Museu Nacional, Depto. de Invertebrados, Malacologia, Quinta da Boa Vista, São
Cristovão, Rio de Janeiro, RJ-Cep. 20940-040, Brasil, nsalgado@openlink.com.br

Leiostracus Albers, 1850 and *Pseudoxychona* Pilsbry, 1930 and their species were characterized, including synonymy and geographical distribution. Studies of the shell and soft parts were carried out to determine their taxonomic positions and to confirm their generic validity. Described as subgenera of *Bulimulus* Leach, 1814, the taxa studied were interpreted differently through the years. The species, studied only by shells, were subjected to many new combinations. *Pseudoxychona spiritualis* (Ihering, 1912) and its reproductive system were described and illustrated by its author and Breure (1978). Material studied was deposited in many American and European mollusk collections. The methods used were according to Salgado & Leme (2000). The present work on the genera *Leiostracus* and *Pseudoxychona* from the northeast and southeast of Brazil presents important materials for the evaluation and future phylogenetic interpretation of the superfamily Bulimuloidea, which is of wide Neotropical distribution.

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Using neontological data in the interpretation of shell shape variation in paleontological series: How to recognize intraspecific *versus* interspecific variations?

Sarah SAMADI

Institut de Systématique, Service de Systématique Moléculaire, Muséum National d'Histoire Naturelle, 43 rue Cuvier, F-75005 Paris, France, sarah@mnhn.fr

Interpreting paleontological data is often difficult because the genetic nature of observed morphological variation is generally unknown. It is indeed hardly possible to distinguish among several sources of morphological variation, including phenotypic plasticity, sexual dimorphism, within-species genetic variation or differences among species. This can be addressed using fossil organisms with recent representatives. The freshwater snail *Melanooides tuberculata* ranks in this category. Fossil series of this and other species have been studied in the Turkana basin (Kenya), and is presented as one of the best examples illustrating the punctuated pattern of evolution by the tenants of this theory. *Melanooides tuberculata* today occupies most of the Tropics. We studied variation of shell shape in natural populations of this parthenogenetic snail using Raup's model of shell coiling. We considered different sources of variation on estimates of three relevant parameters of Raup's model. (i) Variation in shell shape was detected among clones, and had both genetic and environmental bases. (ii) Sexual dimorphism, in those clones in which males occur, appeared as an additional source of shell variation. (iii) Ecophenotypic variation was detected by comparing samples from different sites and years within two clones. We then tested the performance of discriminant function analyses, a classical tool in paleontological studies, using several datasets. Although the three sources of variation cited above contributed significantly to the observed morphological variance, they could not be detected without a priori knowledge of the biological entities studied. On the other hand, it was possible to distinguish between *M. tuberculata* and a related thiarid species using these analyses. Overall, this suggests that the tools classically used in paleontological studies are poorly efficient when distinguishing between important sources of within-species variation. Our study also gives some empirical bases to the doubts cast on the interpretation of the molluscan series of the Turkana Basin.

Populational studies of Mediterranean *Cerithium*

Sarah SAMADI¹ and Marie-Catherine BOISSELIER-DUBAYLE^{1,2}

¹ Institut de Systématique, Service de Systématique Moléculaire, Muséum National d'Histoire Naturelle, 43 rue Cuvier, F-75005 Paris, France, sarah@mnhn.fr

² Laboratoire de Biologie des Invertébrés Marins, Muséum National d'Histoire Naturelle, 55 rue Buffon, F-75 005 Paris, France, dubayle@mnhn.fr

The genus *Cerithium* is represented in the Mediterranean Sea by several common species that have either planktotrophic or non-planktotrophic larvae. Planktotrophic taxa are expected to disperse more than non-planktotrophic taxa. Larval development is thus supposed to affect population structure. A set of nine microsatellite loci was characterised for five Mediterranean *Cerithium* species. Loci were generally highly polymorphic (up to 40 alleles per locus and observed heterozygosity up to 0.938). These markers are used to genotype adults but also egg-masses and hatchlings. A wide-range study of planktotrophic and non-planktotrophic *Cerithium* species of the Mediterranean shores will be presented.

Mapping the Unionidae from the eastern tributaries of the Tisa River: past and present-day status

Andrei SÁRKÁNY-KISS¹ and Ioan SÎRBU²

¹ Babeş-Bolyai University, Department of Ecology and Genetics, 5-7 Clinicilor St.,
RO 3400 Cluj, Romania.

² Lucian Blaga University, Department of Ecology and Environmental Protection, 31
Oituz St., RO 2400 Sibiu, Romania.

Most old references concerning the Unionidae from the eastern tributaries of the Tisa River are ambiguous or out of date. Almost all quotations are reported to whole rivers or valleys, without mentioning specific locations and estimates of abundance. The authors attempt to initiate the establishment of sound distribution maps with the past and present-day range of populations and communities, in order to highlight the changes that have occurred mostly in the last decades. In the past 30 years a lot of information gathered in field-studies became outdated because long sectors of most rivers were exposed to a severe human impact. Our maps are using four categories of signs: locations from references (*i.e.* before 1970), the period between 1970 and 1990, then up to 1995, and the last 6 years. It is possible to figure out the communities' spatial dynamics. The main characteristic is the decrease both in terms of range and abundance of almost all populations, although a slightly improvement in the years after 1990 was also noticed, explained mainly by the reduction of industrial activities and of pollution. Monitoring the Unionidae communities means to investigate the ecological state of the aquatic habitats. Among the species the most endangered seems to be *Pseudanodonta complanata* that has almost totally disappeared from the main part of the investigated area. On the other side the adventive swan-mussel *Anodonta woodiana* became more and more abundant and is in full process of expansion, especially in the lower sectors of most rivers. Although Red Lists from western Europe contain also *Unio crassus*, in the Carpathian Basin it is not considered endangered because it inhabits mostly the upper sectors of the rivers, that were not, or in a less extent, polluted. The hydrotechnical works caused the destruction of most flood-areas in the middle and lower rivers' courses, representing an impediment in the repopulation of the former degraded aquatic habitats.

Systematic revision of patelliform gastropods from deep-sea chemosynthetic communities in Japanese waters

Takenori SASAKI¹, Takashi OKUTANI² and Katsunori FUJIKURA²

¹ The University Museum, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo
113-0033, sasaki@um.u-tokyo.ac.jp

² Japan Marine Science and Technology Center 2-15, Natsushima, Yokosuka City
237-0061

Numerous chemosynthetic sites have been extensively explored since 1980s using various gears of the deep-sea research system by Japan Marine Science and Technology Center (JAMSTEC). As a result of enormous sampling efforts many animal taxa totally new to science were discovered from hydrothermal vents and cold seeps around the Japanese archipelago. In the course of the revision of molluscan fauna from deep-sea chemosynthetic communities, rich material of patelliform gastropods was found in accumulated and newly provided biological samples collected mainly by the submersible Shinkai-2000. Our anatomical research revealed 5 known species, 5 new species and 2 indeterminable species belonging to 5 families and 6 genera as follows. (1) *Bathyaecmaea* (Patellogastropoda: Acmaeidae): In addition to two already known species (*B. nipponica* and *B. secunda*), two new species were discovered from North Iheya Ridge (969-1000 m) and Ryuyo Canyon (1100 m), respectively. A single specimen from Sumisu Caldera (676 m) is possibly another new species. (2) *Serradonta* (Patellogastropoda: Acmaeidae): The genus had been represented only by the type species (*S. vestimentifericola*) from Sagami Bay (1110-1200 m). An additional new species was collected from a relatively very shallow chemosynthetic site, Kanesanose, Nankai Trough (284-322 m). (3) *Puncturella* (Vetigastropoda: Fissurellidae): The geographic and bathymetric range of *P. parvinobilis* was extended to several sites of Okinawa Trough (690-1430 m). *P. rimaizenaensis* from Izena Hole (1430 m) has not been collected again since the original description. (4) *Lepetodrilus* (Vetigastropoda: Lepetodrilidae): *L. nux* is very abundant in Iheya Ridge, Okinawa Trough (ca. 1000-1400 m). Another Japanese species, *L. japonicus*, is hitherto endemic to Minami Ensei Knoll (700-710 m). (5) *Pyropelta* (Cocculiniformia: Pyropeltidae): A new species of *Pyropelta* was collected from Sumisu Caldera (676 m). This record is first occurrence of the genus from western Pacific. (6) *Shinkailepas* (Neritopsina: Shinkailepadidae): A new species collected from Myojin Knoll (1288-1340 m) is similar to *S. kaikatensis* described from Kaikata Seamount (400 m). An unidentified single specimen was obtained from North Iheya Ridge, Okinawa Trough (976 m).

Seasonal change of phytoplankton abundance recorded in the shell microgrowth patterns of bivalves

Shin'ichi SATO

The Tohoku University Museum, Aoba, Aramaki, Aoba-ku, Sendai, 980-8578, Japan,
kurosato@mail.cc.tohoku.ac.jp

Seasonal patterns of shell microincrement growth in a venerid bivalve *Phacosoma japonicum* were analyzed for the three populations from Hakodate, Ariake, and Kagoshima Bays around the Japanese coasts. The northernmost Hakodate population in Hokkaido grew rapidly in a limited interval between late spring and summer. The number of microincrements within an annual increment in the specimens from this population was smallest (200 - 250 increments) among the three samples of populations examined, and each microincrement width was largest (0.25 - 0.3 mm) at the central part of an annual increment. By contrast, in the southernmost Kagoshima population in southern Kyushu, shell growth occurred slowly in a long term between early spring and fall. The specimens from this population are characterized by having narrowest microincrements (each 0.10 - 0.12 mm) and largest number of microincrements in the annual increment (300 - 350 increments). In this species, it has been confirmed that the growing season reflects the seasonal change of phytoplankton abundance. The phytoplankton bloom usually occurs in spring in embayments of northern Japan and in summer in those of central and southern Japan. In Ariake Bay (central Kyushu), however, the phytoplankton becomes most abundant in winter and remains at low levels in the other seasons. The Ariake population of *P. japonicum* showed the most active growth in intervals between winter and early spring. In this sample, the microincrement width attained a maximum in the earlier portion of each annual increment, and the annual increment showed a particularly right-skewed pattern which reflects the winter phytoplankton bloom in this bay.

Function and construction of bivalve hinges as evolutionary constraints

Enrico SAVAZZI¹ and Elizabeth M. HARPER²

¹ Institute of Earth Sciences, Villavägen 16, 75236 Uppsala, Sweden,
enrico@savazzi.net

² Department of Earth Sciences, Downing Street, Cambridge CB2 3EQ, UK,
emh21@cus.cam.ac.uk

Bivalve hinges are accretionary features. In most cases, their construction is controlled by a growth-conformable programme, with each hinge element following a growth trajectory that approximates a logarithmic helicospiral. Hinges also must allow the valves to articulate, *i.e.*, they must allow hinge elements to slide against opposing ones along circular trajectories centred about the hinge axis. The helicospiral and circular geometries, together, define a region of morphospace in which hinge elements can be built in a growth-conformable manner, without requiring secondary resorption and/or secretion of shell material. Several common bivalve hinges, including the heterodont type, comply with this model. The growth patterns of bivalve hinges are easily recognised by observing shell microstructure and growth lines.

Taxodont hinges pose special constraints, because of their geometry. Near the anterior and posterior extremities of long taxodont hinges, for instance, helicospiral and circular trajectories differ too much to allow useful hinge teeth to be built in a growth-conformable manner. As a consequence, modern taxodont hinges follow a growth-unconformable process, in which individual teeth do not migrate in the anterior or posterior direction along the hinge line, and new teeth are added at the extremities of the hinge line.

Taxodont-like hinges that evolved secondarily in unionaceans do not conform to this pattern, but instead follow a growth-conformable program, thanks to a few tradeoffs. The fact that two distinct growth programmes exist in superficially similar hinges makes it potentially possible to recognise instances of parallel evolution in early "taxodont" bivalves.

Other hinge types display adaptations to circumvent the constraints shared with growth-conformable and/or taxodont hinges. For instance, the secondary striations on the hinge teeth and sockets of *Neotrigonia*, and probably of fossil trioniids as well, change position slightly during growth.

Fine structure of protonephridia of *Haminoea* spp. (Gastropoda, Opisthobranchia)

Kurt SCHAEFER

Institut für Zoologie, Universität Wien, Althanstrasse 14, A-10190 Vienna, Austria,
kurt.schaefer@univie.ac.at

The character set of (marine) larval types of the major metazoan taxa has been a topic of far reaching phylogenetic considerations. Protonephridia are presumable excretory organs that predominantly appear in stages without coelomic organisation (*e.g.* larvae). Up to date protonephridia have been reported in nearly all spiralian phyla. Consequently the comparison of protonephridial structures within smaller - better defined taxonomic units seems to be justified. The protonephridia of *Haminoea cymbalum*, *H. exigua*, *H. callidegenita* and *H. navicula* had been investigated by electron microscopy. Despite different developmental types (intracapsular larvae, pelagic larvae, poeciligonous development) the principal organisation is the same in these species: A ciliary flame originates from a terminal cell and protrudes into an excretory duct. The terminal cell forms the inner closure of the protonephridium and build up the ultrafiltration apparatus. The nephrocyst as part of the protonephridium is provided with a duct bearing microvilli which contains the ciliary flame. The excretory duct, the cells of which are ciliated too, opens with a pore to the outside. There is no special pore cell, but the pore is built up by the surrounding epithelial cells of the body wall. The left pore opens to the subpallial cavity while the right one opens in front of the mantle cavity. As investigated in detail in *H. cymbalum* each terminal cell is in contact to a large rhogocyte. These rhogocytes lie dorsolaterally on the esophagus and are connected to the dorsal body wall by fine muscle bundles. This observation of rhogocytes in the direct neighbourhood of the protonephridia is new. While this further finding widens the knowledge of the distribution of rhogocytes new questions concerning their role and function arise. The duct accompanies the pleurovisceral connective. In tangential sections the filtration weir is visible as meandering slits. Cross sections of this area show the typical view with extracellular matrix, slits and lacunae. The adjacent positioned rhogocyte show a very similar structure. The nephrocysts are a portion of the protonephridium which are visible in total preparations and living specimens. Since such organs have been reported in a many opisthobranch larvae, the general presence of protonephridia in the Opisthobranchia can be assumed. This enhanced knowledge of the important larval character "protonephridia" will give support in further phylogenetic discussion.

Daily activity of the pest slug *Arion lusitanicus* (Mabille, 1868) under laboratory conditions

Karin SCHAUMBERGER¹ and Brigitte GRIMM²

¹ Institute of Zoology, Karl-Franzens-University of Graz, Universitätsplatz 2, 8010 Graz, Austria, karin.schaumberger@kfunigraz.ac.at

² The Natural History Museum, Mollusca Research Group, Cromwell Road, London SW7 5BD, England, pbm@nhm.ac.uk

Arion lusitanicus is known to be the most important pest slug in northern and central Europe. Previously, only the daytime activity and the influence of weather on its activity have been investigated. The aim of the present study was to establish the complete 24-hour activity pattern in order to determine the preferred times of day for locomotor activity, feeding, resting, and for the acceptance and role of artificial shelter traps.

The daily activity of *Arion lusitanicus* was studied using time-lapse video analysis in the laboratory. Track lengths were determined using image analysis. Under constant temperature (18° C) and 16-hours photoperiod *A. lusitanicus* was found to be most active at 5:30, 1.5 hours after sunrise, and at 21:00, 1 hour after sunset; least locomotor activity occurred at 13:30. The mean distance travelled by *A. lusitanicus* in 24 hours was 9.72 m. The largest slug was the most active and the smallest the least. Slugs spent 69% of the day resting, the major part of which was spent under artificial shelter traps. The remainder of the 24-hour cycle was spent in locomotor activity (27%) or feeding (4%). Feeding was observed mainly during the hours of the scotophase (76.1%). Track lengths and duration of locomotor activity varied greatly between individuals and also between days. Homing to artificial shelters and other roost sites was regularly observed within 24 hours (41.1%), but decreased heavily thereafter.

The data proved to be applicable to field conditions, and can subsequently be used to determine the timing and application of specific pest-management measures.

Neomenioid aplacophorans are numerically dominant on two East Pacific seamounts

Amélie H. SCHELTEMA

Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA,
ascheltma@who.edu

On the summit of two massive East Pacific seamounts, Fieberling Guyot and Volcano 7, neomenioid aplacophorans were numerically dominant in quantitative box core samples taken in soft sediments from the deep submersible RSV Alvin. Unlike species of Prochaetodermatidae, sometimes numerically dominant (Scheltema 1997), neomenioids have not yet been so reported. A single, and different, neomenioid species occurred on the summit of each seamount, where they live in physically demanding environments. The summit of Fieberling Guyot lies 4300 m above the bottom and 500-700 m below the surface. It experiences strong diurnal tidal currents 20-40 cm s⁻¹ (Levin *et al.* 1994). The neomenioid was taken in both heavy, basaltic sand with low sediment transport and light, foraminiferal sand with high sediment transport. Many more individuals occurred in the lighter, constantly moving sand (means 83.3 and 335.4 m⁻², respectively). Although polychaetes were the dominant higher taxon, in the light sand the single neomenioid species was 2 to >4 times more numerous than the number of individuals in any one polychaete family.

Volcano 7 rises 3400 m to ~730 m below the surface, where it intercepts the oxygen minimum zone; tidal currents are low, <6.9 cm s⁻¹ (Levin *et al.* 1991). Oxygen ranged from 0.08-0.09 ml/l at the upper summit between 745-760 m, where the neomenioid was dominant at an average abundance of 17 per 196 cm², more abundant than all polychaetes together and 1/3 total macrofauna. In contrast, oxygen was higher at the lower summit, 0.11-0.16 ml/l, but neomenioid abundance was low, averaging 0.5 per 196 cm² at 857 m. This neomenioid species is thus a creature of the hypoxic zone, with numerous exposed respiratory folds in the mantle cavity which is wide open despite fixation and contraction.

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Biodiversity of Loyalty Islands' Vermetidae and Siliquariidae (Mollusca, Caenogastropoda)

Stefano SCHIAPARELLI

Dip.Te.Ris., Dipartimento per lo studio del Territorio e delle sue Risorse, Università di Genova, I-16132 Genova, Italy, steschia@dipteris.unige.it

In the framework of the LIFOU 2000 expedition (Lifou Island, New Caledonia, Oct-Dec. 2000) of the Muséum National d'Histoire Naturelle of Paris (MNHN), particular attention was focused on two hard bottom sessile gastropods families, the Vermetidae and the Siliquariidae, which are usually scarcely taken into account during standard sampling efforts. This is mainly due to their cryptic life-style, which can be represented by sciophilic environments (Vermetidae) or, in the case of the genus *Tenagodus* (Siliquariidae), by the living body of a demosponge. The lack of a regular shell coiling pattern and the general similarity with serpulids made these families so unpopular a research subject that, to date, it is not possible to ascertain the actual number of living species.

On the whole, twenty-eight different "morphospecies" belonging respectively to the genera *Stephopoma* (3 species), *Tenagodus* (7 species), *Vermetus* (7 species); *Serpulorbis* (3 species), *Petalconchus* (2 species) and *Dendropoma* (6 species) were collected, from 0 to 50 metres depth. All of these "morph" are currently under revision in order to ascertain their correct taxonomic status. The biodiversity found in Lifou seems to be high. Among other Indo-Pacific areas, it is similar only to Japan (20 species; Okutani 2000), although the species composition is different.

Some of the most common Indo-Pacific vermetids species were not found here. This was true for the "giant vermetid" *Dendropoma maxima* Sowerby and *Vermetus enderi* Schiaparelli, 2000 (= *Serpulorbis roussaei*, Vaillant), which live in association with massive corals (*e.g.* *Porites* spp.) and gorgonians or black coral, respectively. The two species seem to be replaced by other co-generic vermetids within the same ecological niche.

On the other hand, some rarer species as "*Vermetus*" *tokyoensis* Pilsbry, 1895, which have a broad but scattered distribution as far as the western Indian Ocean (Maldives and Seychelles), seem to be quite common in Lifou.

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A sponge-dwelling vermetid (Mollusca: Caenogastropoda): a unique case of convergence with the slit-bearing Siliquariidae

Stefano SCHIAPARELLI and Riccardo CATTANEO-VIETTI

Dip.Te.Ris., Dipartimento per lo studio del Territorio e delle sue Risorse, Università di Genova, I-16132 Genova, Italy, steschia@dipteris.unige.it

Siliquariids, together with the unrelated vermetids, belong to a group of sessile caenogastropods whose shells undergo a "derailing" process which alters the regular coiling pattern of the classic gastropod Bauplan. Some members of this family (Siliquariinae), are deeply adapted (*e.g.* the presence of a long longitudinal shell slit) to the life inside a sponge, and they are obligatorily associated with these organisms. Their heteromorphic shell architecture can be explained by analysing the sponge morphology, the latter influencing the development of the whorls and, to some extent, the degree of coiling (Pansini *et al.* 1999). On the other hand, although vermetids, like siliquariids, are filter-feeders, they did not evolve any adaptation to a particular host and their shells are influenced exclusively by the topography of the surrounding hard substratum.

On a scientific expedition in the Bunaken-Manado Tua Marine Park (North Sulawesi, Indonesia), inside the cave of Raymond (30 metres depth), a strange, uncoiled vermetid species was found living in the body of a sponge (*Crybrochalina* sp.). The association cannot be considered casual, since many juveniles were found to have settled inside the canals of the aquiferous system, suggesting further research of the currents caused by the filtering activity of the sponge.

The majority of shells of this vermetid show a characteristic stretching of whorls, since they are "forced" to follow the extremely elongated sponge shape. On the contrary, specimens growing in the "wrong" direction (*e.g.* on the side of a sponge side instead of its top) are compelled to "compress" their whorls producing more "regularly" coiled shells. This behaviour can be regarded as a phenomenon of morphological and ecological convergence with the Siliquariidae.

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The evolution of highly endemic, highly derived micro-prosobranchs on isolated limestone hills in Borneo

Menno SCHILTHUIZEN

Institute for Tropical Biology and Conservation, University Malaysia Sabah, Locked Bag 2073, 88999 Kota Kinabalu, Sabah, Malaysia, schilthuizen@excite.com

As in most of Malaysia, limestone hills in Sabah (North Borneo) have a scattered distribution. At least seventy hills, ranging in size from that of a modest house to impressive karstic towers of several kilometres across, occur here. Although they tend to occur in clusters, many are separated by tens of kilometres of acidic, non-limestone soil.

The malacofauna of these limestone hills is dense and rich. Besides ubiquitous taxa, many species, especially from the prosobranch family Diplommatinidae, have only been recorded from these limestone localities, where they exhibit high degrees of endemism: many species only occur on a single hill. Moreover, they often show very curious shell shapes, which include spikes, flanges and lamellae on the whorls, and also detached, upturned, and reverse-coiled apertures.

Although it seems logical that obligate calcicolous, geographic isolation and endemism go hand-in-hand, the situation in these snails poses a number of questions:

- (1) how can any land snail species be an ecological specialist when it cannot actively seek out its habitat?
- (2) how isolated are these populations in reality? do they experience some form of long-distance gene-flow or not?
- (3) how have colonisation processes taken place?
- (4) what are the phylogenetic relationships among the endemic species?
- (5) what is the adaptive significance of those unusual conchologies?

This presentation describes the attempts currently being made to answer these and other questions using field studies, classical conchology, and molecular population genetics. Some preliminary data are presented on natural selection and gene flow.

Hybrizymes and rare haplotypes in land snail hybrid zones

Menno SCHILTHUIZEN¹, Rolf F. HOEKSTRA² and Edmund GITTENBERGER³

¹ Institute for Tropical Biology and Conservation, University Malaysia Sabah, Locked Bag 2073, 88999 Kota Kinabalu, Sabah, Malaysia, schilthuizen@excite.com

² Laboratory of Genetics, Wageningen University, Wageningen, The Netherlands

³ Institute for Evolutionary and Ecological Sciences, Leiden University, Leiden, The Netherlands

In hybrid zones, which are regions where genetically differentiated populations of organisms meet and produce hybrids, allozyme studies have often revealed unexpected alleles. The cause of this "hybrizyme" or "rare allele" phenomenon has been elusive, although it has variously been ascribed to natural selection or increased mutation rates. If the latter hypothesis is correct, selectively neutral markers should demonstrate increased variability in contrast to expressed markers such as allozymes. In this study, we screened selectively neutral variation in an intron of the Calmodulin (CaM) gene in a hybrid zone between two subspecies of the Greek land snail, *Albinaria hippolyti*. In previous allozyme studies, this hybrid zone has been shown to exhibit the rare allele phenomenon. We used a variant of the single-strand conformation polymorphism technique to detect seven haplotypes in both parental taxa. In the zone, one of these occurs at unexpectedly high frequencies. Since no additional mutants were found, we concluded that this is the result of selection.

The relation between burrowing depth and shell morphology of *Chambardia nyassaensis* (Bivalvia, Mutelidae) from Lake Malawi (East Africa)

Henning SCHOLZ

Institute for Palaeontology of the University of Wuerzburg, Pleicherwall 1, 97070 Wuerzburg, Germany, henning.scholz@mail.uni-wuerzburg.de

Unionid and mutelid mussels have been collected in Malawi between April and July 2000 with SCUBA diving and snorkeling. Altogether about 2500 specimens from 22 sample sites are now available. These specimens belonging to three species: *Coelatura nyassaensis*, *Chambardia nyassaensis*, and *Mutela alata*. The morphometric analysis of the shells of *Chambardia nyassaensis* shows a relation between burrowing depth and shell morphology. The size (parallel to the shell-length) of the area covered with algae in the posterior part of the mussels is being used as an indicator of the burrowing depth. Evaluation of bivariate scatterplots of shell-length vs. burrowing depth reveals that small mussels burrow deeper than big mussels and mussels in offshore habitats burrow deeper than mussels in onshore habitats. To quantify the shell morphology the elliptic Fourier analysis (Crampton & Haines 1996) followed by principle component analysis is being used. Comparison of the burrowing depth with the shell morphology in terms of PC1 shows similar shell morphology of relatively deep infaunal mussels irrespective of size. There is the same morphologic trend from onshore to offshore habitats and from big to small mussels. Offshore habitats in Lake Malawi and infaunal habitats in general are supposed to be more stable than onshore habitats and semi-infaunal habitats. Maybe a trade-off between the strength of the ligament and the shell weight to increase probing power for burrowing in dependence of habitat stability is responsible for the observed morphologic trends (Eagar 1978). However, to explain the change in behaviour is still a problem: Why do young and offshore mussels burrow deeper than old and onshore mussels?

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The big river effect in a big lake: *Coelatura nyassaensis* (Bivalvia, Unionidae) from Lake Malawi (East Africa)

Henning SCHOLZ

Institute for Palaeontology of the University of Wuerzburg, Pleicherwall 1, 97070
Wuerzburg, Germany, henning.scholz@mail.uni-wuerzburg.de

Between April and July 2000, 2500 unionid mussels from 22 sample sites along the western shore of the Lake Malawi have been collected. *Coelatura nyassaensis* is the only representative of the family Unionidae in Lake Malawi. The morphometric analysis of the shells has been done using some important shell measurements (length, posterior length, height, width) and elliptic Fourier analysis followed by principal component analysis and canonical correlation analysis. One result of the analysis is evidence of the big river effect in shell morphology as known from some rivers in the USA (Ortmann 1920, Watters 1994). Mussels in headwaters of these rivers are elongate, thin-shelled and compressed. Mussels from downstream habitats are more rounded, have thicker shells and have a high obesity. The shells of *Coelatura nyassaensis* are in onshore habitats elongate, thin-shelled and compressed and in offshore habitats less elongate, thick-shelled and relatively obese. Onshore and headwater habitats are more stable in terms of water energy conditions (turbulence, waves, currents) and changing water levels than offshore and downstream habitats. So the change in shell form has to be considered as a reaction of the increasing habitat stability from onshore/headwater habitats to offshore/downstream habitats.

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Locomotion behaviour of unionid mussels from Lake Malawi (East Africa)

Henning SCHOLZ

Institute for Palaeontology of the University of Wuerzburg, Pleicherwall 1, 97070
Wuerzburg, Germany, henning.scholz@mail.uni-wuerzburg.de

Unionid mussels from Lake Malawi have been studied from April to July 2000. So far, very little is known about the ecology of African unionids. Some behavioural aspects of the mussels have been studied in the Senga Bay area (southern part of the lake) for about five weeks. The experimental set-up consisted of an aquarium with sediment and water directly from the lake to create nearly natural conditions for the mussels. All three species of the Unionoidea from the lake were available for this experiment, *i.e.* *Mutela alata*, *Chambardia nyassaensis*, and *Coelatura nyassaensis*. The mussels were placed on the sediment surface and the time for the complete burrowing process and crawling process, including the time for the interval of individual rocking movements, were recorded in detail. In contrast to the crawling process the mussels slow down while burrowing. This is probably because of increasing viscosity and flow resistance of the medium (sand and water). Moreover, after reaching a stable position in the sediment there was no necessity to continue the burrowing process at the same speed. The instability of the habitat is probably the main trigger of crawling. During the experiment mussels only started crawling after removing them from life position. However, other explanations for crawling behaviour must exist, because in their natural environment with relatively stable conditions (18 m depth) mussels crawl as well.

Variation among populations of two pulmonate limpet species with different developmental modes (*Siphonaria capensis* and *S. serrata*)

Jennifer SEAMAN¹, Christopher D. MCQUAID¹, Willem FERGUSON² and Martin VILLET¹

¹ Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa.

² Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa.

Successful gene flow in any animal species requires some form of dispersal. Within populations of benthic marine invertebrates, larvae often fulfil this function. Two intertidal pulmonate limpets, occurring abundantly along the coast of South Africa, show different types of larval development. *Siphonaria capensis* produces larvae which live planktonically for at least one month before settling. *S. serrata* produces egg masses from which completely metamorphosed juveniles hatch. The potentially high levels of dispersal of *S. capensis* larvae should result in high genetic similarity among populations, with high gene flow along the coast. *S. serrata* is expected to show low genetic similarity among populations due to low dispersal and hence low gene flow. Gene flow is particularly difficult to measure directly in natural populations and so numerous biologists turn to indirect estimations. In this study two techniques are discussed; morphometrics and allozyme analysis. Morphological variation in both species was found to be greatly influenced by environmental factors (60 to 70%), rather than by the underlying genetic variation. The pattern of variation in both size and shape was similar in the two species. Through allozyme analysis genetic differentiation was estimated by F_{st} , a measure of allele frequency differentiation among populations. This was found to be higher in *S. serrata*, the direct developer, ($F_{st} = 0.40 \pm 0.28$) than *S. capensis* ($F_{st} = 0.25 \pm 0.08$). The two species also showed very different levels of gene flow, measured using Nm values. Nm estimates the number of individuals exchanged between populations in a single generation. This was high among *S. capensis* populations, especially along the east coast ($Nm = 46.1$). There is a strong suggestion that hydrography plays a role in influencing dispersal of *S. capensis* larvae, which were found to disperse long distances of up to 1400 km. Gene flow in *S. serrata* was highly variable, but generally low. Thus, while these two species show similar morphometric trends, *S. capensis* does indeed disperse relatively long distances, while *S. serrata* shows limited gene flow and higher differentiation among populations.

Nudibranch assemblages in the Gulf of Maine, USA: two decades of change

Kenneth P. SEBENS

Biology Department, University of Maryland, College Park, MD 20742 USA, and Marine Science Center, Northeastern University, Nahant, MA 01908 USA.

Nudibranchs are common and important predators on sessile benthic organisms in the Gulf of Maine rocky subtidal communities. The abundance of all nudibranch species has been recorded as part of a long term study of shallow subtidal sites (1978 to present), and the effects of particular species have been examined in detail. During the 23 years of this study, nudibranch densities and diversity have remained relatively constant despite some major changes in the character of the subtidal communities. An increase in sea urchin abundance caused several sites to lose most sessile invertebrates and to become dominated by crustose coralline algae. In 1984, *Tritonia plebeia*, a nonindigenous species from northern Europe, appeared and had severe negative effects on populations of its prey, the soft coral *Alcyonium siderium*. Although this nudibranch was present for only three years, the soft coral populations have not recovered to date. This change may be responsible for the decline in populations of other nudibranchs that utilize this prey.

Measuring the threats to conservation of Molluscs: the new IUCN 2001 criteria

Mary B. SEDDON

Department of Biodiversity and Systematics, National Museum of Wales, Cathays Park, Cardiff CF10 3NP, Cardiff, UK.

The IUCN Red list of Threatened Species 2000 includes species assessments on animals and plants, and has listed Molluscs since 1988. Many of the participants in the Unitas meeting have contributed data to the process, with over 170 molluscan scientists worldwide submitting data. In 1994 a new more objective quantitative method was introduced for the assessment of species. In 2000 there were 2017 Molluscs listed, of which 938 are Highly Threatened; 27% of these species were reassessed in 1999-2000 and 18 additions were made. Full documentation requirements made it impossible to up date all records without a resource base. The system introduced in 1994 did make the assessment of some groups, especially marine exploited species, difficult. Since 1997 there has been a widescale review of the categories and criteria used undertaken through a series of workshops, with different species specialists (taxonomists, applied & theoretical ecologists involved). The results of these workshops are available on the web (<http://www.iucn.org/ssc/themes/>). These resulted in some changes to the categories and criteria, and these came into effect on January 1st 2001. Since 1998, several changes have been made to the way that assessments are compiled: 1) A Red List office has been established in Cambridge, UK, with a permanent a IUCN Red List Officer. 2) IUCN have set-up their own web-site, (<http://www.redlist.org>) with a searchable database which will now be updated on an annual basis. 3) From 2000 all species listed must be fully documented. This included standardised descriptions of their range, habitat and threats (<http://194.158.18.4/intranet/DocLib/Docs/IUCN973.pdf>). 4) From 2001, selected taxon groups will be used to provide an indicator of the state of biodiversity.

Future needs: All of the Mollusca currently listed need review and complete documentation submitted to IUCN in the next year. In addition the targeted species groups include assessment of all Freshwater species, which will allow Mollusca to be included in the proposed "State of Biodiversity" equivalent of the Dow-Jones index measuring the global changes over time. The poster will demonstrate the data required to add species to the IUCN List of Threatened Species and summarise some current issues worldwide.

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Efficacy of different land-snail sampling methods in African forests

Mary B. SEDDON¹, Dai G. HERBERT² and Peter TATTERSFIELD¹

¹ Department of Biodiversity and Systematics, National Museum of Wales, Cathays Park, Cardiff CF10 3NP, Cardiff, UK

² Natal Museum, P. Bag 9070, Pietermaritzburg, KwaZulu-Natal, 3200, South Africa.

In 1998 different sampling strategies were used to sample land-snail faunas from 8 sites in KwaZulu-Natal, South Africa, from the coastal forest belt to the afro-montane forests in the Drakensberg Mountains. The methods used were developed from those used in East Africa where two different methods were combined:

1) Fixed-time sampling (direct search for live & dead snails, to sample from all suitable microhabitats)

2) Fixed-volume, litter layer sampling (indirect search for micro-snails that are leaf-litter dwellers)

In KwaZulu-Natal, 4 methods were deployed, using four collectors (1 inexperienced, 1 with experience in the local area and 2 experienced collectors with no knowledge of local area).

1) Fixed-time and fixed-area sampling (direct search for live & dead snails to sample from all suitable microhabitats in a 20 x 20m quadrat in 1 hour)

2) Fixed-volume litter layer sampling (indirect search for micro-snails that are leaf-litter dwellers from 5 fixed points (0.25m x 0.25m subquadrats within larger 20x20m quadrat).

3) Fixed-time, not restricted to area sampling (random, direct-search for live & dead snails to sample from all suitable microhabitats in 1 hour).

4) Selected litter samples of approximately fixed volume.

This poster compares estimates of land-snail diversity & richness, and snail abundance, obtained using each sampling method. It also looks at the effectiveness of different sampling strategies in terms of compiling a complete inventory of the land-snail fauna of a forest. Environmental site data were also collected, which will allow more detailed analysis of the influence of environmental factors on snail diversity in the future.

Molluscan biodiversity of East African forests

Mary B. SEDDON¹, Charles N. LANGE², Norbert KAYUMBO³, Christine MEENA³, Peter TATTERSFIELD¹ and Charles WARUI²

¹ Biodiversity and Systematics, National Museum of Wales, Cathays Park, Cardiff CF10 3NP, Cardiff, UK.

² Malacology Section, Dept of Invertebrates, National Museums of Kenya, PO Box 40658, Nairobi, Kenya.

³ National Museums of Tanzania, PO Box 512, Dar es Salaam, Tanzania.

Between 1996 and 2001, there was a UK government supported research and training programme aimed at building resource centres in Kenya and Tanzania, staffed with scientists able to carry out field surveys for terrestrial molluscs in critical ecosystems in each country. This poster shows the development of the project and presents some of the results from these surveys.

Tanzania: Surveys have been carried out in the Udzungwa and Mahenge forests, Pare Mountains, Mbulu Plateau, Kilimanjaro, Arusha National Park adding to those carried out by Tattersfield's earlier research in the Eastern Arc mountains (Tattersfield 1998, Tattersfield *et al.* 2000).

Collections are now stored in the main Museum at Dar-es-Salaam under the care of Christine Meena. A reprint library contains many papers describing Tanzanian Molluscs. Christine has continued work on Tanzania Molluscs with surveys in coastal forests and on the offshore islets around Dar es Salaam. New surveys in SW Tanzania on Mt Rukwa and Poroto Mountains took place in June 2001, from close to the border with Malawi.

Kenya: Surveys have been carried out in the Northern Kenyan mountains and Kakamega in western Kenya. In addition Charles Warui has completed his M.Sc. study on Mt Kenya (see *Unitas* paper: Tattersfield *et al.*) and Charles Lange has undertaken work on Taita Hills and Araboko-Sokoke Forests (Lange, this volume). Voucher collections are stored in the main Museum at Nairobi, where Bernard Verdcourt's voucher collections also reside. A small reprint library in the section contains many papers describing Kenyan Molluscs. New work is proposed on the Mau escarpment forests and the Aberdare Mountains.

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The extincting (relict) fauna in the Neogene of the Eastern Paratethys

Vladimir N. SEMENENKO

Institute of Geological Sciences, 55-B O.Gonchar street, Kiev, Ukraine, 01601,
ignnanu@geolog.freenet.kiev.ua

The problem of the possible co-existence of two different faunistic types, *i.e.* Caspian (or Pontian) and Mediterranean, or brackish water and normal marine fauna within the same basin and in the same time is frequently discussed. When taking advantage of the actualistic approach, the modern Azovian and Black sea basins may be given as a striking example. The rivers are there characterized by the Caspian type fauna, preceding that of the modern type (New Euxinian stage in the basin evolution). Thus, brackish water fauna (of "Caspian" type) in the Black Sea basin occurs at two stratigraphic levels: New Euxinian (the upper part of the Pleistocene), corresponding to the period when it occupied the whole area of the Azov-Black Sea basin, and the modern level, localized within river estuaries. In the later case it is synchronous to deposits containing the modern Black Sea fauna, represented by the euryhaline Mediterranean immigrants.

As an example may be taken fauna of the so-called *Oncophora* beds, which representatives are found also at two stratigraphic levels in the Paratethys Miocene (Upper Ottnangian and Karpatian regional stages of the Western and Central Paratethys; Kotsakhurian regional stage and Gurian beds of the Tarkhanian regional stage of the Eastern Paratethys). However, the simultaneous long-term existence of faunas of two types within the same basin is not apparent. Rather, it is appropriate to speak about fading of the preceding fauna over a rather short time period, whereas the preceding stage was characterized by brackish water conditions, and the hydrological regime had changed significantly.

Critical examination of the literature showed that the stumbling-block is the presence of small separated areas, usually on the periphery of the basin with fauna to its principal residents (*e.g.* the brackish-water "*Oncophora*" in a basin with the marine fauna, normal Cimmerian fauna and that of its "Duabian facies"). The area of distribution of such "extincting" relict fauna may be a few hundred kilometers more wide than the preceding basin, in which such fauna has prevailed. For instance, the New Euxinian basin was considerably smaller than the modern Black Sea basin; the relicts of its fauna, however, at present are fading in the estuaries at a significant distance from their preceding habitats. It is obvious that such a process is inevitable for Neogene epicontinental basins, connected periodically to the ocean, when brackish water fauna of the preceding stage for a time still has existed in limans of the basin, populated with fauna of other (marine) type.

Studies on the anatomy, radula structure, and protoconchs of endemic Acroloxidae (Pulmonata) of Lake Baikal and their ecological distribution in regard to depth and substrates

Alena SHIROKAYA¹ and Peter RÖPSTORF²

¹ Limnological Institute, Ulan-Batorskaya str., 3, Irkutsk, 664033, Russia, sit@lin.irk.ru

² Institut für Geologische Wissenschaften - Paläontologie, Freie Universität Berlin, Malteserstrasse 74-100, 12249 Berlin, Germany, rpeter@zedat.fu-berlin.de

Studies on the anatomy of 8 species of Baikalian acroloxids. The results revealed differences in the radula on genus and species level according to the number of teeth in one row and in the shape of the lateral teeth. Anatomical differences of the digestive system were found on species level concerning the number of platelets building the jaw, the color of the odontophor: greyish in all examined species of *Pseudancylastrum* and reddish in the *Gerstfeldtiancylus*, except for one species - *G. benedictiae*. Differences in radula structure and odontophor probably may be explained by a different manner of feeding. The muscular system of the species of *Pseudancylastrum* and *Gerstfeldtiancylus* is mainly identical: the anterior adductor lies on the longitudinal axis of the body. In the species of *Baicalancylus* the anterior adductor is shifted to the right (the angle to the longitudinal axis amounts to 40°). The shape of the embryonic shell varies on genus-level. In the genus *Baicalancylus* the protoconch is separated from the definitive shell by a mound-like structure. Some species differ significantly from the others species by the dimensions of their protoconchs. Phylogenetic trees are presented and discussed. Ecological observations showed that acroloxids prefer hard substrate in depths deeper than 2m (in the wave zone of 0-2 m they are nearly missing), while in depth of 2-5 m, where the impact of waves is still important, acroloxids are found mainly on the lateral sides of the stones. In depths of 5-20 m, the top of stones is preferred. The basic side of the stones is rarely settled by acroloxid and only if the stones are lying in several layers. The small species of *Baicalancylus* inhabit cracks and smaller deepenings. The highest diversity was observed on larger rocks (>100 cm²) in depths of 3-5 m.

The studies were supported by RFFR projekt 01-04-49365, Deutsche Forschungsgemeinschaft project RO 2236/1-2.

Phylogeny of the Caenogastropoda based on morphological characters

Luiz Ricardo L. SIMONE

Museu de Zoologia da Universidade de São Paulo, Cx. Postal 42594, 04299-970 São Paulo SP, Brazil, lrsimone@usp.br

A cladistic analysis of the Caenogastropoda was carried out based on the detailed morphological study of more than 250 species. The studied sample has representatives of most caenogastropod families, and, as outgroups, representatives of other gastropod taxa. The study was divided into two stages. The first stage consisted of subsidiary phylogenies of each caenogastropod superfamily. These analyses were done separately, in order to determine their phylogenetic identity and ground plan. The results support the monophyly of 13 superfamilies. Several previously separate superfamilies resulted as monophyletic taxa, while the taxon Architaenioglossa resulted as paraphyletic. The caenogastropod superfamilies are now considered as follows: Cyclophoroidea; Ampullaroidea; Viviparoidea; Cerithioidea (including Campaniloidea and Vermetoidea) (Simone 2001); Rissosoidea (including Littorinoidea); Stromboidea (including Xenophoroidea); Calyptraeidea (including Hipponicoidea and Capuloidea); Naticoidea; Cypraeoidea (including Lamellarioidea); Tonnoidea (including Ficoidea) and Neogastropoda (Conoidea, Muricoidea, Cancellarioidea). The second stage was the main phylogenetic analysis of the Caenogastropoda as a whole, with the superfamilies as terminal taxa. The characters used were obtained from the ground plans of each superfamily. The outgroups used were Patellogastropoda, Vetigastropoda, Neritimorpha and Heterobranchia. A single most parsimonious cladogram was obtained having 13 superfamilies disposed successively along the tree. The obtained cladogram agrees in several aspects with the results of Haszprunar (1988) and Ponder & Lindberg (1997). However, some important differences were detected. Its systematic and evolutionary implications will be discussed.

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Phylogeny of the Caenogastropoda based on morphological characters – complementary data

Luiz Ricardo L. SIMONE

Museu de Zoologia da Universidade de São Paulo, Cx. Postal 42594, 04299-970 São Paulo SP, Brazil, lrsimone@usp.br

A cladistic analysis of the Caenogastropoda was carried out based on the detailed morphological study of more than 250 species. The studied sample has representatives of most caenogastropod families, and, as outgroups, representatives of other gastropod taxa. This study consisted of subsidiary cladistic analyses of each caenogastropod superfamily, and the main analysis of the whole order with the superfamilies as terminal taxa. The details of the analysis are presented, supplementing the oral presentation on the same subject. The list of studied species, morphological characters used, the matrix obtained will be available for comments and discussion, since most of the data are still unpublished. The resulting optimized cladograms of each superfamily and of the whole Caenogastropoda are also presented.

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Human impact effects on the freshwater mollusc fauna from Transylvania and Banat (Romania)

Ioan SÎRBU

"Lucian Blaga" University, School of Sciences, Department of Ecology and Environmental Protection, 31 Oituz St., 2400 Sibiu, Romania, sirbui@yahoo.com

In the last 5 years the author has investigated the biodiversity of the freshwater mollusc fauna from Transylvania and Banat (Romania), establishing a synthesis on the present-day state of the specified group and its environment. The major rivers and wetlands from these areas were researched, namely the Olt, Mures and Somes rivers basins (in Transylvania), Bega, Timis, Caras, Nera and Cerna rivers basins (in the Romanian Banat). The sampling points have been selected in order to cover the whole area, to find and evaluate the effects of the human impact sources, and to identify zones of high diversity. The adverse human impact was followed both in space and time, the latter by comparing the present-day diversity and chorology with all the available data from references. In the specified area, 73 species of freshwater molluscs have been recorded (51 species of gastropods and 22 of bivalves), and for the first time dispersal maps have been plotted for these areas. The Red List proposed by the author comprise 25 species: 2 are most likely extinct, 5 are highly endangered, 7 are vulnerable, 8 are rare, and 3 species have an indeterminate status. The present-day status of the freshwater mollusc fauna proves the great habitat changes of the last decades, mainly caused by pollution of large river sectors, by hydrotechnical works and the drastic reduction of wetland areas. Most species have a patchy distribution, some became rare or have disappeared from the main part of their former range. In these areas, the the main trend is the prevailing of some euryoec basommatophoran pulmonates in correlation with the debasement of most prosobranch snails and of the unionid assemblages. The respective situations for each river basin are discussed, highlighting the present-day diversity of the aquatic mollusc fauna, the main sources of pollution and the effects of other human activities. The poor mollusc fauna, indicating degraded environmental quality, was registered in the riverbeds of some sectors of the main rivers from Transylvania (especially in the upper course of the Olt River, the middle and lower courses of the Mures and Somes rivers). The best ecological state was found in the southern part of the Banat, especially in the Nera River, and also in the springs, rivulets and glacial lakes from the Carpathian Mountains. Despite the human impact, some scattered, small-sized wetlands have preserved their natural status, sheltering remnant mollusc communities that should be protected and that can serve in the future as natural repopulating sources.

Baicalian gastropods: Species diversity and evolution

Tanya Ya. SITNIKOVA

Limnological Institute of SD RAS, Irkutsk, Ulan-Batorskaya str., 3, 664033, Russia,
sit@lin.irk.ru

Of 151 species of gastropods found in Lake Baikal, 118 are endemic. There are two entirely endemic prosobranch hydrobioid families: Benedictiidae (17 species) and Baicaliidae (43 species). The rest of the malacofauna includes prosobranch valvatids (16 species - 11 endemic), pulmonate planorbids (32 species - 22 endemic *Choanomphalus*, 2 endemic *Gyraulus*), and pulmonate acroloxids (26 species - 25 endemic). Other gastropod families are found in the lake, but have no Baicalian endemic species.

The first fossil gastropods of Baikal rift zone were dated as Oligocene-Miocene, 20-25 MYA (Popova *et al.* 1989). Zubakov's molecular analysis (1999) indicated divergence between the grazing benedictiids and filter feeding baicaliids at this time. During the long time period up to late Pliocene the Baicalian and Siberian faunas were isolated and the first steps of vicariant speciation occurred in Baikal. Significant glaciation (2.8-2.5 MYA) deposited large amounts of fine terrigenous material in the lake, resulting in increased turbidity of the water, significant change of diatom species composition and an almost total lack of biogenic sedimentation (Karabanov 1999). Thus, we propose that many gastropods went extinct from starvation and contamination of the mantle cavity with fine sediment. A molecular phylogeny of 26 Baicaliidae species shows that within the family there are two burst radiations (or star phylogenies) of present species dating from 2.5 MYA (Zubakov 1999) which correlate with a peak in diatom abundance and diversity (Karabanov 1999). Plio-Pleistocene Baikal was a series of several lakes with various biotopes repeated in each lake (Popova *et al.* 1989). We suggest that the rapid divergence correlates with allopatric evolution of molluscs in these biotopes. Formation of a single deep lake (about 1 MYA), occasional Holocene climate cooling, formation of new horizontal and vertical water flows led to intensive mollusk migration and clinal speciation for some species and hybridization for other species.

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Marine Prosobranchia and Bivalvia in the Faroe Region

Jon-Arne SNELI

Norwegian University of Science and Technology, Trondhjem Biological Station, N-7491 Trondheim, Norway, jon.sneli@vm.ntnu.no

Contributors: Jørgen Knudsen, Zoological Museum, Copenhagen; Kurt W. Ockelmann, Marinbiological Laboratory, Elsinore; Tom Schiøtte, Zoological Museum, Copenhagen; Jon-Arne Sneli, Institute of Natural History, Trondheim; Øystein Stokland, SINTEF, Trondheim; Anders Warén, Swedish Museum of Natural History, Stockholm; Per Bie Wikander, Grimstad
Investigations of the marine benthic fauna of the Faroese fishery territory started in 1987 with a Nordic programme called BIOFAR with sampling efforts concentrated at depths greater than 100 m. After the BIOFAR sampling concluded in 1993, a new programme called BIOFAR 2 from 1995 to 1998 sampled the depth area from the intertidal to 100 m depth. In the BIOFAR 1 programme roughly 600 localities were sampled with 790 deployments of sampling gear of which a triangular dredge, a detritus sledge, an epibenthic sampler and a bottom trawl were the gear most commonly used (Nørrevang *et al.* 1993).

Before BIOFAR 44 species of prosobranchs and 84 species of bivalves had been reported from the Faroese fishery territory. The BIOFAR 1 sampling increased the number of reported species to 84 and 59 respectively. At least five species new to science were found.

Using field data and estimated hydrographical data, the Swedish oceanographer Håkan Westerberg (1990) provided estimated bottom temperature, bottom salinity, and likely type of bottom water mass to each station sampled. The BIOFAR fauna may thus be related to depth and water mass preferences.

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Data on the habitat preferences of the three hungarian species of *Truncatellina* Lowe (Gastropoda, Vertiginidae)

Péter SÓLYMOS

Department of Zoology, University of Debrecen, 4010 Debrecen, POB 3, Hungary,
solymos@tigris.klte.hu

Three species of *Truncatellina* Lowe are known from Hungary. The European *Truncatellina cylindrica* (Férussac, 1807) lives both in plains and mountains. The Mediterranean/southern alpine *T. claustralis* (Gredler, 1856) lives in the mountainous ranges of the country only. Contrary, the also Mediterranean/southern alpine *T. callicratis* (Scacchi, 1833) is found only in the Transdanubian mountains. These three small species are sympatric at a few locations like, e.g., the Villány Hills. This sympatric occurrence of the three closely related species allows us to investigate their environmental demands and the habitat preferences.

The material studied was collected in the years 1996-1999 on the Szársomlyó and the Fekete Hill (Villány Hills). This survey yielded 16776 individuals of 28 mollusc species from 18 sampling sites (72 soil samples).

Cluster analysis of the sampling sites shows primary disjunction of the open and closed groups. Within these main groups we can differentiate subgroups on lower cluster levels. These subgroups can be named as extreme (moderately diverse) and moderate (diverse) cluster groups.

Truncatellina cylindrica is the more widely distributed and has the broadest tolerance range among the three species. Open-moderate areas provide optimal conditions for the species. *Truncatellina callicratis* and *T. claustralis* are usually allopatric, but when found together, *T. callicratis* is represented in very small numbers. *Truncatellina claustralis* never occurs in open habitats. It is also remarkable that within the sampling area, *T. callicratis* occurs only on The Szársomlyó. This pattern corroborates the refugial island function of the Szársomlyó.

All the three *Truncatellina* species are characteristic for different parts of the cluster hierarchy. This indicates different habitat patterns and preferences and different environmental demands. The open-moderate cluster groups serves proper conditions not only for the *Truncatellina* species but also for many other molluscs. This is probably caused by the heterogeneity of the habitats characterized by different vegetation structures, geomorphologic formations, and microclimates.

Spermathecal morphology and variation of spermathecal sperm content in two populations of the land snails, *Helix lucorum* and *Cepaea vindobonensis*, differing in timing and duration of reproductive period

Alexandra STAIKOU

Department of Zoology, School of Biology, Aristotle University of Thessaloniki, 540
06 Thessaloniki, Greece, astaikou@bio.auth.gr

The morphology of the spermatheca was studied in two populations of *Helix lucorum* and *Cepaea vindobonensis* living sympatrically in two different climatic regions in North Greece. The climate of the region of Edessa is of a humid mediterranean type with rainfalls during summer, while that of the region of Axios is of an intermediate mediterranean type with dry summers. In Axios, both species reproduce during spring and enter aestivation by mid-June. In Edessa, both species do not aestivate and may extend their reproductive period into summer.

Two samples were taken from each population, one in mid-April at the beginning of reproductive period for both sites, and the other in the beginning of June, which for Axios corresponds to the end of reproductive period while for Edessa it corresponds to the middle or even start of reproductive period for *Helix lucorum* and to the end or middle of reproductive period for *Cepaea vindobonensis*.

The morphology of the spermatheca and the sperm content of its tubules were studied in a total of 183 specimens, 93 *Helix lucorum* and 90 *Cepaea vindobonensis*. In both species the spermatheca consists of a simple fertilization chamber and a variable number of lateral tubules. The number of tubules in *Helix lucorum* ranged from five to sixteen and no interpopulation difference was observed. In *Cepaea vindobonensis* the number of tubules ranged from one to eight and there was a significant interpopulation difference. Snails from Axios had one to five tubules, while snails from Edessa had three to eight tubules. No intrapopulation difference was detected in both species from Edessa while a significant intrapopulation difference was detected in *Helix lucorum* snails from Axios.

The sperm content of the spermatheca tubules in each sample reflected the differences described above in timing and duration of reproductive period.

Molecular phylogeny of Scaphopoda - initial results from 18S rDNA sequences

Gerhard STEINER and Hermann DREYER

Institute of Zoology, University of Vienna, Althanstr. 14, A-1090 Vienna, Austria,
gerhard.steiner@univie.ac.at, hermann.dreyer@univie.ac.at

Molecular data on the conchiferan class Scaphopoda are scarce. Only a handful of 18S rDNA sequences were available from general molluscan or bivalve molecular phylogenies (e.g. Steiner & Hammer 2000). We here present a phylogenetic analysis based on 16 near-complete 18S rDNA sequences of seven families, using parsimony and maximum likelihood methods.

Scaphopod monophyly within the Mollusca is strongly supported, although sistergroup relationships to other molluscan classes remain obscure. Thus, there is no support from this data set for the Diasoma/Loboconcha concept deriving both Scaphopoda and Bivalvia from a common rostroconch ancestor. Within the Scaphopoda, the split between the two major taxa, *i.e.* Dentaliida and Gadilida, is robust unless gaps are considered as fifth base. This is due to inserts in two expansion regions in the Gadilida. The limited taxon sampling of dentaliid species does not allow for well-founded conclusions. There is, however, support for a deep rooting of *Fustiaria*, in accordance to some morphological analyses (Steiner 1998, 1999). The family Dentaliidae appears diphyetic due to two *Antalis* species being separated from the rest by the *Rhabdus* sequence, which is likely to be a long branch effect. Within the Gadilida, both Entalimorpha and Gadilimorpha are robustly monophyletic. However, monophyly of the family Gadilidae is not supported. The two *Siphonodentalium* species constitute the first gadilimorph offshoot, whereas *Pulsellum* is the sister taxon to the *Gadila* and *Cadulus* species. This topology is not only supported by sequence similarity but also by the lengths of the expansion regions.

Despite the presently limited taxon representation in the data set, there is good evidence for the monophyly of all major scaphopod groups from the 18S rDNA. Additional sequences will help elucidating the possible polyphyly of the families Dentaliidae and Gadilidae.

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Non-optimal shell construction: the overlap of theoretical and functional morphology

John R. STONE

Department of Animal Ecology, Evolutionary Biology Centre, Uppsala University,
Norbyvagen 18D, SE-752 36 Uppsala, Sweden, jon.stone@evolution.uu.se

A brief history of theoretical morphology based shell surface area and volume analyses (complementing and amending recent synopses in the literature; e.g., Stone 1997, Hutchinson 2000) and their application to functional morphology studies is presented. The ratio volume of material used : volume of space enclosed (Vshell:Vspace) was used as a measure of inefficiency and combined with empirical and theoretical analyses (e.g., Heath 1985, Stone 1999) to demonstrate that gastropod shells are constructed nonoptimally. On the basis of the species analysed, terrestrial gastropod shells are more compact (*i.e.*, exhibit more whorl overlap) than their most efficiently constructed, hypothetical forms, whereas marine gastropods are less compact (*i.e.*, exhibit less whorl overlap).

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***Bulinus* (Gastropoda: Planorbidae) on Madagascar: molecular taxonomy and transmission status**

J. Russell STOTHARD

Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, r.stothard@nhm.ac.uk

Urinary schistosomiasis is present on Madagascar and presently afflicts some 0.5 million people across western areas of the island. As in Africa, freshwater snails of the genus *Bulinus* are responsible for transmission of this disease and four species are reported to occur on Madagascar. These species have unclear affiliations to those on the African mainland and their transmission potential is not fully resolved. This presentation reports on recent work characterising populations of *Bulinus* and addresses two salient questions. Firstly, what is the evolutionary history of Madagascan *Bulinus*? Secondly, how are these species involved in transmission of urinary schistosomiasis?

Patterns of morphological differentiation in a monophyletic (?) species flock: the evolution of feeding and reproductive biology among Lake Tanganyika gastropods

Ellen E. STRONG and Matthias GLAUBRECHT

Institut für Systematische Zoologie, Museum für Naturkunde, Invalidenstrasse 43, D-10115 Berlin, Germany, ellen.strong@rz.hu-berlin.de, matthias.glaubrecht@rz.hu-berlin.de

The gastropods of East African lakes, particularly of Lake Tanganyika, have inspired interest since the first shells were returned by the expeditions of Burton and Speke in 1858. Despite continuing fascination with the evolutionary biology of African lakes and their endemic species flocks, anatomic knowledge of Lake Tanganyika's cerithioidean gastropods is limited to a minority of taxa, from several papers written during the late 1800's and first half of the 1900's. However, speculation on the origins of the assemblage, including extrinsic and intrinsic mechanisms involved in formation of the species flock, has not suffered despite this paucity of comparative data on which to found such conjectures. Although molecular analyses are beginning to refine the phylogenetic framework, such studies are still in their infancy. Consequently, the systematics of tanganyikan gastropods, their origin and relationship to non-lacustrine freshwater groups, and monophyly of the flock are not well established and have not been evaluated from a morphological perspective. Investigations revealed that tanganyikan gastropods display an anatomical diversity unrealized in any family of limnic Cerithioidea. This new morphological data and pre-existing descriptions were compiled in a matrix of 51 characters for 13 ingroup taxa (representing 13 of 17 genera) and five outgroups (*Melanoides tuberculata*, *Cleopatra johnstoni*, *C. ferruginea*, *Paludomus conicus*, *Potadomoides pelseneeri*). Optimization revealed several interesting patterns, particularly among alimentary and reproductive characters. For example, similar to results of phylogenetic analyses of the superfamily, lake clades are characterized by unique suites of midgut characters that differ from those of other clades occurring sympatrically on identical substrates; this conservatism is evident even in clades with diverse substrate associations (e.g. sand and mud). In addition, the invention of a viviparous reproductive mode has occurred at least three times within the lake, in the uterine brooders *Lavigeria* and *Tiphobia* as well as in *Tanganyicia*. The latter possesses a brood pouch within the mesopodium that is unique among viviparous Cerithioidea. The origin of incubatory structures as well as the implications of these new data for monophyly and relationship to non-lacustrine African taxa will be discussed.

Monophyly and systematic position of the enigmatic Ptenoglossa (Caenogastropoda)

Ellen E. STRONG¹, M.G. HARASEWYCH² and Patrick M. GILLEVET³

¹ Institut für Systematische Zoologie, Museum für Naturkunde, Invalidenstrasse 43,
D-10115 Berlin, Germany, ellen.strong@rz.hu-berlin.de

² Department of Invertebrate Zoology, Smithsonian Institution, National Museum of
Natural History, Washington, DC, 20560, harasewych@nmnh.si.edu

³ Institute for Bioscience, Bioinformatics, and Biotechnology, George Mason
University, Prince William Campus, 10900 University Boulevard, MSN 4E3,
Manassas, VA 20110, gillevet@ib3.gmu.edu

The Infraorder Ptenoglossa is a diverse group of marine caenogastropods that currently encompasses ~3000 species. As currently recognized, these species are distributed among six families in three superfamilies. Members of the group range in life mode from opportunistic predators to facultative ectoparasites and obligate endoparasites on sponges, cnidarians, and echinoderms. In addition to modifications in alimentary and reproductive anatomy reflecting their predatory and parasitic life modes, many species have become reduced in size (commonly < 5 mm). Thus, they are extremely differentiated compared to other closely related caenogastropods. This has contributed to confusion regarding the taxonomic composition and placement of the group. Higher order cladistic analyses are only beginning to address the phylogenetic placement of the Ptenoglossa and have failed to reach a consensus; such studies have not addressed monophyly of the infraorder.

For this analysis, a data matrix of morphological characters has been assembled, including conchological, external, alimentary system, reproductive system, and nervous system characters. A segment of the COI mitochondrial DNA gene (~650 bp) has been sequenced as well. In order to assess monophyly of the Ptenoglossa, at least one representative of each constituent family has been included (Triphoridae, Cerithiopsidae, Eulimidae, Aclididae, Epitoniidae, Janthinidae). To refine the systematic placement of the group, a series of outgroup taxa, representing all hypothesized sister taxa, has been incorporated. Implications for the monophyly and systematic placement of the infraorder within the Caenogastropoda will be discussed.

Late Badenian Paratethys connections based on bivalve faunas

Barbara STUDENCKA

Museum of the Earth, Polish Academy of Sciences, Al. Na Skarpie 20/26, 00-488
Warsaw, Poland, mzpaleo@warman.com.pl

Late Badenian (ca 14.0-13.2 Ma, age-equivalent to the early Serravallian) constitutes the last period of fully marine conditions in the history of the Central Paratethys. The total Late Badenian bivalve faunas from sandy facies include 316 species. The Late Badenian bivalve assemblages consist largely of Early Badenian survivors. The majority of them, *i.e.* 235 species were widespread, while 39 species were limited to the Paratethys. Apart from the Early Badenian remnants this fauna contains as many as 26 open-marine migrants which populated the Central Paratethys during the Late Badenian. At the same time, *i.e.* during the Konkian, the come back of the sea in the Eastern Paratethys led to its recolonization by marine fauna, whose composition documents a seaway connection towards the East Mediterranean through the re-opened Middle Araks Strait.

Because of the closure of the western Transtethyan Trench "Corridor", a broad re-opening of the Indo-Pacific seaways (from eastern Anatolia along the Pontides) towards the Central Paratethys was proposed. This is not confirmed by the composition of faunal communities which appeared in the Central Paratethys together with Late Badenian transgression. They resemble those of the Mediterranean, Atlantic and North Sea Basin. Moreover, the occurrence of boreal siliceous planktonic organisms was documented in the Central Paratethys and, even more important, the presence of an age-diagnostic holoplanktonic gastropods and calcareous phytoplankton bolboforms, both in common with the North Sea Basin. In addition, the immigration of the Mediterranean decapods and brachiopods has taken place and the distinct Atlantic - Mediterranean affinities at the generic level of the new evolved species are observed as well. In conclusion, the species composition of Late Badenian faunas strongly supports still operative connections between the Central Paratethys and Mediterranean in spite of closure of the western Transtethyan Trench "Corridor". The exact way of migration is, however, still disputable because of insufficient geological data.

Comparison of the species composition of Konkian and Late Badenian bivalve assemblages suggests an active faunal interchange between Eastern and Central Paratethys. Out of 97 bivalve species constituting Konkian fauna, 90 species were found in the Central Paratethys, 70 of which show wide geographic distribution, while 20 species appear to be restricted to the Paratethyan. It is remarkable that out of 20 endemic species, 9 evolved in the Early Badenian in the Central Paratethys and spread during early Konkian in the Eastern Paratethys area through the Predobrogean Strait.

A new pupilloid from Baltic amber

Ewa STWORZEWICZ¹ and Beata M. POKRYSZKO²

¹ Institute of Systematics and Evolution of Animals, Polish Academy of Sciences,
Sławkowska, 17, 31-016 Kraków, Poland, stworzewicz@isez.pan.krakow.pl

² Museum of Natural History, Wrocław University, Sienkiewicza 21, 50-335
Wrocław, Poland, bepok@culex.biol.uni.wroc.pl

Snail inclusions in amber are very rare; only three pupilloid inclusions have been described to date. A lump of Baltic amber (Eocene) from the collection of the Amber Inclusion Museum, University of Gdańsk, kindly made available to us by Prof. Ryszard Szadziwski, contains a very well preserved adult pupilloid. Based on the shell size, shape, colour and surface sculpture, the snail represents a new species of a genus related to extant European *Odontocyclas* and *Walklea*.

Land snail fauna of North Korea - Polish studies in an inaccessible country

Ewa STWORZEWICZ¹, Beata M. POKRYSZKO², Adolf RIEDEL³ and Andrzej WIKTOR²

¹ Institute of Systematics and Evolution of Animals, Polish Academy of Sciences,
Sławkowska 17, 31-016 Kraków, stworzewicz@isez.pan.krakow.pl

² Museum of Natural History, Wrocław University, Sienkiewicza 21, 50-335
Wrocław, bepok@culex.biol.uni.wroc.pl, awiktor@culex.biol.uni.wroc.pl

³ Batorego 15, 05-840 Brwinów, Poland.

Since the division of the Korean Peninsula after World War II, malacological studies have concentrated mainly on South Korea (Kwon 1990). Earlier data, though pertaining also to the northern part of the peninsula, are largely limited to areas located along the railroad from Seoul to the Chinese border. Scarce North Korean data from the 1980s made it possible to identify 18 land snail species.

Polish field studies in North Korea started in 1965, initiated by Riedel, and were continued in 1983-1991 by Stworzewicz (Pawłowski *et al.* 2000). Due to these investigations the list of land snail species of the area increased to ca. 50 (including new species), but this constitutes only about 50% of the terrestrial malacofauna reported by Kwon (1990) from South Korea. Regrettably, not all provinces could be explored equally thoroughly - travelling of foreigners close to the Chinese border is limited.

In the Korean malacofauna (including North Korea) the highest proportion is constituted by species found also in Japan and China, though the endemism is rather pronounced. Bradybaenids and helicarionids are very numerous in the North Korean malacofauna. Contrary to the southern part of the Peninsula, the malacofauna of North Korea is more similar to Holarctic or Palaearctic fauna. Such species as *Cochlicopa lubrica*, *Vallonia costata* and *Nesovitrea hammonis* are known from both Poland and North Korea.

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Biodiversity of molluscan assemblages in East Carpathian forests

Anna SULIKOWSKA-DROZD

Department of Invertebrate Zoology and Hydrobiology, University of Lodz, 12/16
Banacha Street, 90-237 Lodz, Poland, sulik@biol.uni.lodz.pl

Eleven forest patches in a protected area of Bieszczady Mts. National Park (Poland, East Carpathians) were quantitatively sampled for Mollusca assemblages. Study sites, each of 100 m² surface, represented different forest communities along an elevation gradient (650 - 1250 m a.s.l.): alder, beech, sycamore forests and subalpine shrubs. 25 samples (= 1 m²) were taken twice on each station: in spring and in autumn. Additionally, snails were collected directly from trunks and under logs.

Altogether 61 species were found, including 2 species of bivalves: *Pisidium personatum* Malm, 1855 and *Pisidium casertanum* (Poli, 1791). The species richness ranged from 11 to 41 taxa on different sites. The richest snail assemblage was recorded in the alderwood. Snails with a wide geographical distribution were most abundant, but also typically Carpathian species: *Semilimax kotulai* (Westerlund, 1883), *Vitrea transsylvanica* (Clessin, 1877), *Macrogastrea tumida* (Rossmässler, 1836), *Pseudalinda stabilis* (L. Pfeiffer, 1847), *Vestia gulo* (E.A. Bielz, 1859) and *Vestia turgida* (Rossmässler, 1836) were dominants and subdominants (D>5%).

Biodiversity of molluscan assemblages (Shannon-Weaver index) was significantly higher (ANOVA and Tukey's test, p<0,05) in alderwood than in other studied communities. The assemblage in rich beechwood was more diverse than that in dry grassy beechwood.

High biodiversity of molluscs was positively correlated with the number of plant species at the study site. Variety of plants was a good representation of overall habitat diversity and also created a diverse litter layer being a source of food and a shelter for most of snails and slugs. Shannon-Weaver index of diversity decreased along the altitudinal gradient, which was mostly caused by climatic factors limiting the species richness.

Late quaternary environmental changes and the influences of human communities: the molluscan evidence from the protected marshland at Bátorliget (NE Hungary)

Pál SÜMEGI, Tamás DELI and Gábor SZILÁGYI

University of Szeged, 6701 Szeged P.O.B. 658, Hungary, sumegi@geo.u-szeged.hu
Hortobágy National Park, 4025 Debrecen Sumen u. 2, gabor@www.hnp.hu

This study details a multidisciplinary palaeoecological and geoarchaeological study of some sedimentary sequences from Bátorliget marshy natural conservation area, in northeastern part of the Great Hungarian Plain. The principal aim is to review the effects of past human impact on the surrounding environment and reconstruct ancient environment within natural evolution of vegetation, soil, fauna developments and catchment basin ontogeny before occurring of productive economy using sedimentological, geochemical, isotope geochemical, palynological, macrocharcoal, vertebrate, malacological analysis. Unfortunately, the long-term relationship between different prehistoric human impacts and landscape evolution is hardly understood in the Carpathian Basin. Thus, a number of problems with nature conservation and geoarchaeological, palaeoecological aspects arise, like the following ones: Are the marches of the Carpathian Basin natural landscapes or were they created by human activity? It is known that population density, farming techniques and grazing pressure are some of the main reasons for land degradation nowadays. However, is this finding also true of prehistoric times? How can the Quaternary climatic effects be separated from prehistoric human impacts? As an unglaciated region during the last glacial the Carpathian Basin may have provided an important refuge to temperate flora and fauna, this region is an important intermediate zone between Balkan Peninsula and the western, eastern and northern parts of Europe. As a result of the above, Hungary occupies an important geographical position for European palaeoenvironmentalists and archaeologists, who explore the interactions among the effects of the lateglacial/ postglacial environmental changes and the natural faunal as well as floral expanding processes, furthermore between diffusion of agricultural activity and spread of different cultures in Europe. The research was carried out on Bátorliget marsh, a nature reserve area ~2 km west of the Hungarian-Rumanian border, in the northern edge of the Great Hungarian Plain. This region, named by Nyírség and surrounded by the high ridge of Carpathians (running in NW to SE) and the flat expanses of the Great Hungarian Plain to the West, can be found in a unique geographical position.

Malacological examinations of Pleistocene sequences in Dunaszekcső (Hungary)

Pál SÜMEGI and László HUM

Institute of Geology, University of Szeged, Egyetem u. 2-6. H-6723 Szeged, Hungary, sumegi@geo.u-szeged.hu, hum@geo.u-szeged.hu

We studied two sections in Dunaszekcső, one of them is the outcrop by Felszabadulás street, the other is the borehole on the Vár-hill. In the borehole we found the *Helicella obvia* in the Paks Lower paleosoil complex. In the upper part of the borehole there is a typical Upper Würmian mollusc fauna. Within the profile of the Felszabadulás street outcrop below the "Bag Tephra" horizon appears a very characteristic ecological level. The poor fauna with a low number of species reflects extremely cold climatic conditions. The mean July temperature during the cold maximum of the stadial decreased to 10-11° C. The cold dry open steppe area was occupied by only a couple of species. In this layer we found the Middle-Pleistocene *Neostyriaca corynodes*. In the next paleoecological level of the loess layer underlying the BA, the mean July temperature values were above 15° C. In the thin loess layer interbedded between the BD₂ and BD₁ paleosol horizons we defined a mild climatic period. Above the Mende Upper soil complex we found the paleoecological levels of the *Catinella arenaria* - *Semilimax kotulai* subzone of the *Bithynia leachi* - *Trichia hispida* biozone. We assigned the fauna of the strongly-weathered loess layer overlying the MF₁ paleosoil into the *Pupilla triplicata* zonula. During this warm climatic period with a relatively significant amount of rainfall and mean July temperatures of 17° C, the vegetation cover in this area was generally much more closed than in the central and northern areas of the Carpathian Basin. The fauna of the following paleoecological level have been assigned into the *Vallonia tenuilabris* zonula. The fauna assigned to the *Vallonia costata* zonula marks one of the mildest periods of the Würm3 stadial with mean July temperatures between 16° and 18° C. The fauna of the succeeding cooler and more humid period have been assigned into the *Columella columella* zonula. The values of the mean July temperature of the rainy period are generally 3-4° C higher than those identified for the north-eastern areas of the country. We could not identify representatives of the fauna belonging to the *Pupilla sterri* zonula in the area. The climate continued to be mild and humid. The layers overlying the ones belonging to the *Punctum pygmaeum* - *Vestia turgida* zonula can be divided into two on the basis of the malacofauna. The upper part of it belongs to the *Columella edentula* zonula. Sediments deposited in the latest loess sedimentation phase of the Würmian (*Vertigo antivertigo* - *Vertigo geyeri*) were missing from the upper part of the studied sequences.

Quaternary malacological analysis for modelling of the upper Weichselian palaeoclimatic changes in the Carpathian Basin

Pál SÜMEGI and Endre KROLOPP

University of Szeged, 6701 Szeged P.O.B. 658, Hungary, sumegi@geo.u-szeged.hu
Hungarian Geological Institute, 1143 Budapest Stefánia u. 14, Hungary

The Late Pleistocene environmental history of the Carpathian Basin can be regarded as one of the missing links to our understanding of the last glacial development of Europe. Changes in the radiocarbon-dated Mollusc faunas of the loess areas, along with the palaeogeographic interpretations implied by them seem to underlie the latest results gained from radiocarbon dated pollen analysis of the region. Changes in the Mollusc fauna refer to nine short-lived (1000 - 3000 years), cyclical palaeoclimatological alterations, which repeatedly transformed the palaeoecological conditions and vegetation in the Carpathian Basin between 34 - 12 kyr. On the basis of malacological data the presence of a major palaeoclimatic trend could be assumed for both the periods of warming up and cooling in the Carpathian Basin. The mildest July palaeotemperatures were recorded in the SW parts, while the coldest ones were recorded in the NE parts of the basin. Humidity and vegetation cover displayed a large-scale mosaic type heterogeneity reflecting the modifying effect of local factors. It seems that the Upper Weichselian environment was mosaic or mosaic-like in the Carpathian basin. According to the analysis of radiocarbon dated malacological data from the Upper Weichselian short-term climatic fluctuations with 2000-5000 years cyclically, the so-called subMilankovits cycles could be identified in the Carpathian Basin. Palaeotemperatures seem to have displayed large-scale fluctuations with mean July temperature values 8 °C lower than today during the coldest periods. During the short-lived warmer phases only a 1-2 °C difference could be inferred between the former and present July palaeotemperatures. Results of the malacothermometric and compositional analysis of the malacofauna seem to display good correlation with data gained by the climate simulation model of Kutzbach and the fluctuations of the oxygen isotope curve of the annual-layer-dated GISP2 core. However, as the malacothermometric analysis was carried out on samples with a larger scale embedding 400-600 year periods, no direct correlation of this data could be made with the fine-scale, high resolution climate curve, embedding changes lasting for some decades only, gained from the annual-layer-dated GISP2 core. Correlation was feasible only with major trends in the data such as the cooling phases of the Heinrich events or the Dansgaard – Oeschger interstadial horizons.

Gastropod evolution in a special palaeoenvironment, represented by the Lower Jurassic Hierlatz Limestone (Austria, Hungary)

János SZABÓ

Geological and Palaeontological Department, Hungarian Natural History Museum
1431 Budapest, Pf. 137, jszabo@paleo.nhmus.hu

The Hierlatz Limestone is a predominantly Austrian (Northern Calcareous Alps) and Hungarian (Transdanubian Central Range) sedimentary formation of Sinemurian–Pliensbachian age. Uncertain indications are also reported from the Southern Alps (Italy) and from Slovakia (Western Carpathians). Typically, this lithology appears either as (usually multi-phased) fissure-filling or poorly stratified surface deposition. The underlying limestones are of shallow water platform origin. Reconstruction of the depositional palaeoenvironment of the Hierlatz Limestone suggests hilly sea bottom topography, formed from earlier submerged, drowned and tectonically disintegrated large carbonate platform(s) ("horst & graben pattern"). Genetically, the Hierlatz Limestone is connected to the submarine elevations, most probably to the highest ones, reaching sometimes also the photic zone. However, the sedimentary characteristics as well as the microfossils suggest belonging to the Jurassic pelagic realm. The most probable Jurassic palaeogeographic position of the Hierlatz Limestone depositional area was the interior of the Tethys, without significant communication with the Euro-African shelf and epicontinental seas.

From the point of view of the global evolutionary events, the Early Jurassic belongs to the recovery period, following the Late Triassic mass extinction. The scattered topographic heights in the pelagic area provided lots of more or less isolated benthic biotopes of usually reduced extension from several hundreds of square meters to a few square kilometres. The isolation is one of the most common inducing factors of the independent evolutionary processes. As a consequence, the rather poor and monotonous post-Triassic survivor gastropod faunas changed into numerous, diverse endemic associations. Presence of new, endemic taxa in single or several neighbouring Hierlatz Limestone localities is also quite common.

Most of the new gastropods belong to the Archaeogastropoda, but precursors of more advanced forms are also present in the fauna. Some of the supraspecific novelties: earliest known occurrence of pleurotomarioidean type, persisting up to present; first fissurelloidean (fissurellid) having trema as exhalant opening on the shell; appearance of turriculate trochoideans; development of trochomorph gastropod with foliated shell structure; needle-shaped early rissoinimorph caenogastropods; bucciniform shell (? earliest *Maturifusus*).

Differences in the genetic structure of two sympatric lithophilous gastropods: history vs present-day distribution

Magdalena SZAROWSKA and Andrzej FALNIOWSKI

Department of Malacology, Institute of Zoology, Jagiellonian University, R. Ingardena 6, 30-060 Kraków, Poland, szar@zuk.iz.uj.edu.pl

The genetic structure of two rock-dwelling pulmonate snails, *Chondrina clienta* (Westerlund, 1888) and *Clausilia parvula* Férussac, 1807, were studied by means of cellulose acetate allozyme electrophoresis, on respectively 13 and 7 populations from Kraków-Częstochowa Upland, South Poland. Five of the studied populations were sympatric. In *C. clienta*, 16 enzyme systems coded by 25 loci were assayed. In 8 populations the loci were monomorphic; in the remaining 5 one or two of the following loci were polymorphic: Aat-1, Aat-2, Est-1. For the polymorphic loci there were heterozygote deficits and high values of pairwise q . In *C. parvula* 9 enzyme systems coded by 12 loci were assayed, one third of them were polymorphic. There were significant heterozygote deficits in almost all populations and loci and q values were low. In both species the observed deficits are probably due to mainly selfing/inbreeding, but the levels of polymorphism and q are strikingly different. In the bigger, more mobile and less associated with the exposed rock surface *C. parvula* selfing is rarer (or absent), inbreeding less severe and isolation less complete than in *C. clienta*. Consequently, the evolutionary effective population size in the former species may be much higher, thus polymorphism decay due to genetic drift much slower, than in the latter. The differences in genetic structure may reflect the different histories of the two species. The habitat *C. parvula* occurs in is that of limestone rocks in a woodland. A few centuries ago that type of habitat was almost continuous in the studied area. Then the forested area began to shrink and vast discontinuities appeared in it. The continuous big population was split into many isolated small populations. The time of isolation was, however too short for the local populations to become conspicuously differentiated. It seems that neither founder events nor bottlenecks have considerably contributed to the present-day pattern so that the fragmented polymorphic populations have retained the ancestral polymorphism. On the other hand, deforestation caused the proliferation of dry, sun-exposed rocky habitats suitable for *C. clienta*. These new habitats were subsequently colonized, one by one, by immigrants maintaining small populations. The genetic structure of the populations reflects the founder events and bottlenecks, through which the populations have gone. It is prone to polymorphism decay as a consequence of genetic drift and selfing.

Distributional patterns of freshwater Bivalvia in Argentina

Mónica P. TASSARA, Inés I. CÉSAR, Alejandra RUMI, Diego E. GUTIÉRREZ
GREGORIC, M. Andrea ROCHE, Stella M. MARTÍN and Verónica NÚÑEZ

Invertebrate Zoology Div., Facultad de Ciencias Naturales y Museo, Universidad
Nacional de La Plata, Paseo del Bosque s/n°, 1900 La Plata, Buenos Aires, Argentina,
mtassara@museo.fcnym.unlp.edu.ar

At the moment there are few general works about the distributions of freshwater and mixohaline shellfish in Argentina (Parodiz 1969, Bonetto 1961, 1986). The aim of this work was to study the species richness and geographical taxonomic diversity patterns throughout areographical methods (Rabinovich & Rapoport 1975). The number of species and families of bivalves were presented in the form of isoline maps. The specific distribution trends related to hydrographic subregions following Bonetto (1994) were analysed. The isorichness lines throughout latitudinal and longitudinal gradients (five W-E longitudinal and eight N-S latitudinal transects), were described. The record areas were plotted on a reticular map. Each surveyed squared area (N= 336) comprised 10,000 km², using a 100 x 100 km grid. The material examined belongs to the most important collections of Argentina. The taxonomic diversity of Bivalvia was estimated by the Shannon & Weaver formula.

For Argentina, 57 species which belong to 7 families were described, 3 of these species were introduced. The Mycetopodidae and Sphaeriidae had the highest numbers of species, both of them with 18.

The highest specific richness was recorded in the Guayano-Brasilic subregion (Del Plata basin), at the east of Río de la Plata river, where the Uruguay river and the Paraná-Paraguay system flow out. The richness decreased to NW, W and S. The Chileno-Patagonian subregion (Atlantic flowing) showed the highest richness of the region at the Colorado, Neuquén and Limay river basins. In Patagonia, the richness decreased rapidly in the NW-SE direction and slowly in the NW-SW direction because it is supported by the big lakes and the Andean headwaters of the rivers. The endorreic Córdoba province basins and the headwaters of the rivers which originate at the subandean region are endemic areas with specific increments.

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Biogeographical and biodiversity patterns of land-snails in East and South African forests

Peter TATTERSFIELD¹, Mary B. SEDDON¹, Dai G. HERBERT², Charles WARUI³, Charles N. LANGE³ and Christine MEENA⁴

¹ Department of Biodiversity and Systematics, National Museum of Wales, Cathays Park, Cardiff CF10 3NP, Cardiff, UK

² Natal Museum, Private Bag 9070, Pietermaritzburg, 3200, South Africa

³ Department of Invertebrate Biology, National Museums of Kenya, P.O. Box 40658, Nairobi, Kenya

⁴ National Museums of Tanzania, P.O. Box 512, Dar-es-Salaam, Tanzania

Between 1993 and 1998 land-snail faunas have been sampled using reasonably standardised and semi-quantitative methods, in 32 East African and 8 South African forests sites, overall spanning a latitudinal range from 29.5° S in KwaZulu-Natal to 2.44° N in North Kenya, and an altitudinal range of 15 m (Indian Ocean coastal forests) to over 2800 m (Afromontane forest) on Mount Kenya. The sites sampled include examples of the main forest types in Africa, including east African coastal forest in the Zanzibar-Inhambane region, and Afromontane, Guineo-Congolian and Tongaland-Pondoland types (White 1983). Elevational gradients have been studied in South Africa, extending from the coastal forest belt to the Drakensberg Mountains, and in East Africa from Guineo-Congolian lowland forest to Afromontane communities on Mount Kenya and in the Rwenzori Mountains of Uganda. This paper will describe the work undertaken and examine both local and large-scale geographical patterns in the forest land-snail faunas. Variations in land-snail species diversity and richness, snail abundance and the distribution of the main taxonomic and faunal groupings will be examined in relation to site latitude, elevation, rainfall, environmental history and other eco-geographical variables.

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Adaptations to chemosymbiosis: disparity and diversity of Lucinidae

John TAYLOR and Emily GLOVER

Department of Zoology, The Natural History Museum, London SW7 5BD, UK,
j.taylor@nhm.ac.uk

Of the five families of bivalves in which chemosymbiosis has been demonstrated, the Lucinidae are by far the most diverse, are geographically the most widespread, live in the greatest range of habitats and have the longest and richest geological history. All species studied so far possess chemosymbiotic bacteria housed in bacteriocytes within the ctenidia. In addition to the highly modified gills lucinids possess a range of other anatomical features associated with the chemosymbiosis, these include: periostracal pipes, the elongate cylindrical foot, position and shape of the anterior adductor muscle, the posterior apertures, the mantle septum, mantle gills and the large pallial blood vessel (Taylor & Glover 2000). These features will be briefly reviewed focussing on the mantle gills which are often complex, secondary respiratory structures conspicuous in *Codakia*, *Lucina*, *Phacoides*, *Anodontia* and *Fimbria*.

Lucinids are anatomically disparate and this is reflected in their differing biologies and the range of habitats and environments they inhabit. Although lucinids are often associated with habitats having a high organic input they can also be diverse and highly abundant in what are considered oligotrophic environments such as the outer Great Barrier Reef. New data from intensively sampled sites, such as around New Caledonia, demonstrate that in the tropics lucinid diversity has been severely underestimated and there are many undescribed species and genera. Despite the biological interest in the Lucinidae there is no recent phylogenetic framework, using either morphological or molecular characters, on which to test hypotheses of evolution within the group. Preliminary results of a molecular phylogeny of Lucinidae will be presented.

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Effects of extracts and isolated amides of *Piper tuberculatum* on *Biomphalaria glabrata* (Say, 1818)

Edson TEIXEIRA¹, Hosana M. D. NAVICKIENE², Maysa FURLAN², Massuo Jorge KATO³ and Toshie KAWANO¹

¹ Laboratório de Parasitologia, Instituto Butantan, São Paulo, SP, Brasil.

² Departamento de Química Orgânica, Instituto de Química, Universidade Estadual Paulista, Araraquara, SP, Brasil.

³ Departamento de Química Fundamental, Instituto de Química, Universidade de São Paulo, SP, Brasil.

The effect of the extract obtained from leaves of *Piper tuberculatum* and several isolated amides on different stages of *Biomphalaria glabrata*, the vector of *Schistosoma mansoni*, were evaluated. The powder of dried leaves was extracted by dichloromethane/methanol (2:1) and concentrated under vacuum to give the crude extracts. *Biomphalaria glabrata* from Belo Horizonte (Barreiro) have been maintained at laboratory conditions over 20 years. Adult snails of 10-18 mm shell diameter and egg-masses at blastula, gastrula and trochophore stages were analysed regarding the effect of extracts obtained from leaves of *Piper tuberculatum*. Effects of extract were detectable on trochophore stages at concentrations of 15 ppm (11% mortality and 84% of malformation). The extract obtained from leaves of *Piper tuberculatum*, was submitted to chromatographic fractionation and three amides have been isolated so far: piplartine, F-2C-69, and F-2C-64. One of the most active compounds isolated from the extract, the amide piplartine, was 100% active at concentrations of 2 and 6 ppm in egg-masses and adults of *B. glabrata*. A second amide F-2C-69, was effecting 100% of blastula and gastrula stages at a concentration of 10 ppm. The amide F-2C-64 was effecting 100% of blastula stages at the concentration of 10 ppm, and stages from gastrula to trochophore at the concentration of 15 ppm. These results showed that the extracts of *Piper tuberculatum* can be considered as a molluscicide with potential for further development to control schistosomiasis in tropical countries.

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Morphology and taxonomy of some neotropical species of *Pomacea* (Gastropoda; Ampullariidae)

Silvana C. THIENGO¹, Luiz Ricardo L. SIMONE² and Monica A. FERNANDEZ¹

¹ Inst. Oswaldo Cruz, Depto Malacologia, 4365 Av. Brasil, 21045-900 Rio de Janeiro, Brasil, sthiengo@ioc.fiocruz.br

² Museu Zoologia USP, Caixa Postal 42594, CEP 04299-970 São Paulo, Brasil, lrsimone@usp.br

Ampullariids are amphibious freshwater snails distributed throughout the tropical regions in the world. Besides *Pomacea* Perry, 1810, three genera, *Asolene* Orbigny, 1837; *Felipponea* Dall, 1919 and *Marisa* Gray, 1824 occur in Brazil. Some species as *Marisa cornuarietis* (L.) and *Pomacea haustum* (Reeve, 1856) were used in biological control programs of the intermediate hosts of *Schistosoma mansoni* Sambon, 1907 while others are considered agricultural pests. *Pomacea canaliculata* (Lamarck, 1822) had been introduced in Asia and became a pest in rice fields. The genus *Pomacea* includes the largest freshwater snails and ranges from north to south Brazil. In spite of abundance and wide distribution, the taxonomy of the group, based chiefly on highly variable shell characters, is still confused with almost fifty specific names recorded to Brazil. Studies on the shell, radula, pallial complex, macro and microanatomy of male and female reproductive systems aiming the taxonomic revision of this genus have been done by the authors based chiefly on specimens collected at type-localities. This paper deals with the morphology of shell, radula and reproductive system of *Pomacea bridgesii* (Reeve, 1856), species originally described to Bolivia and common in the Amazon river drainage. Albino specimens are known as golden apple snails and are nowadays largely spread in the world due to the aquarists trade. Morphological comparisons with other nearer congeneric species: *Pomacea glauca* (L.), *Pomacea scalaris* (Orbigny, 1835) and *Pomacea sordida* (Swainson, 1823) are also given. Significant morphological differences between these species are mainly in the male reproductive system: the length of the sheath, prostate and penis, the penial sheath and prostate shape, and the distribution of the glands on the sheath. This is the first description of the inner morphology of *P. bridgesii*.

The bivalve *Panopea faujasi* and its trace fossil

Elsebeth THOMSEN¹, Richard G. BROMLEY² and Nils-Martin HANKEN³

¹ Tromsø University Museum, Department of Geology, N-9037 Tromsø, Norway, elsebeth@imv.uit.no

² Geological Institute, University of Copenhagen, Østervoldgade 10, DK-1350 Copenhagen K, Denmark, rullard@geo.geol.ku.dk

³ Department of Geology, University of Tromsø, N-9037 Tromsø, Norway, hanken@ibg.uit.no

The bivalve genus *Panopea* has a cosmopolitan distribution today and has been identified back to the Middle Jurassic. It is predominantly a shallow-water genus, generally preferring nearshore muddy sand or sand substrates in water depths less than 60 m. Panopeans are deep-burrowing bivalves that have been reported to live in burrows from 0.5-1.5 m beneath the sea floor.

Panopea faujasi Ménard de la Groye, 1807 is locally abundant in shallow marine Late Pliocene sediments on the island of Rhodes in the Aegean Sea. The Panopeans occur in life position within their burrow-fill, e.g. at a single horizon at two localities in the Ladiko area. Several specimens of *Panopea faujasi* have been collected for further studies, and their trace fossils have been studied in detail, i.e. by vertical and/or horizontal sectioning (Hanken *et al.* 2001).

The object of the poster is to illustrate these large-scale, well-preserved trace fossils, which can be of importance for the interpretation of the local sedimentary depositional history, i.e. sedimentary accretion or erosive phases.

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Imposex in the gastropods *Trunculariopsis trunculus* (L., 1758) and *Bolinus brandaris* (L., 1758) from the littoral of Málaga (South of Spain)

Cristina TIRADO and Carmen SALAS

Dept. Biología Animal, Facultad de Ciencias, Universidad de Málaga, 29071 Málaga, Spain, casanova@uma.es

High percentages of imposex (development of penis and vas deferens in females) have been observed in the gastropods *Trunculariopsis trunculus* (L., 1758) and *Bolinus brandaris* (L., 1758) from the littoral of Málaga during an annual study of their reproductive cycles, from June 1999 to May 2000.

Bolinus brandaris showed a higher annual percentage of imposex (58.5%) than did *T. trunculus* (34.3%). The percentages of imposex ranged in *B. brandaris* between 16.6 % in November to 85.7% in April, but in most months the percentage was greater than 50%. The imposex in *T. trunculus* ranged between 16.1% in September and 47.8% in March.

The imposex of gastropods is related to contamination by organotin compounds, particularly tributyltin (TBT), used as a biocide in antifouling paints of ships; because of that, this type of contamination is particularly evidenced near harbour areas. Although international legislation has restricted the use of TBT, the existence of imposex in these species, living in the open sea, far from harbours, is evidence of the occurrence of organotin pollution in the Strait of Gibraltar area, probably in relation to high shipping activity and to the increase along the littoral of Málaga of recreational marinas.

Species diversity of the *Lavigeria* species flock (Gastropoda: Thiaridae) of Lake Tanganyika - a re-evaluation using multiple datasets

Jonathan A. TODD¹ and Ellinor MICHEL²

¹Department of Palaeontology, The Natural History Museum, London, SW7 5BD, UK, J.Todd@nhm.ac.uk

²Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, PO. box 90766, 1090-GT Amsterdam, The Netherlands, michel@science.uva.nl

Species delimitation in the endemic thiarid *Lavigeria* has posed considerable problems ever since first described 140 years ago. Although shells have complex, prominent ornament, a wide variety of gross morphologies and range of adult sizes, systematists found it difficult to separate conchologically discrete species. Bourguignat introduced 46 species and 4 genera between 1885 and 1890 that are now assigned to *Lavigeria* and another 7 extant species described since. Almost all of these species were based on small numbers of abraded, beach-collected, empty shells, often lacking what we show to be species-diagnostic characters. In the 1950's, reaction to his essentialist species discrimination was formed by the trend to "lump" species. This resulted in all these species being subsumed within a single species in the last revision, a situation that still stands.

Over the past 15 years extensive sampling of scores of sites around the lake by snorkelling and SCUBA has allowed the great majority of the published nominal species to be identified with living populations. We have examined the shell morphology of 700 lots of ~15,000 newly collected specimens by SEM and light microscopy and have discovered an abundance of systematically useful characters in: protoconch and early teleoconch morphology, adult shell form, ontogeny and details of shell micro- and macrosculpture, opercular type, and colour patterns. We delimited working species-concepts using these shell characters, independent of geographical considerations to prevent occurrence information biasing our identifications and then assigned the nominal species to our concepts. Our "conchological species" have proved to be congruent with those so far delimited by gross anatomy, radular, allozyme, COI and 16S molecular analyses, studies of brooding patterns (Kingma & Michel, this volume) and adult modifications (Papadopoulos & Todd, this volume). Previous studies were misled through cursory treatment of shell characters, coupled with the presence of homeomorphy, extensive intra- and inter-populational variation, and high sympatric diversities.

Our systematic framework for the genus currently consists of over 30 species. *Lavigeria* species range from almost lake-wide to substrate-specific point endemics and we shall present occurrence and sampling data that suggest many more species remain to be discovered as sampling improves.

Histochemistry and ultrastructure of salivary, pedal and sole glands in *Wirenia argentea* (Solenogastres, Wireniidae)

Christiane TODT and Luitfried SALVINI-PLAWEN

Institute of Zoology, University of Vienna, 14 Althanstraße, A-1090 Wien, Austria,
a9002654@unet.univie.ac.at

The solenogaster *Wirenia argentea* Odhner, 1921 is part of the epibenthic soft bottom fauna of the Northern European Atlantic Ocean. It is found on mudflats in water depths of 400 to 600 m.

Salivary glands and glands of the pedal system of *Wirenia argentea* are compared in regard to their histochemical properties, their histology and ultrastructure. Standard histochemical techniques for the detection of mucopolysaccharides and proteins were applied. Ultrathin sections were analysed, additionally applying selective staining for lipids and neutral polysaccharides.

Cylindrical gland cells containing electron dense, proteinous vesicles are scattered throughout the epithelium of the anterior portion of the pharynx. In contrast to these single epithelial gland cells, the subepithelial follicles of the posterior salivary glands lateral to the radular apparatus are conspicuously elongated. Their proteinous secretions are discharged into the pharynx via long and narrow ductules running through the pharyngeal muscle layers. The diversity of vesicles - reflected in different size and staining properties - within these follicle cells indicates the production of at least three different secretion products.

The voluminous pedal gland secretes into the pre-pedal ciliary pit. It is composed of large, flask-shaped elements containing sulfatized, acid mucopolysaccharides, and of smaller glandular cells filled with proteinous vesicles. Structurally similar gland cells (sole glands) are lining the entire length of the pedal fold. These sole glands contain small, electron-dense vesicles deeply staining with protein dyes and secrete non-mucous substances.

Solenogastres in motion

Christiane TODT¹, Luitfried SALVINI-PLAWEN¹, Constantine MIFSUD² and Jörg OTT³

¹ Institute of Zoology, University of Vienna, Althanstr. 14, A-1090 Vienna, Austria.

² Rabat RBT 02, 4 Shepherds Street, Malta.

³ Institute of Ecology and Conservation Biology, University of Vienna, Althanstr. 14, A-1090 Vienna, Austria.

Short video sequences of Solenogastres are shown to give an impression of their mobility: the typical locomotion by ciliary gliding, movements of the anterior body end for chemical and tactile orientation, and burrowing attempts upon ooze to reach firm substrate. Four species are shown: *Wirenia argentea* Odhner (4-6 mm) from Trondheim/Norway, *Meioherpia* sp. (1-2 mm) from Bermuda, *Micromenia subrubra* Salvini-Plawen (4-6 mm) from Malta, and *Biserramenia psammobionta* Salvini-Plawen (2-3 mm) from Plymouth/England.

A study of the reproduction in Gastropoda

Okoisama TOJU

Department of Zoology, University of Benin, Benin City Edo State, Nigeria

Matured gastropods thrust their penis into the female aperture during copulation releasing sperms to fertilize the eggs, which is either internal (terrestrial species) or external (aquatic species). As hermaphrodites, they exhibit cross-fertilization resulting from two individuals of the snails reciprocate to exchange sperm (*Littorina* spp) and self-fertilization involving one individual with synchronized ripening of male and female gonads, although usually prevented by autosterility (*Arianta arbustorum*). Maturation of gametes is set off by a combination of factors; namely thermal, mechanical, genetic hormonal, triggers the actual spawning and gamonic actions begins. Union gametes may be extensive (*Archidoris pseudoargus*), forming eggs which hatched into develop zygotes and rapidly to young snails with their sexual development maybe affected by species specific hormone (in aquatic females) and alternation in gametes (archaeogastropods).

A new species of *Obscuranella* Kantor & Harasewych, 2000 (Gastropoda, Ranellidae) from Kerguelen Islands, South Indian Ocean

Nicolás TRONCOSO¹, Jackie L. VAN GOETHEM² and Jesús S. TRONCOSO¹

¹Departamento de Ecoloxía e Bioloxía Animal. Facultade de Ciencias, Campus de Lagoas Marcosende, Universidade de Vigo, E-36200, Spain, nicoflin@uvigo.es, troncoso@uvigo.es

²Institut Royal des Sciences Naturelles de Belgique, Rue Vautier 29, B-1000, Bruxelles, Belgium.

Preliminary data are presented on a new species of *Obscuranella* (Gastropoda, Ranellidae) found in Morbihan Bay, Kerguelen Is. Specimens were collected during the mission Ker-82 of the Institut Royal des Sciences naturelles de Belgique. This genus was described by Kantor & Harasewych (2000) based on several specimens tentatively attributed to *Bathydomus* Thiele, 1912 by Dell (1990). This species is located within the genus *Obscuranella* based on its shell, radular and anatomical characters that agree with the original description. Rachidean teeth are lacking lateral basal denticles, the salivary glands are large and differentiated, the osphradium is bipectinate and the proboscoid wall is thick. The shell is large and pyriform with a large aperture and a very small operculum. Our species differs from *O. papyrodes* in its shell sculpture, a more sharply-pointed operculum and a small size.

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**Evaluation of the "host-specificity paradigm" for sacoglossans
(Gastropoda: Opisthobranchia) associated with introduced macroalgae**

Cynthia D. TROWBRIDGE

Hatfield Marine Science Center, Oregon State University, Newport, OR 97365 USA,
trowbric@ucs.orst.edu

On temperate European shores, the native stenophagous marine herbivore *Placida dendritica* (Alder & Hancock, 1843) associates with the green macroalga *Codium fragile* introduced from north Pacific shores. On Scottish coasts, adult specimens of *P. dendritica* collected from introduced hosts prefer to associate with and consume the introduced *C. fragile* ssp. *atlanticum* and ssp. *tomentosoides* to the native *C. tomentosum*, comparable to my previous reports on the sympatric slug *Elysia viridis* (Montagu). On Irish west-coast shores, where the native algal hosts are common, significantly more *P. dendritica* on the shore associate with the native *C. tomentosum* than with the introduced hosts. *Elysia viridis*, however, disproportionately attacks the exotics, especially *C. fragile* ssp. *tomentosoides*. On temperate Australian shores, the native stenophagous marine herbivore *Placida aoteana* (Powell, 1937) associates with the introduced green macroalga *C. fragile* ssp. *tomentosoides* as well as with native congeners and conspecifics. *Placida aoteana* is common and its herbivory evident in Port Phillip Bay, Victoria and on both sides of Bass Strait. Slugs collected from native *C. fragile* exhibit no preference between algal subspecies in Victoria but a strong preference for introduced ssp. *tomentosoides* in Tasmania. Seasonal slug recruitment to available hosts coupled with an apparent flexibility in host use indicates that stenophagous marine herbivores can rapidly respond to introduced hosts on ecological time scales. Thus, the implicit peril of the host-specificity paradigm - that specialists could change their association - does occur in these stenophagous sacoglossan herbivores.

**Phylogeny of opisthobranch gastropods inferred from mitochondrial
gene arrangement: A case study for comparing phylogenetic performance
between gene sequence and gene order data**

Rei UESHIMA

Department of Biological Sciences, University of Tokyo, Bunkyo-ku, Tokyo 113-
0033, Japan, rueshima@biol.s.u-tokyo.ac.jp

Although opisthobranch gastropods have long been classified as a distinct subclass in the traditional taxonomic system, monophyly of opisthobranchs is now dubious. Most of morphology-based cladistic analyses suggest the opisthobranchs to be polyphyletic or paraphyletic with respect to pulmonates. In recent years, several molecular phylogenetic analyses were carried out and the results also suggest the polyphyly of opisthobranchs.

We have determined a complete sequence of mitochondrial genome of an acteonid opisthobranch *Pupa strigosa* and found the mt-gene arrangements to be slightly different from those of stylommatophoran pulmonates (Kurabayashi & Ueshima 2000a). Such changes in mt-genome structure provide excellent information for phylogenetic reconstruction (Kurabayashi & Ueshima 2000b). To test whether opisthobranchs are monophyletic or not, I have determined partial mt-gene arrangements for various euthyneuran taxa covering major subgroups of pulmonates and opisthobranchs and cladistic analysis was performed using some heterostrophan gastropods as outgroups. I also carried out standard molecular phylogenetic analysis based on gene sequence data of mt-tRNA, 18S rRNA and mt-lrRNA genes. Reliability of previous molecular phylogenetic studies were tested by adding some heterostrophan sequences. Unexpectedly, the results of two different molecular phylogenetic approaches, the gene order and gene sequence analyses, are not concordant. Such a discrepancy provides an invaluable opportunity to test phylogenetic performance of the two different molecular data sets. Power and limit of gene sequence and gene order analyses will be discussed focusing on systematic position of opisthobranch gastropods.

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Distribution and ecology of freshwater snails in Edo State, Nigeria

U. S. UGBOMOIKO¹ and O. Chris OKE²

¹ Zoology Dept., Ambrose Alli University, Ekpoma, Edo State, Nigeria.

² Zoology Dept., University of Benin, Benin-City, Edo State, Nigeria.

Freshwater snails in rivers, streams and ponds in Edo State were studied. A total of 17 species representing 14 genera and 7 families was collected. Seven species (41%) were prosobranch gastropod while 10 species (59%) were basommatophoran gastropod mollusks. The prosobranchs dominated the rivers numerically, constituting 84% of the total molluscan fauna, with *Lanistes lybicus* and *Melanoides tuberculata* contributing 59% of the total faunal assemblage. In streams and ponds, the basommatophorans were dominant, constituting 90% and 99% respectively. Snails of the family Planorbidae were the most abundant.

Molecular evidence demonstrates widespread homoplasy in a complex morphological character among clausiliid snails (Gastropoda, Pulmonata)

Dennis R. UIT DE WEERD

Institute of Evolutionary and Ecological Sciences, Leiden University, P.O. Box 9516,
NL-2300 RA Leiden, The Netherlands, uitdeweerd@rulsfb.leidenuniv.nl

Shells of clausiliid snails are characterised by a clausilial apparatus (CA), a structure to block the aperture of the shell by a movable plate. Two types of CA are recognised: the open type has a bypass-canal next to the clausilial plate supported by two parallel lamellae; the closed type lacks this bypass-canal and is considered the apomorphic condition. Despite the fact that the closed type has obviously arisen several times independently within the family, it has been used as an important taxonomic character state.

Both types of CA are found in a group of closely related Greek and Turkish clausiliids. Based mainly on the CA-type three genera were once recognised within this group: *Albinaria* (open type), *Isabellaria* (closed type) and *Sericata* (open type). Since then, molecular evidence has demonstrated extensive parallel evolution of the closed CA-type in a clade consisting of *Albinaria* and some of the traditional *Isabellaria* species. These results have led to the inclusion of these so-called *Isabellaria* species into the genus *Albinaria*.

This study focuses on the relationships between the remaining *Isabellaria* species and the *Sericata* species. The CA-based interpretation of these genera conflicts with overall shell morphology and biogeography. Both nuclear (ITS) and mitochondrial (COI) DNA sequences were obtained for nearly all species of these two alleged genera and for additional *Albinaria* species. Consequently, this is the most extensive investigation into the CA problem to date, both in number of sequences and breadth of taxa.

The results of this study are more consistent with overall shell morphology and biogeography than the traditional classification and indicate even more extensive homoplasy in the CA-type than previously thought.

Distribution and abundance of land snails in a post minor house park

Maria URBAŃSKA

Zoology Department of Agricultural University, ul. Wojska Polskiego 71C, 60-625
Poznań, Poland, urbanska@au.poznan.pl

During this research the malacofauna of a post minor house park was compared quantitatively and qualitatively in five periods of a year, *i.e.*, in early spring, late spring, summer, early autumn and late autumn. The study was carried out in the park that is visited very rarely and situated nearby a military training ground.

In order to characterise the malacofauna in the examined park the quantity method was applied using the biocenometer of 20 x 20 cm size. After collecting snails and species identification, the following statistical quantities were calculated using the database software: quantity, constancy, dominance, index Q (geometric mean of constancy and dominance), dispersion and diversity.

The juv. and ad. population was presented as species spectrums that have shown that *Cochlicopa lubricella* is superdominant or dominant all time. The index Q confirms that *Cochlicopa lubricella* has the highest dominance and frequency. The dispersion in late spring is three times greater than in other periods. It indicates that there was very different density of population in that one season. The Shannon-Waever species diversity (H') is nearly uniform for all periods and equal of ca. 2.5. That value proves that the researched terrain is enough high diverse and has multicomponent character. One may come to the same conclusion if one takes into consideration the standardised index of diversity (TDI), index of malacofauna diversity (ADI) and Simpson's index of species diversity (D).

The dendrogram of dissimilarity was also plotted using the tree clustering method with the single linkage formula. The similarity probability was computed with the Marczewski and Steihaus equation. It has appeared that the composition of the malacofauna is the most similar in late spring and early autumn and the less similar for early spring.

A new species of *Laevipilina* (Mollusca, Monoplacophora) from Northern Spain

Victoriano URGORRI¹, Óscar GARCÍA-ÁLVAREZ¹, Ángel LUQUE² and Luis DANTART³

¹ Departamento de Biología Animal. Universidade de Santiago de Compostela, E-15706 Santiago de Compostela, Spain. bavituco@usc.es

² Laboratorio de Biología Marina, Departamento de Biología, Universidad Autónoma, 28049 Madrid. Spain.

³ Centre de Recursos de Biodiversitat Animal, Facultat Biologia, Universitat de Barcelona, Diagonal, 645, 08028 Barcelona, Spain.

To date 23 species of monoplacophorans have been described. They are grouped in eight genera, and their classification is mainly based upon shell structure, radular characteristics and external morphology. Most part of the species were described exclusively based on shell morphology, the soft parts being unknown. Thus, in most cases their classification remains uncertain.

Within the 23 known species, 8 are from the Atlantic Ocean: *Micropilina minuta* was discovered off the coasts of Iceland; *Rokopella brummeri* and *Rokopella segonzaci* were collected near a midatlantic dorsal ridge in the North Atlantic; *Veleropilina goesi* is from the Virgin Islands in the Caribbean Sea; *Neopolina rebainsi* was collected in the Scotia Sea, SE of the Falkland Islands in the South Atlantic; *Veleropilina zografi* and *Rokopella euglypta* are described from the Azores Islands and finally *Laevipilina rolani*, described from the Galician Coasts (NW Spain) is the only species known from Iberian Waters.

The new species was collected off the Asturian coasts, North Iberian Peninsula, in "El Cachucho" (44°02'13"/19"N; 04°50'28"/51'05"W) between 580 and 600 m deep on a bottom of ferromanganese nodule plates. Two specimens were collected (1.9 mm long and 1.5 mm wide; 1.6 mm long and 1.3 mm wide). The shell is fragile, transparent with a ratio width/length of 0.32. They have five pairs of gills with up to three digitations per gill. The foot is small and oval. The velum is developed, with postoral tentacles, rounded and bunched. The radula has 35-37 rows with 11 V-shape teeth in each. The three lateral teeth have protruding cusps and the first marginal tooth has 53 falciform hooks in a fan-like arrangement.

**Comparative anatomical studies of *Thapsia* sp. from South Nigeria
(Mollusca: Pulmonata: Urocyclidae)**

O. Ekuase UZEBU and O. Chris OKE

Zoology Department, University of Benin, Benin City, Edo State, Nigeria

Comparative anatomical studies were carried out on the land snails of the genus *Thapsia* collected from different parts of Southern Nigeria. Four taxa were distinguished based on the genital anatomy.

**Total evidence phylogeny of the Cryptobranchia (Opisthobranchia,
Doridacea)**

Ángel VALDÉS

Department of Malacology, Los Angeles County Museum of Natural History, 900
Exposition Boulevard, Los Angeles, California 90007, USA.

Department of Invertebrate Zoology and Geology, California Academy of Sciences,
Golden Gate Park, San Francisco, California 94118, USA, avaldes@calacademy.org

The Cryptobranchia, with around 1500 described species, is the most diverse group of dorid nudibranchs. The major synapomorphy of this clade is the ability of its members to retract the gill into a cavity. Morphological phylogenetic analysis shows that there are four major clades within this group: Chromodorididae + Actinocyclidae, Dorididae, Discodorididae and the radula-less dorids (Porostomata). The caryophyllidia-bearing dorids are a derived clade within the Discodorididae, and the Discodorididae lacking caryophyllidia appear to be paraphyletic. The Porostomata is the sister group to the rest of the Cryptobranchia. In light of the new evidence, a radical change of the traditional classification is proposed, including the introduction of a new name for Chromodorididae + Actinocyclidae + Dorididae + Discodorididae. Molecular data, based on the 16S mtDNA gene seems to support the morphological phylogenetic hypothesis. The traditional group Phanerobranchia is probably paraphyletic due to the absence of synapomorphies.

Phanerobranch dorids: clade or grade?

Yvonne VALLÈS^{1,2}, Mónica MEDINA^{1,3} and Terrence GOSLINER²

¹ California Academy of Sciences, Golden Gate Park, San Francisco CA, USA,
yvalles@calacademy.org

² San Francisco State University, San Francisco CA, USA.

³ DOE Joint Genome Institute, Walnut Creek CA, USA.

The Doridina, one of the four clades of Nudibranchia, traditionally comprises three major groups: Gnathodoridoidea, Cryptobranchia and Phanerobranchia. The monophyly of the Doridina is well supported by multiple sources (Wollscheid & Wägele 1999). The Gnathodoridoidea, represented by the genera *Doridoxa* and *Bathydoris*, is the sister group of a clade including phanerobranch and cryptobranch dorids. Although the monophyly of the cryptobranchs has been already suggested (Wägele & Willan 2000), the status of the phanerobranchs remains unclear. The phanerobranch dorids exhibit a large range of external morphology, colors, diets and internal anatomy (*i.e.* radulae and reproductive system). In an attempt to elucidate if phanerobranch dorids constitute a clade or a grade, we have sequenced the complete 16S mitochondrial gene for the majority of the phanerobranch genera and some of the cryptobranch genera.

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Margaritifera river quality

Ilmari VALOVIRTA

Finnish Museum of Natural History, PO Box 17, FIN-00014 University of Helsinki,
Finland, ilmari.valovirta@helsinki.fi

A river is a chain of habitats linked in an energetic continuum, from source to estuary, consisting of rapids and pools, of turbulent stream sections, deep stream sections and slow flowing pools. All links in the chain have considerable influence on the fluvial animals and plants of any one link. Restoration work on a semi-natural river that concentrates only on rapids, restores only part of the "patient" to health. Each general habitat, like a rapid, contains many macrohabitat categories, a number of mesohabitats and thousands of dynamic microhabitats. The degree of success achieved in restoring a semi-natural river, *e.g.* for freshwater pearl mussels, depends basically on how well we recognise these habitats and how well we can provide appropriate levels of natural water energy for them, as determined by channel slope and friction typical for each habitat type.

The Habitats Directive stresses the importance of conservation of natural habitats and wild fauna and flora, ensures high bio-diversity and elimination of risks to Natura 2000 network sites. Natural rivers have decreased considerably in number in Finland. The ones are extremely important to fluvial organisms, *e.g.* *Margaritifera*. The presence of a breeding population of *Margaritifera margaritifera* is considered an indicator that a natural river is in peak condition regarding river bed, water quality and the primeval history of the mussel and trout together. Here, no restoration work should be carried out on the natural parts of the river or its catchment.

In a semi-natural section of the river, it is possible to restore its catchment if the risks are not too high for *Margaritifera*. It is important, that slow flow dynamic processes changing the river bottom (wearing, drifting, sorting, accumulation) continue. It is also important to restore the original state. In particular management of river for salmon, restructuring a rapid into series of short rapids and pools by deepening and introducing bottom dams, will have a domino effect on habitats, causing breakdown in natural progression and consequent reduction in the sustainability of their conservation value.

"The *Margaritifera* working group" established by WWF-Finland acting together with the Finnish Museum of Natural History has done sub-aqua inventory work for 23 years. The Finnish Life/Nature project "Restoration of fluvial ecosystems containing pearl mussels" operates since 1997.

The Tanganyikan problem revisited: coevolution of molluscs and molluscivorous fish in ancient African rift lakes during the Late Cenozoic

Dirk VAN DAMME¹, Kathlyn STEWART² and Martin PICKFORD³

¹ Laboratorium voor Paleontologie, Univ. Gent, Krijgslaan 281, S8, B-9000 Gent.

² Paleobiology, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4, Canada.

³ Laboratoire de Paléontologie, URA 12 CNRS, 8, rue Buffon, 75005 Paris, France.

Malacofaunas of most ancient lakes, compared to marine communities, consist of a restricted number of morphotypes often recurring spatially and temporally. The prosobranch fauna of Lake Tanganyika (6 my - Recent), which its marine-like (thalassoid) appearances is the main exception. Longevity, stability, size and habitat heterogeneity of the Tanganyikan ecosystem and a prey/predator arms race are claimed to be the factors that made the Tanganyikan revolution in shell design possible. This explanation is so vague as to be useless and it provides no insight in the degree of importance of the factors involved. A comparative palaeontological study was therefore undertaken on the changes in morphology and community composition of the malacofaunas of other ancient and palaeo-ancient African lakes in relation to the factors cited. The fossil records of the Malawi Basin with Lake Malawi, the Turkana Basin with Palaeo-Lake Shungura and the Albertine Basin with Palaeo-Lake Obweruka were chosen as case-studies. In the first two long lived lakes the lacustrine malacofaunas showed only very modest changes. There is no conclusive evidence of a coevolutionary prey/predator interaction leading to anti-predatory improvements of the shell designs notwithstanding the dominance of specialised molluscivorous fish in Palaeo-Lake Shungura and their abundance in Lake Malawi. In Palaeo-Lake Obweruka the existence of Tanganyika-like conditions and specialised molluscivores was also insufficient to create a morphological response in the molluscs in the earliest stage of the lakes existence and the first quantum change that occurred was a true revolution in shell design but completely insignificant on community level. Only after 2 my a complete and sudden turnover from a discretely ornamented community to a thalassoid community took place. The comparative study of the changes in mollusc and fish faunas in the three basins revealed that the evolutionary reality is vastly more complex than the fashionable theoretical debates. Finally revisiting the Tanganyika problem on the background of the new palaeontological synthesis also produced some novel insights.

Population genetic structure of introduced North American and native European populations of *Arion subfuscus* (Gastropoda, Pulmonata, Arionidae)

Natalie VAN HOUTTE¹, Jan PINCEEL¹, Kurt JORDAENS¹ and Thierry BACKELJAU^{1,2}

¹ Evolutionary Biology Group, Department of Biology, University of Antwerp (RUCA), Groenenborgerlaan 171, B-2020 Antwerp, Belgium, navaho@ruca.ua.ac.be

² Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, Belgium

Introduced populations are often characterized by a loss of genetic variability (both in terms of number of alleles and heterozygosity levels) as a consequence of founder effects and elevated inbreeding levels. This may limit their ability for further colonization. We compared allozyme variation at 15 enzyme loci of indigenous European and introduced North American populations of the land slug *Arion subfuscus*. We observed no differences in the number of alleles and heterozygosity levels between European and North American populations. Probably, *A. subfuscus* has been (and still is) introduced several times into North America. This may explain why *A. subfuscus* was able to colonize large parts of North America in a relatively short time and why the species is one of the most abundant pest gastropods in North America. Moreover, our results are congruent with SSCP data and support the idea that *A. subfuscus* is a complex of at least two different taxa.

Strong genetic differentiation between introduced Azorean and Belgian populations of *Lymnaea ovata* (Gastropoda, Pulmonata, Lymnaeidae)

Kate VAN LOOCK¹, Kurt JORDAENS¹ and Thierry BACKELJAU^{1,2}

¹ Evolutionary Biology Group, Department of Biology, University of Antwerp (RUCA), Groenenborgerlaan 171, B-2020 Antwerp, Belgium, jordaens@ruca.ua.ac.be

² Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, Belgium.

Introduced populations often have lower levels of genetic variation compared to populations from their native distribution. Additionally, introduced and isolated populations may be strongly genetically differentiated from populations from their native distribution. For this, introduced populations may substantially form part of the global biodiversity. Yet, introduced species may also interact negatively with native species. We used allozyme electrophoresis (polyacrylamide gel electrophoresis and isoelectric focusing) and DNA-sequence variation of the rDNA internal transcribed spacer 1 (ITS-1) were used to compare the genetic variation of populations of the freshwater snail *Lymnaea ovata* from the Azores (introduced) with populations from Belgium (native). Expected heterozygosity values, the number of polymorphic loci and the mean number of alleles per locus were lower in the Azorean populations. Several loci in the Azorean populations showed heterozygosity deficiencies that may indicate inbreeding (with self-fertilization as an extreme form). Nei's (1978) genetic distance revealed a strong differentiation between the Azorean and Belgian populations. We also measured several shell characters that were analysed with several multivariate morphometric techniques. These results showed that Azorean individuals were significantly smaller than Belgian individuals. The strong genetical and morphological differentiation between Azorean and Belgian individuals may be indicative for a taxonomic difference. ITS-1 sequences showed little variation and no differentiation between Azorean and Belgian individuals so that sequence information of other genes or gene fragments (e.g. mitochondrial DNA) will be necessary for further comparison.

Genetic and morphologic variation within Azorean Leptaxinae (Mollusca, Pulmonata)

Patrick VAN RIEL, Kurt JORDAENS, Ron VERHAGEN and Thierry BACKELJAU

University of Antwerp (RUCA), Evolutionary Biology, Groenenborgerlaan 171, B-2020 Antwerp, Belgium, vanriel@ruca.ua.ac.be

The Leptaxinae are a group, of pulmonate land snails, endemic for Macaronesia (Azores, Madeira, Cape Verde and Canarian Islands). The systematics of this subfamily is incomplete and almost solely based on shell morphology, thereby obscuring the evolutionary relationships between the different representatives. The Azores islands are of relatively recent origin compared to the other archipelagoes with ages varying between 8 my and 40000 years. Recurrent volcanic activity has destroyed large parts of some islands or caused different islands to collide in relatively recent times. Colonisation history, recolonisation of suitable habitat and secondary contact between populations after eruptive phases or after the fusion of independantly colonized islands, may have important implications for the genetic structure of populations and species.

Morphometric data and phylogeographic patterns deduced from nuclear (ITS-1, ITS-2) and mitochondrial (CO-1, CYT-B, 16S) DNA sequences, suggest long term isolation between populations of *Leptaxis azorica* from eastern and western São Miguel, Flores and Santa Maria, concordant with the geological history of the islands. However, although the two easternmost islands Santa Maria (8 my) and São Miguel (4 my) are much older, the molecular phylogeny suggests that colonization of the younger islands has not simply proceeded from thereout. The population of *L. azorica* from the westernmost (900 km from São Miguel), and younger island, Flores (2 my) represents an older lineage than the populations from São Miguel. The species on the central islands group represent a relatively recent radiation, surprisingly including the morphologically distinct genus *Helixena*, endemic for the oldest island Santa Maria.

Variation at 12 allozyme loci (PAGE) reveal the same patterns of variation and suggests loss of genetic variability in species that are represented by small, isolated populations, due to the effects of genetic drift and inbreeding. There's also an indication that some degree of hybridisation may have occurred between some sympatric species.

The land snails of Rodopi (north Greece)

Katerina VARDINOYANNIS, Kostas TRIANTIS and Moysis MYLONAS

Natural History Museum of Crete, University of Crete, P.O. Box 2208, 71409,
Irakleio, Crete, Greece, mollusca@nhmc.uoc.gr, kostas@nhmc.uoc.gr,
director@nhmc.uoc.gr

The Rodopi massif forms the core of the Balkan Peninsula. It is the natural border between north Greece and southwest Bulgaria. It is a mountainous area of 18700 km², 22% of it lie in Greece and the rest in Bulgaria.

The whole area is densely forested, with coniferous and deciduous forests. There are also some maquis and cultivations. Many areas of Rodopi in both countries are under certain protection status, since the area, for many centuries, has had and still has the least human disturbance. Also the surrounding area is not heavily populated.

Although the malacofauna of Rodopi has been studied in the past, the most recent paper is Reischütz (1988), its mountainous part was not accessible till the late 80's, so only the lowlands were surveyed.

We sampled in detail the whole area, especially the mountainous and the least accessible parts, during two field trips, one in June 1996 and one in July - August 1999.

Our study revealed that there are very few endemics. Most of the species belong to Balcan or central European element, while the Mediterranean element is very poorly represented.

The comparison with the Bulgarian fauna revealed high similarity, more than 90%. The difference is mainly due to species that occur in the east (Black Sea area) or north Bulgaria. On the contrary the similarity with other Greek areas, even on the generic level, is low (less than 50%), especially with the southern parts of the islands.

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Field observations on the aestivation of *Lymnaea glabra* (Gastropoda, Lymnaeidae) in swampy zones

Christiane VAREILLE-MOREL¹, Gilles DREYFUSS² and Daniel RONDELAUD³

¹UPRES-EA n° 3174, Faculté des Sciences, 123 avenue Albert-Thomas, 87060 Limoges, and ²Facultés de Pharmacie et de ³Médecine, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud@pharma.unilim.fr

Field investigations in 12 populations of *Lymnaea glabra* were carried out from 1996 to 2000 to study the ability of snails to aestivate when summer drying occurred in habitats. The 5 first road ditches studied were located in the department of Indre (central France) and were connected with ponds. Each was constituted by a 5-8 cm deep layer of marl, covered with slow-running water from October to mid-August. The 7 other ditches were located in the department of Haute Vienne and were connected with open drainage networks existing in close meadows. In these last ditches, water ran from November to the end of June on bare granite gravel and the speed of the water current was variable, being faster in winter. In the marl habitats, the survival of snails after aestivation ranged from 51 to 88% and concerned all classes of snail age, as more than 50% of 12-16 mm high snails could survive. When stagnant water disappeared at the end of August, numerous snails were actively observed burrowing into the marl and aestivated at a depth of 1-6 cm. A few snails with their mouth attached to the surface of the marl were noted. Inversely, in the granite habitats, the survival of snails after summer drying ranged only from 11 to 24% and only concerned juvenile snails, measuring less than 4 mm in height. No snail burrowing was seen in these ditches and most juvenile snails were observed with their mouth attached to the surface of a gravel or that of soil. Some fluctuations in the survival rate of aestivating snails in relation to their location in ditches were noted. In the marl ditches, the survival of *L. glabra* burrowed into the marl of ditch bottoms was slightly greater than that of snails in ditch slopes (53.3% vs 46.7%). In contrast, in granite ditches, snail survival was significantly greater for slopes than for ditch bottoms (64.1% vs 35.9%), probably because of the vegetation present in the former sites. These variations noted in the aestivation of *L. glabra* are of interest in the local epidemiology of fasciolosis due to *Fasciola hepatica*, as this lymnaeid species might assure the larval development of this trematode when infected in the first days of its life or when it was co-infected with another trematode: *Paramphistomum daubneyi*.

Experimental colonization of new habitats by *Lymnaea truncatula* (Gastropoda, Lymnaeidae)

Christiane VAREILLE-MOREL¹, Daniel RONDELAUD² and Gilles DREYFUSS³

¹UPRES-EA n° 3174, Faculté des Sciences, 123 avenue Albert-Thomas, 87060 Limoges, and ²Facultés de Médecine et de ³Pharmacie, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud@pharma.unilim.fr

Experimental introductions of *Lymnaea truncatula* in new habitats were carried out over the 30 last years in the department of Haute Vienne (central France) to study the details of snail settlement and the outcome of these populations, and to determine any changes in the susceptibility of these new colonies to experimental infections with the trematode *Fasciola hepatica*. A total of 51 samples (100 adult snails each) were collected from 3 populations living on siliceous soils and known for their high susceptibility to *F. hepatica* infections. Each sample was introduced in March in an open drainage furrow (36 meadows) or in a road ditch (15 sites) which had never been inhabited by snails. All these sites were located on granite soils, within a radius of 5 km around Limoges and were covered with slow-running water (pH 5.8-7.0) from November to the end of June. Introduced snails from 29 samples had not survived in 27 furrows and 2 road ditches, because of predation by the terrestrial snail *Zonitoides nitidus*. In contrast, in the 22 other new colonies, the number of *L. truncatula* increased up to the second or the third year post-introduction (up to 244-631 overwintering snails counted in March) and progressively decreased in the following years to become stable from the sixth or seventh year p.i. (less than 40 overwintering snails per site). In these 22 colonies, the mean number of spring-born snails for each overwintering *L. truncatula* ranged from 6.4 to 8.5 in May. However, the summer drying of habitats and snail predation by *Z. nitidus* reduced this number to 0.7-1.4 progeny snails per overwintering *L. truncatula*. In 13 populations, bimiracidial infections of snails with *F. hepatica* performed under laboratory conditions did not demonstrate any variation in survival rates and prevalences of infections when compared to the rates recorded in the 3 populations of origin. In the 9 other populations, experimental infections of snails resulted in a decrease in the prevalences (< 40%), whereas the survival rates of snails at day 30 post-exposure did not change. This last result might be explained by a change in natural parasite pressure in the new snail habitats, being probably lower than that existing in the 3 sites inhabited by the populations of origin.

The distribution of Lymnaeidae (Gastropoda) and other related species in the northern part of the Haute Vienne department (central France)

Christiane VAREILLE-MOREL¹, Philippe VIGNOLES², Gilles DREYFUSS² and Daniel RONDELAUD³

¹UPRES-EA n° 3174, Faculté des Sciences, 123 avenue Albert-Thomas, 87060 Limoges, and ²Facultés de Pharmacie et de ³Médecine, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud@pharma.unilim.fr

Field investigations were carried out in 172 road ditches, 71 ponds, and 73 brooks and rivers from the Basse Marche (northern part of the Haute Vienne department, central France) to list the species of freshwater pulmonates, draw maps of their distribution using 5-km squares, and determine their frequencies of colonization per type of habitat. The subsoils of this district were constituted by granites or metamorphic rocks, and the calcium ion contents in water ranged from 5.7 to 26.8 mg/l. Ten species belonging to Lymnaeidae, Physidae, and Planorbidae, and a total of 484 populations were found during these investigations in the district studied. Four species had a wide distribution and a high number of habitats. *Lymnaea truncatula* was found in all squares of the Basse Marche and colonized 80.8% of road ditches, 71.8% of ponds, and 20.5% of rivers. A similar distribution was noted for *Physa acuta* that was especially found in ponds and rivers (76.0% and 60.2%, respectively). The distributions of *Lymnaea glabra* and *Lymnaea ovata* were more limited and their populations were concentrated in the valleys of large rivers. The frequency of *L. glabra* habitats was 23.8% in road ditches, 12.6% in ponds, and 20.5% in brooks and rivers; in contrast, *L. ovata* inhabited 36.6% of ponds and 73.9% of rivers. Three other lymnaeid species (*Lymnaea fuscus*, *L. palustris*, *L. peregra*) had spotted distributions and the numbers of their habitats were low. The habitats of the 3 last species (*Aplexa hypnorum*, *Lymnaea stagnalis*, and *Planorbis spirorbis*) were only found in the north of Basse Marche, in an area bordering the sedimentary soils from the Vienne department. Monospecific populations were frequent for *L. truncatula* and *L. peregra*. Bi-, tri-, or quadrispecific communities of snails were often observed for each of the other pulmonate species. These results might be explained by a great adaptation of *L. glabra*, *L. ovata*, *L. truncatula*, and *P. acuta* to the low calcium ion contents present in water, whereas the distributions of other snail species would be more dependent of higher calcium concentrations.

Highland populations of *Lymnaea truncatula* (Gastropoda, Lymnaeidae) infected with *Fasciola hepatica* survive longer than lowland ones under experimental conditions

Philippe VIGNOLES¹, Loïc FAVENNEC², Gilles DREYFUSS¹ and Daniel RONDELAUD¹

¹UPRES-EA n° 3174, Facultés de Pharmacie et de Médecine, 2 rue du Docteur-Marcland, 87025 Limoges, France, rondelaud.pharma.unilim.fr

²UPRES-EA n° 3234, Faculté de Médecine-Pharmacie, 22 boulevard Gambetta, 76183 Rouen, France.

A retrospective study on the experimental infections of *Lymnaea truncatula* with *Fasciola hepatica* performed over the 20 last years under laboratory conditions was carried out to determine if the populations of snails living in mountains (highland snails) had the same ability to sustain trematode larval development than lowland ones. The six highland populations originated from the Peruvian Altiplano (2800 m altitude), the French Alps (2300 m), and Massif Central (900-1400 m), whereas the 13 lowland populations came from different sites located in central France (90-250 m). Bimiracidial infections of 4-mm high snails were performed to study the development of the redial burden (at a constant temperature of 20°C) and cercarial shedding. Compared to lowland populations, the survival rate of infected snails at day 30 post-exposure was significantly higher in the highland *L. truncatula* (57-75% instead of 31-45%) and their span life was greater (a mean of 87-96 days for cercaria-shedding snails instead of 64-77 days). The prevalences of infections (calculated on the numbers of cercaria-shedding snails), the numbers of live and free rediae developing within snails (a mean of 12-23 per infected snail and per population), and the number of cercariae shed (a mean of 57 to 145 per cercaria-shedding snail and per population) did not show any significant differences between highland and lowland snails (although the numbers of cercariae shed from snails were higher in the Peruvian and three French populations of *L. truncatula*). In the 6 highland populations of *L. truncatula*, slower larval development of *F. hepatica* was noted in several snails (less than 20%), whereas this finding was not found in the lowland populations of *L. truncatula*. The better ability of highland snails to sustain parasite larval development suggested that they were better intermediate hosts in the life cycle of *F. hepatica* than lowland ones.

Spermatophore morphology in the Octopodidae

Janet R. VOIGHT

The Field Museum, 1400 S. Lake Shore Dr., Chicago, IL 60605 USA,
Jvoight@FieldMuseum.org

At mating, male cephalopods deliver sperm to females in spermatophores. Cephalopod spermatophores are complex tubular structures that rely on osmotic pressures generated by internal fluids to release sperm from the sperm reservoir. Spermatophore size relates to overall body size, with larger species producing larger spermatophores, but within a species, spermatophore length increases with male mantle length only up to a point. Spermatophore length apparently reaches a species-specific maximum, although maximum spermatophore length may differ among populations.

Sexual selection literature predicts that males increase their odds of fertilizing eggs, and thus their fitness, by transferring more sperm at copulation. Among octopodids, this would require increasing the size of the sperm reservoir, the section of the spermatophore that contains sperm. To document the variation seen in sperm reservoir length relative to spermatophore length, the two variables were plotted for 53 octopodid species from 11 genera. Remarkably little variation was seen. The plot shows two lines, each explaining over 97% of the variation among the data that define the line. One line shows the significantly longer sperm reservoirs of four Atlantic species of *Eledone* and the second, the smaller and extremely similar data from spermatophores of all other octopodid species considered.

The unexpectedly consistent relationship between sperm reservoir and spermatophore length in octopodids may reflect physical constraints associated with the generation of osmotic differentials. If males are to deliver more sperm, their only option may be to make larger spermatophores. Plots of spermatophore length versus mantle length for 59 octopodid species, however, show that only a few cold water species, species of the *Octopus aegina* group and *Eledone cirrhosa* produce relatively large spermatophores. Spermatophores of the latter species and at least one member of the *O. aegina* group also have hooks. If the energetic cost of producing large spermatophores is high, these hooks may have evolved in convergence to maximize male fitness. Because the hooks become external on the sperm bladder that forms inside the females' oviduct, they may reduce sperm competition by blocking the female's oviducts.

Architecture and flow in the gastropod mantle cavity: soft rules in hard places

Janice VOLTZOW

Department of Biology, University of Scranton, Scranton, PA, 18510-4625, USA,
voltzowj2@scranton.edu

Flow through the gastropod mantle cavity follows the physical laws of the movement of a fluid through a pipe. Mantle cavities can be modeled as a series of single or multiple parallel pipes of varying dimensions. The smallest and most numerous set of parallel pipes are the spaces between the gill leaflets. Because the gills lie at the maximum cross-sectional area of the mantle cavity, velocity should be lowest at the gill surface, which serves as both the site of exchange and as the pump. The relatively restricted incurrent and excurrent windows are the sites of maximal flow velocity. In gastropods having the primitive condition of two bipectinate ctenidia, such as *Diodora aspera*, flow through paired incurrent windows is controlled primarily by manipulations of the soft tissue, or mantle epithelium. Some species, such as *Haliotis kamtschatkana*, have hard morphology (shell) that restricts incurrent flow, but even in these cases the soft tissue lining the shell openings restricts or permits incurrent. In contrast, the excurrent windows in species having paired ctenidia are extremely restricted by narrow openings in the shells. Thus, by controlling the mantle lining these openings, an animal can control the rate of movement of water through the entire mantle cavity. Gastropods that have the derived condition of one monopectinate ctenidium appear to have reversed the site of minimal cross-sectional area maximal velocity. Excurrent windows in these species tend to be poorly defined by shell features and are lined by quite plastic regions of the mantle. Incurrent windows, in contrast, frequently involve elongated shell siphons. Even in these cases, however, the mantle lining the siphon has overriding control over flow. Neritopsines such as *Nerita versicolor* have a single bipectinate ctenidium. Their shells lack any obvious elaboration for incurrent or excurrent; flow through both windows is controlled exclusively by the mantle.

Land snails in calcareous fens in the province of Östergötland (E. Sweden) with some remarks on threats and conservation

Ted VON PROSCHWITZ

Dept. of Invertebrate Zoology, Museum of Natural History, Box 7283, S-402 35
Göteborg, Sweden

During the years 1998-1999 71 calcareous fens in the province of Östergötland were investigated on request of the Nature Protection Unit of the local government. For some of the sites, results from earlier collecting in the years 1921-1982 were available for comparisons. The aims of the present investigations were to study the fauna, with special respect to rare and red-listed species, to identify threats against the species and recommend conservation measures for the fens with special respect to these species.

Totally 65 species were found in the surveyed localities. Of these five are placed on the Swedish red-list: *Succinella oblonga* (Draparnaud) (NT), *Cochlicopa nitens* (M. von Gallenstein) (VU), *Vertigo geyeri* Lindholm (NT), *Vertigo genesii* (Gredler) (NT) and *Perforatella bidentata* (Gmelin) (NT). The two *Vertigo* species and a further species, *Vertigo angustior* Jeffreys, are also on the NATURA 2000 species list.

The following threats could be identified:

- Draining, ditching and deepening of watercourses and all measures which alter the hydrology in and near calcareous fens are severe threats against the species. In historical times, a large parts of the species' localities have probably been destroyed in this way.
- Exploitation of calcareous fens due to constructions of roads etc.
- Eutrophication due to leakage of fertilizing substances from the agriculture. Similar effects, due to faeces from the grazing cattle, are seen also in fens with too hard grazing pressure.
- Closure of open or half-open habitats through choking-up with bushes, reed etc. - due to ceased cultivation (grazing or haymaking) - is a serious, increasing threat.
- A secondary threat is mechanical damage, which originate from one-sided and incorrect cultivation (such as too hard grazing pressure or too heavy clearance of bushes etc.). Such effects, mainly due to grazing, can be seen in many fens wich are protected as nature reserves.
- In fens situated in the lower part of the species' pH-range, and having bad buffering capacity, the ongoing acidification process may constitute an increasing threat in the future.

Molecular systematics versus morphological systematics - an example of incongruency within the doridoidean opisthobranchs with regard to both methods

Heike WÄGELE

Spezielle Zoologie, Ruhr-Universität Bochum, 44780 Bochum, Germany,
Heike.Waegel@ruhr-uni-bochum.de

Recent investigations based on morphology and histology showed that the Nudibranchia, as well as the Doridoidea within the Nudibranchia, are monophyletic (Wägele & Willan 2000). Further evidence for monophyly of the Doridoidea is provided by the analyses of molecular markers, especially the 18S and 16S genes (Wollscheid & Wägele 1999, Thollessen 1999), but also of the CO1 gene (Wollscheid, unpublished data).

When analysing and comparing these three genes with the results of the phylogenetic analysis based on morphological characters, considerable incongruencies for some species become apparent under different methods of analysis. *Dendrodoris* is selected to show the incongruent results concerning the four different data sets. According to morphology and the 18S gene, *Dendrodoris* is a typical dorid, whereas the analysis of the 16S gene and the CO1 gene exclude the genus from the dorid taxon, or even from the Nudibranchia. An evaluation of the different data sets and computer techniques is given.

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Morphological analysis of *Melongena corona* populations from the Gulf of Mexico (Gastropoda, Melongenidae)

Jennifer M. WALKER and Thomas S. HOPKINS

University of Alabama, P.O. Box 870345, Tuscaloosa, AL 36081, USA,
walke008@bama.ua.edu

The current classification of *Melongena corona* in the Gulf of Mexico is based on morphological shell measurements. Within the Gulf, this classification recognizes two species, *Melongena corona* which has three subspecies, *M. corona corona*, *M. corona johnstonei*, and *M. corona altispira*, and *Melongena bicolor*. Of the subspecies recognized for *Melongena corona*, *M. corona corona* and *M. corona johnstonei* occupy the largest geographical ranges and share an area of subspecific overlap which is approximately 107 miles in length. For this analysis, 30 individuals from 15 populations along the Alabama and Florida Gulf coasts were measured as to shell height, shell width, spire height, spire width, aperture height, and aperture width. Using these measurements, populations were analyzed using a sheared principal components analysis (PCA), to factor out for individual size differences within populations. Scatterplots generated as a result of this analysis show little support for the current subspecific classification based on these morphological measurements due to the fact that populations from all three subspecific ranges overlap with little graphical separation.

Genetic variation in oligophagous herbivores (Sacoglossa: Opisthobranchia) on native and introduced hosts

Elizabeth J. WALSH¹ and Cynthia D. TROWBRIDGE²

¹ Department of Biological Sciences, University of Texas - El Paso, TX. 79968 USA, ewalsh@utep.edu

² Hatfield Marine Science Center, Oregon State University, Newport, OR 97365 USA, trowbric@ucs.orst.edu

Coastal marine communities are being homogenized and degraded by introduced species. The widely distributed, green macroalgae pest species *Codium fragile* ssp. *tomentosoides* ("oyster thief" or "deadman's finger") and *Caulerpa taxifolia* ("killer algae") are consumed primarily by sacoglossan (= ascoglossan) sea slugs. We are investigating genetic variation of the common marine herbivore associated with native and introduced *Codium fragile*: the sea slug *Placida dendritica* (Alder & Hancock, 1843). This species has been considered a single phenotypically variable species on temperate to boreal shores throughout the world, despite considerable evidence that it may actually be a complex of morphologically similar sibling species. This uncertainty has hindered the understanding of marine specialist herbivores and the ecological and evolutionary processes driving their host-plant use. We are investigating three major ecological questions: (1) Are sympatric conspecific slugs from different green algal host species genetically differentiated? Thus, do sympatric slugs belong to a single population or to genetically interconnected sub-populations? (2) Do "conspecific" populations of *P. dendritica* from Pacific and Atlantic shores in northern and southern hemisphere form a single widely distributed species or a complex of sibling species? Preliminary sequence data support the latter. (3) Are slugs feeding on the native, non-weedy subspecies of *C. fragile* genetically differentiated from conspecifics on introduced conspecific hosts? We are using AFLP (Amplified Fragment Length Polymorphism) and mitochondrial sequencing techniques (cytochrome oxidase I) to quantify genetic diversity among sympatric and allopatric slugs on the same vs. different algal hosts. Using AMOVA (Analysis of Molecular Variance), we will determine the spatial scale at which most genetic variation occurs. This project has broad implications for marine biological control of green macroalgal pest species.

Scanning electron microscopy studies on embryonic development of *Pomacea lineata* (Spix, 1827).

Liz C. WATANABE and Toshie KAWANO

Lab. Parasitologia, Instituto Butantan, Av. Vital Brasil 1500, CEP: 05503-900, São Paulo, Brasil, lizwatanabe@hotmail.com, tkawano@usp.br

Stages of the embryonic development of *Pomacea lineata* (Spix, 1827) are described using scanning electron microscopy. The aim of this study was to describe some stages of the embryonic development, with emphasis to the cephalic region. Specimens were collected in São Paulo, Brazil. The bunch-like spawn of *Pomacea* contains 10 – 100 eggs and is deposited 10 - 15 cm above the water level. Eggs are calcareous and of pink color. After 3 days, an early trochophore stage is reached. The prototroch is well developed with the mouth and the anlage of the foot on its ventral side. In the pretrochal region, no difference between apical plate and cephalic plates are apparent, in contrast to *Biomphalaria* (Camey & Verdonk 1970, Watanabe 1997), *Lymnaea* (Verdonk 1965) and *Planorbis* (Holmes 1900) where the apical plate consists of 7 cells with a pair of small-celled cephalic plates on either side. *Pomacea* embryos acquire a top-toy form. After four days, a late trochophore stage is attained, characterized by the outgrowth of the foot-anlage and the shell gland. Embryos reach an early veliger stage after about 5 days, and a late veliger stage after 7 days. Shell and tentacles start to develop. Initially, the shell gland is placed just at the opposite side of the blastopore. Then it moves toward to the left side of the embryo, indicating the future position of the shell aperture in the dextral direction. The outgrowing foot is clearly separated from the head organs and forms the sole. The hippo stage is reached after 9 days. It has well developed eyes and a large shell field lined by the mantle edge, which bears tufts of cilia. After two weeks, creeping juveniles hatch. Financial support: FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo).

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Aspects of the ecology of the mudwhelks *Terebralia palustris* and *T. semistriata* in northwestern Australia

Fred E. WELLS¹ and Carol M. LALLI²

¹ Western Australian Museum, Perth 6000, Western Australia,
wellsf@museum.wa.gov.au

² Institute of Oceanographic Sciences, Department of Fisheries and Oceans, Sidney,
British Columbia, lallicm@home.com

Potamidid snails, particularly the genus *Terebralia*, are dominant component of the molluscs in many mangroves throughout the region. However, despite the wide range of these snails, their size and numerical abundance, there have been relatively few studies of the biology and ecology of *Terebralia*. This study examines several aspects of the basic ecology of *T. palustris* and *T. semistriata* in northwestern Australia.

Predation was examined by tethering snails in groups of 80 in various parts of the mangroves. All individuals of *T. palustris* on the sandflat in the mangroves were alive after 10 consecutive low tides. Seventy-nine *T. semistriata* tethered in A. marina were alive at the end of the experiment; a single adult individual had been removed by predation, as evidenced by the tether having been broken. Survivorship was also high on the landward sandflat where 4 animals had been predated and one juvenile had died. The greatest losses occurred on the seaward mudflat, where 11 animals were predated and 8 died. Four types of predation were found in each species. In most cases, the predator simply chipped back the shell aperture until the withdrawn snail could be attacked and removed; 54% of *T. semistriata* were predated in this manner and 74% of *T. palustris*. Secondly, a predator breaking off the top of the shell spire attacked 38% of *T. semistriata* but only 10% of the larger *T. palustris*. A small number of shells had been attacked using both methods. Additionally, the dorsal surface of the body whorl had been chipped away in a few shells. Juveniles were more heavily predated than adults. Shells of a broad range of sizes were attacked, ranging from 24 mm to 45 mm in *T. semistriata* and from 22 mm to 95 mm in *T. palustris*, but there was a clear preference for larger juveniles.

There was a clear pattern of movement of both *T. semistriata* and *T. palustris* over a two-week tidal cycle. During the spring tides the animals were covered twice daily at high tide. There was considerable movement and dispersion of the population during this period. As neaps approached, inundation was for progressively shorter periods of each day, culminating in several consecutive days when the animals were exposed for the entire 24-hour period. During neaps movement was minimal.

The ultrastructure of the subradular organ of *Patella caerulea* (L.)

Patricia WERNSDORF

Department of Systematic Zoology and Developmental History, Institute of Zoology,
University Vienna, A8806485@unet.univie.ac.at

The structure of the subradular organ of *Patella caerulea* is investigated and compared to that of *Chiton olivaceus*.

In *Patella*, the subradular organ is an unpaired cushion lying below the anterior end of the radula. It consists of a singular epithelium, folded to transverse ridges and covered by an extracellular matrix. It is composed mainly of one cell type, bearing microvilli. This cell type indicates by vesicles and endoplasmatic riculum a high metabolic activity.

Additionally, two other cell types can be distinguished. There are a few dendritic endings with cilia. The dendritic processes fuse to a small paired nerve joining the labio-buccal-connective. Near the edge of each fold there lie a couple of mucus-secerning cells. The main function of the subradular organ of *Patella* is more likely a mechanical than a secretory or sensory one.

The present investigation of the subradular organ of *Chiton* confirms the interpretation of a sensory organ. Its single epithelium is divided into a posterior secretory and an anterior sensory region, in the latter five cell types can be distinguished. Most abundant are the supporting cells, bearing microvilli and containing prominent opaque lysosomes. Interspersed between the supporting cells are neurosecretoric cells and ciliated cells. The glia cells form a dense layer above the basal membrane. Occasionally mucus cells can be found in the sensory region of the subradular organ of *Chiton*.

Long-lived lakes as laboratories and archives for molluscan evolution

Frank P. WESSELINGH¹ and Ellinor MICHEL²

¹ National Natural History Museum Naturalis, PO. box 9517, 2300-RA Leiden,
wesselingh@naturalis.nnm.nl

² Institute for Biodiversity and Ecosystem Dynamics (IBED), University of
Amsterdam, PO. box 90766, 1090-GT Amsterdam, Netherlands,
michel@science.uva.nl

Geologically long-lived lakes (10^5 - 10^7 years) with their characteristic faunas are known from a variety of geological and climatic settings, and from different geological ages. Clades of endemic molluscs have evolved in these lakes that are notable for their elevated taxonomic and morphological diversity. Modern long-lived lakes have been termed laboratories of evolution, stimulating genetic, ecological, morphological and behavioral distinction of species and species complexes and spawning contrasting hypotheses of species formation. The ancient lake molluscs include characteristic and often highly derived morphologies, such as "open" coiling, miniaturization, heavy ornamentation of shells and a wide variety of fine sculptural details. By placing these radiations in phylogenetic context, we can test for ecological and the physical factors that interact with speciation-prone clades to stimulate endemic diversification. Molluscan phylogenies that might be a basis for testing these hypotheses have previously been sparse, but several will be presented during this symposium. Molluscs are both major players in benthic ecosystems and have a significant fossil record, which gives them advantages over other long-lived lake species flocks (*e.g.* fish and crustaceans) for evolutionary studies. Sequence stratigraphy and paleontology document potential environmental causes of molluscan evolution. Fossil molluscs can also provide minimum divergence age estimates for phylogenetic studies of extant molluscs. Although "reading" evolution from the fossil record is complicated by taphonomic loss and stratigraphic incompleteness, a wealth of information is achievable in the fossils, providing us with unique views of past lake environments and their mollusc faunas. In this contribution we will outline outstanding scientific issues concerning evolution of long-lived lake mollusc faunas, involving both biological and paleobiological perspectives.

The present is not a key for the past: fossil molluscs as paleoenvironmental recorders in long-lived lake environments

Frank P. WESSELINGH¹, Hubert B. VONHOF² and Ron J.G. KAANDORP³

¹ Nationaal Natuurhistorisch Museum, P.O. Box 9517, 2300 RA Leiden, the
Netherlands, Wesselingh@naturalis.nl,

² Faculty of Earth Sciences, Vrije Universiteit, de Boelelaan 1085, 1081 HV,
Amsterdam, the Netherlands, vonh@geo.vu.nl; kaar@geo.vu.nl

Inferring paleosalinities from mollusc faunas in the Miocene Lake Pebas (Amazonia) and Lake Pannon (Central Europe) is hampered by the high rates of endemism. Although the general character of the faunas (with *e.g.* a diverse endemic corbulid fauna in Lake Pebas and a diverse endemic limnocoeloid fauna in Lake Pannon) is suggestive for generally brackish conditions, combined stable isotope and strontium geochemical studies indicate for Lake Pebas a mere freshwater depositional environment (apart from a few marine incursion levels). Detailed within-shell analyses exclude seasonal salinity variations. It is demonstrated that (1) faunal surveys of endemic dominant faunas using standard actualistic methods cannot provide paleosalinity estimates, (2) stable isotopes (O, C) alone are insufficient to produce paleosalinity estimates and (3) the general ecological signature of taxa in long-lived lakes (in this case salinity tolerances and preferences of molluscs) does evolve outside the range of closely related taxa in non long-lived environments.

Diversification patterns in the Tanganyikan thiarid gastropod superflock

Kelly WEST¹ and Ellinor MICHEL²

¹ IUCN Eastern Africa Regional Office, P.O. Box 68200, Nairobi, Kenya,
kwest@mac.com

² Institute for Biodiversity and Ecosystem Dynamics (IBED), University of
Amsterdam, PO. box 90766, 1090-GT Amsterdam, Netherlands,
michel@science.uva.nl

The endemic gastropod fauna of Lake Tanganyika is remarkable not only for its great species richness, but also for its unusually ornate and heavily-calcified shell morphologies that are convergent with diverse marine forms. The origin and intralacustrine radiation of these thiarid gastropods have been debated for a century, as they are perhaps the most dramatic lacustrine radiation of gastropods in the world.

We present here a molecular phylogenetic treatment of twelve of the endemic gastropod genera and four outgroups, based on a mitochondrial gene fragment of cytochrome oxidase 1 (CO1). Using *Cleopatra* and *Melanoides* species as outgroups, we found that these thiarid genera from Lake Tanganyika are paraphyletic, but that a larger clade including *Cleopatra*, a cosmopolitan thiarid in East Africa, is monophyletic. Our data reveals five robust clades within this larger group: 1. ((*Reymondia*, *Cleopatra*) *Spekia*); 2. (*Stanleya*, *Tanganyicia*) as sister-group to group 1; 3. the trochiform genera ((*Bathanelia*, *Chytra*) *Limnotrochus*) as a clade, and 4. sister-taxon pairings for new genus, and 5. (*Anceya*, *Paramelania*).

While our analyses using parsimony, neighbor-joining and maximum likelihood analyses agree on sister-taxon relationships at terminal nodes, they do not resolve relationships among these Tanganyikan clades, which we interpret to be an indication of rapid, burst-like radiation at the time of origin of this fauna. We suggest using the term "super-flock" (*sensu* Ribbink) to describe the generic level radiation of Tanganyikan gastropods, as it preserves the information that this is a group of closely-related endemics that have probably radiated *in situ*, but does not imply complete monophyly.

Allozyme, 16S, and CO1 sequence divergence among populations of the cosmopolitan freshwater snail, *Physa acuta*

Amy R. WETHINGTON¹, Robert T. DILLON, Jr.², J. Matthew RHETT² and Charles LYDEARD¹

¹ Department of Biological Sciences, Biodiversity, and Systematics, University of
Alabama, Box 870345, Tuscaloosa, AL 35487, USA, amyw65@juno.com,
wethi001@bama.ua.edu

² Department of Biology, College of Charleston, Charleston, SC 29424, USA,
Dillonr@cofc.edu

In modern times the European *Physa acuta* has been reported from South Africa, Hong Kong, and New Zealand, and seems to have spread throughout much of the old world. Our breeding experiments have recently demonstrated no reproductive isolation between *Ph. acuta* and the North American *Ph. heterostropha* and *Ph. integra*. Here we report that the Nei genetic distances among populations of *Ph. acuta* from Indiana, Philadelphia, Charleston, Ireland and France, based on gene frequencies at seven allozyme-encoding loci, range from 0.017 to 0.284. Percent sequence similarities among these five populations (2 - 4 individuals each) range from 97% to 100% for the mitochondrial CO1 gene and from 95% to 98% for the mitochondrial 16S gene. This reflects no greater divergence than previously reported among *Physa* populations from the immediate vicinity of Charleston. A sixth *Ph. acuta* population from northern Michigan was more distinctive, with Nei's D ranging 0.615 to 0.843 to the other five populations, and sequence similarities of 91% - 92% for CO1 and 89% - 91% for 16S. But such levels of divergence do not approach those we measured between the six *Ph. acuta* populations together and Michigan *Ph. gyrina*, a similar but reproductively isolated species. The results we report here should allow us to calibrate and interpret other estimates of genetic divergence we are currently gathering from diverse elements of the confusing North American Physidae.

Malacologists: What are your priorities?

Tony WHITTEN

Senior Biodiversity Specialist, World Bank, Washington D.C., USA.

We have all heard that global biodiversity is being lost at unprecedented rates and that 'crisis' is not too strong a word. Reefs are poisoned, forests cut and burned, rivers polluted, and limestone hills quarried extensively and inappropriately for cement, lime and hardcore. Yet, at the same time there has never been more money available for biodiversity conservation from governments, foundations, conservation NGOs, multi-lateral agencies, and even the private sector.

And where are the malacologists?

There is global mapping of ecosystems and of more and more taxonomic groups, thus allowing correlations and other spatial analyses. And where are the malacologists? As someone who started in malacology as a rank amateur having previously been vertebrate-orientated, I am aghast that it is so easy for me to find snail species which are new to science and to contribute to understanding species ranges.

And where are the malacologists? Where is the Snail Defence League? Where are the expeditions to undercollected areas? Where is the development of human resources in the malacologically-richest countries? Where are the coordinated efforts to get funds? Where are the efforts to turn around the image of snails and thus provide openings for encouraging greater interest and attention? What are the priorities of malacologists? Conservation is clearly not a priority issue for many malacologists (with some notable exceptions). I shall present some opportunities and approaches that a far larger number of malacologists could consider for filling some of these gaps.

The Oregon-Washington boundary, a dividing line for genetic diversity? Lessons from the arionid *Prophysaon coeruleum*

Thomas WILKE¹, George M. DAVIS¹ and Nancy DUNCAN²

¹ Department of Microbiology and Tropical Medicine, George Washington University Medical Center, 731 Eye Street NW, Washington DC 20037, USA, mtmtwx@gwumc.edu

² USDI - Bureau of Land Management, 777 Garden Valley Blvd., Roseburg OR 97470, USA.

The Oregon-Washington boundary in the north-western United States is of particular biogeographical interest. Avise (2000) discussed the genetic separation of distinct "phylogroups" in plant and animal species north *versus* south of this boundary (with the boundary actually being more in central Oregon along the Columbia River). He suggested a connection between historical population separation and Pleistocene glacial refugia.

In order to test whether such a model holds for slugs, we studied two mitochondrial genes in 46 specimens of *Prophysaon coeruleum* (Gastropoda: Arionidae) from 24 sites in northern California, southern Oregon (south of the Columbia River), and northern Oregon (north of the Columbia River).

The genetic diversity (16S rRNA + COI mtDNA) among populations of so called *Prophysaon coeruleum* ranges from 0 to 28.8% (!). The lowest diversity can be found among populations in northern Oregon where the genetic diversity ranges from 0 to less than 1%. The highest genetic diversity occurs between populations from Oregon and northern California (up to 28.8%). The genetic diversity within populations is rather low and never exceeds 1.8%.

Our data, based on genetic data from a limited set of populations, indicate that the slug species locally identified as *Prophysaon coeruleum* is not monophyletic. Populations from northern California may well represent different species and even a different genus. In southern Oregon we have found eight genetically distinct taxa (occurring within a distance of about 100 km). In northern Oregon only one of these taxa could be detected.

Our data are in concordance with the phylogeographic patterns discussed by Avise (2000). It is reasonable to assume that Pleistocene glaciations had a profound effect on the genetic diversity of slug species. The complex morphostatic radiation found in southern Oregon has its center in the Klamath Province which is geologically very ancient and composed of many jumbled formations. Combined with harsh, dry environments, this has led to high levels of endemism in the area.

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***Nodilittorina* (Gastropoda, Littorinidae) – a model for Indo-Pacific biogeography: A molecular phylogeny**

Suzanne T. WILLIAMS, D. Tim J. LITTLEWOOD and David G. REID

Department of Zoology, The Natural History Museum, London SW7 5BD, UK,
suzaw@nhm.ac.uk

The 26 species of the littorinid genus *Nodilittorina* that occur in the Indo-West Pacific (IWP) marine biogeographic region are a suitable model for the investigation of the origin of the high diversity focus in the centre of the region and for the study of speciation processes in marine invertebrates with high dispersal capacity. A morphological study of *Nodilittorina* suggests that molecular data are needed to resolve the phylogeny of the group, in order to examine these biogeographic questions (see presentation by Reid *et al.*). We present our preliminary findings at this meeting.

As a first step we attempt to infer the phylogeny of the entire genus *Nodilittorina* (57 species worldwide). We have examined sequence variation in three genes, one nuclear (28S ribosomal gene, 1400 bp) and two mitochondrial (12S ribosomal gene and cytochrome oxidase I, 340 and 1200 bp respectively), from almost all species of *Nodilittorina* together with outgroups from the genera *Littorina* and *Littoraria*.

An earlier morphological study of the relationships among littorinid genera (Reid 1989) found only weak support for the monophyly of *Nodilittorina*. Our preliminary analyses suggest that *Nodilittorina* is not monophyletic and distinguish three clades that are closely correlated with geographical distribution. These three are: (1) a southern-temperate group (including the type species *N. pyramidalis*); (2) species from the tropical Atlantic and eastern Pacific (including some possible geminate pairs on either side of the Isthmus of Panama); (3) a tropical Indo-West Pacific clade. The biogeographic implications of this division will be discussed and the Indo-West Pacific clade will be the focus of further studies to examine patterns of speciation and intraspecific genetic variation.

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Ancient lakes as evolutionary reservoirs: evidence from the gastropods of Lake Tanganyika

Anthony B. WILSON¹, Matthias GLAUBRECHT² and Axel MEYER³

¹ Faculty of Biology, University of Konstanz, D-78457, Konstanz, Germany,
tony.wilson@uni-konstanz.de

² Department of Malacology, Institute of Systematic Zoology, Museum für Naturkunde, D-10115, Berlin, Germany, matthias.glaubrecht@rz.hu-berlin.de

³ Faculty of Biology, University of Konstanz, D-78457, Konstanz, Germany,
axel.meyer@uni-konstanz.de

As the oldest and deepest of the African rift lakes, Lake Tanganyika has been a remarkably stable inland habitat for over 10 MY, providing unique opportunities for within-lake diversification of its endemic fauna. Although much of the substantial morphological diversity of the endemic cichlids of the lake is believed to have arisen *in situ*, similar patterns of rapid diversification have long been assumed for groups for which no information was available. In contradiction of the traditional hypothesis of within-lake diversification, we present molecular data from mitochondrial cytochrome oxidase I and 16S rDNA genes that indicate that much of the dramatic diversity of gastropod shell forms presently found within the lake predate its formation and are not the result of within-basin predator-prey coevolution. Lake Tanganyika has played an important role as an evolutionary reservoir of ancient gastropod lineages which have been extirpated outside the Lake.

Reconstructing an invasion: colonization and spread of invasive zebra and quagga mussels in the Laurentian Great Lakes as revealed by microsatellite markers

Anthony B. WILSON¹ and Kerry NAISH²

¹ Faculty of Biology, University of Konstanz, D-78457, Konstanz, Germany,
tony.wilson@uni-konstanz.de

² School of Aquatic & Fisheries Sciences, University of Washington, 1124 Boat St.
NE, Seattle, WA, USA, knaish@u.washington.edu

Life history and dispersal characteristics of bivalve molluscs have contributed to their success as invasive species. Since the ballast water introductions of zebra (*Dreissena polymorpha*) and quagga mussels (*D. bugensis*) to North America in the late 1980s, they have spread rapidly and significantly altered native ecological communities. In this study, we have developed species-specific microsatellite markers in an attempt to quantify the introduction and spread of zebra and quagga mussels in the Great Lakes drainage basin. Census data indicate that *Dreissena bugensis* is replacing *D. polymorpha* in the eastern basin of Lake Ontario, suggesting that the two species are in the midst of a dynamic process of competitive exclusion. Comparative molecular studies will provide information on the population dynamics of dreissenids in the Great Lakes and contribute to our understanding of the processes which govern the introduction and spread of exotic species.

Morphology and systematics of *Fargoa bushiana* and *F. dianthophila* (Heterostropha: Pyramidellidae), including a review of the genus *Fargoa*

John B. WISE

Houston Museum of Natural Science, One Hermann Circle, Houston, TX 77030,
USA, jwise@hmns.org

Currently, four Western Atlantic species (*Fargoa bushiana*, *F. dianthophila*, *F. bartschi*, and *F. gibbosa*), each with differing shell morphologies, are assigned to the genus *Fargoa*. This is not unusual, as different shell morphologies do not a priori eliminate considerations of propinquity. Conversely, convergence in shell shape among disparate taxa is common. Anatomically, *F. bushiana* and *F. dianthophila* share somewhat similar head-foot configurations. However, alimentary tract morphologies, as well as distinctive, differentially shaped cuticularized (e.g., *F. bushiana*) or not cuticularized, (e.g., *F. dianthophila*) spermatophores separate these taxa. A description of the genus and a discussion of the species assigned to this taxon is also presented.

Pacific pyramidellid paradigms

John B. WISE

Houston Museum of Natural Science, One Hermann Circle, Houston, TX 77030,
USA, jwise@hmns.org

The Pyramidellidae is a large pandemic group, containing over 400 nominal genera and 3000–5000 species. Preliminary examination of pyramidellid specimens collected from shallow and deep water off New Caledonia suggests a high regional diversification for this family, supporting the contention that diversity across several molluscan families is quite high in this area (Bouchet 1993; Bouchet pers. comm.). Two New Caledonian sites, Koumac and Touho were chosen for comparative purposes because they are representative of the habitats of the west and east sides of the island. The survey, particularly targeting micromollusks, was conducted under the auspices of the Museum Nationale d' Histoire Naturelle (Paris) and is one of the most thorough and comprehensive studies ever undertaken in the Indo-Pacific. To date, 20 genera and 124 species, as well as 23 genera and 123 species of pyramidellids have been identified for Koumac and Touho respectively. These taxa are being used to answer the following questions:

- 1) Is there a difference in species composition between sites? Between shallow and deep-water assemblages?
- 2) What, if any, are the distributional patterns of these taxa?
- 3) Can a correlation (host-parasite) be made between the pyramidellids and other molluscan taxa found in the same sites?
- 4) How do the phylogenetics of the New Caledonian pyramidellids compare with those of other pyramidellid taxa living elsewhere?

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Visiting the Mollusca Section at the National Museum of Wales, Cardiff

Harriet WOOD

National Museum & Galleries of Wales, Cathays Park, Cardiff, CF10 3NP, Wales,
Harriet.Wood@nmgw.ac.uk

The National Museum of Wales (Cardiff) holds one of the larger molluscan collections in Europe. Our dry collection, comprised of some 380,000 lots, is an amalgamation of scientifically and historically important collections stored in a single systematic sequence. At the core is the Melvill-Tomlin collection acquired in 1955. It was started by J.C. Melvill (1845-1929), and acquired in 1919 by J. R. le Brockton Tomlin (1864-1954) who continued to build one of the largest shell collections ever amassed by a private individual. Between them they obtained material from over 900 sources world-wide. It was Tomlin's friendship with the then Director of the NMW, William E. Hoyle, which inspired him to donate his shell collection and extensive library to the museum. Hoyle himself was a well known cephalopod expert and his wet collection of over 450 lots of cephalopods, containing many types, resides at the NMW. Other important acquisitions include those of R. H. Rippon, J. F. Jackson, and L. W. Dillwyn, and more recently, Tom Pain, the Holyoak-Seddon palaeartic collection and the John Evans collection of archaeological molluscs. The section continues to acquire material today, for example, the Viader collection of Mauritius marine molluscs and land snails from Natal Forest Survey. The number of type, figured and cited material in both the wet and dry collections is currently nearly 3000 lots, but when further research is completed may total up to 10,000 lots.

The museum staff, past and present, also continue to add to the collections, including J. Davy Dean and S. Peter Dance. Current areas of research are the bivalves of the Indian Ocean and the terrestrial molluscs of Africa and Madeira, of which much of the collected material is stored in spirits. These projects illustrate how our expertise is used in a variety of areas, ranging from local biodiversity surveys to alpha taxonomy and overseas training projects.

The Museum encourages visitors to use this vast scientific resource and the section has excellent visitor services facilities. Before arriving at the museum you can search 60% of our dry collection on the museum website [<http://www.nmgw.ac.uk/biosyb/collections/mollusca/index.en.shtml>].

If visiting the collection you can take advantage of our extensive historical molluscan library, reprints and journals. If you are unable to visit the collection, we operate a loan service (subject to status). Please contact Harriet Wood at Harriet.Wood@nmgw.ac.uk for any enquiries.

CephBase II – a new tool for quantifying, cataloging and investigating cephalopod biodiversity

James B. WOOD

National Resource Center for Cephalopods, Galveston, TX 77555-1163, USA.

Online databases allow scientists to collect large amounts of biodiversity, life history, behavior and ecological information in one place. Scientific information has traditionally been held in journal articles that are often difficult to obtain. Additionally this traditional media has some very real limits on the amount and type of data that can be presented. Simply collecting and displaying information from many articles, such as species distribution, is often enough to see new patterns. When we take this information and combine it with what we know about the environment such as bottom type, currents, primary production, temperature and other parameters, we really tap into the power of databases. Putting this data online acts as a catalyst for scientific productivity. It allows many workers from a variety of backgrounds and across geopolitical borders easy access to large amounts of information. Much like a microscope allowed us to see what was always there, this emerging technology allows us to look at something that already existed in new and exciting ways.

CephBase www.cephbase.utmb.edu is an online relational database that catalogs the biodiversity of all living cephalopods in one easy to access place. It contains distribution, predator, prey and image data plus over 3000 references for this productive class of mollusks. A demonstration of the main features of CephBase will be given.

CephBase is part of the Census of Marine Life, an international program to explain the diversity, distribution and abundance of marine life.

Morphological characters of glochidia of Unionidae in China and their taxonomic significance

Xiaoping WU¹, Shan OUYANG¹ and Yanling LIANG²

¹ Department of Biological Science and Technology, Nanchang University, Nanchang, 330047, P.R.China, wuxiao@public.nc.jx.cn

² Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, P.R.China

Traditionally, the classification of unionid mussels has been based mainly on shell characters. However, these characters may vary considerably due to different environmental conditions and are, therefore, often unreliable for identification and phylogenetic questions in unionids. Recently, the morphology of glochidia attracted increasing attention, resulting in new evidence and a widened dataset for both species identification and phylogenetic analysis. Although China is rich in unionids, the glochidia of only a few species have been described so far.

Based on specimens collected from mid-lower basins of Changjiang River, a comparative study of glochidia of 18 unionid species (*Unio douglasiae*, *Acuticosta chinensis*, *Acuticosta aurora*, *Lanceolaria eucylindrica*, *Lanceolaria gladiola*, *Cuneopsis pisciculus*, *Arconaia lanceolata*, *Lamprotula cornnumlunae*, *Lamprotula caveata*, *Aculamprotula fibrosa*, *Hyriopsis cumingii*, *Anodonta woodiana woodiana*, *Anodonta pacifica*, *Anodonta lucida*, *Anodonta angula*, *Anodonta acaeorformis*, *Cristaria plicata* and *Lepidodesma languilati*) was made using light and scanning electron microscopy. The results indicate that the following characters differ between species: shell shape and size, decoration and pore of shells, hook, spines, sensory hairs as well as larval thread. These characters are considered to be significant for species identification and phylogenetic analysis.

The project was supported by NSFC(No. 39760015)

Extant Limnardiidae (Bivalvia: Cardioidea) of Ukraine: research perspectives

Vladimir I. YURYSHYNETS¹ and Alexei V. KORNIUSHIN²

¹ Institute of Hydrobiology and ² Institute of Zoology, The National Academy of Sciences, Kiev, Ukraine, clam@mapinfo.zzn.com

Being typical ecotonic organisms, molluscs of the family Limnardiidae are represented in Ukraine in mixohalinic habitats, such as estuarine lakes of the Danube and estuaries of Dnieper, South Bug and Dniestr. Taxonomy of this group is still disputable. Zhadin (1952) recognised 3 species included in 2 genera: *Monodacna colorata* (Eichwald, 1829), *M. pontica* Eichwald, 1838 and *Adacna laeviuscula* (Eichwald, 1829). Scarlato & Starobogatov (1972) distinguished between 9 species of the only genus *Hypanis*, adding to the Ukrainian fauna *H. caspia* (Eichwald, 1841), *H. angusticostata* (Borcea, 1926), *H. jalpugensis* (Borcea, 1926) and *H. plicata* (Eichwald, 1829). All the mentioned authors based their classifications on traditional shell characters but provided different interpretations of the observed differences.

In our analysis of the distribution of metric characters in the lots from Lake Sasyk near Danube and Dnieper, the rounded form (typical *H. colorata*) and the elongated form (presumably *H. jalpugensis*) could not be discriminated unequivocally. Considerable variation of the other diagnostic shell characters used in the identification key of Scarlato & Starobogatov (1972) was also observed. Anatomical investigation confirmed the differences between *Monodacna* and *Adacna* groups in lengths of siphons and siphonal muscles. While both forms of *Monodacna* were similar to *H. (Adacna) plicata* from Dnieper estuary in gill characters, the form found in Dnieper near Kherson (presumably *H. pontica*) differed in the considerable posterior shift of its outer demibranch (corresponding ontogenetic stages were compared). Thus, the species distinguished by Zhadin (1952) seem to be well justified, whereas the grounds for the further species splitting in the group need to be checked more carefully. Recent changes in the distribution range of the group (decrease of some populations and expansion of the other) are to be studied as well.

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Optimisation of *Anodonta cygnea* L. (Bivalvia, Unionidae) vertical distribution

Katarzyna ZAJAC

Institute of Nature Conservation, Polish Academy of Sciences, Mickiewicza 33, 31-120 Kraków, Poland, nozajac@cyf-kr.edu.pl

The distribution of the swan mussel was studied in Pińczów water reservoir (southern Poland). It was found that vertical distribution of the swan mussel in the water body was non-random: most of the individuals occur close to the banks, with the highest proportion of individuals in the first year of life. Older, larger individuals occur at larger depths.

This distribution pattern was interpreted as an optimisation process between individual growth and predation probability: shallow, warm and rich waters near the banks offer better conditions for quick growth, thus they are advantageous for young individuals, which can quickly reach maturity. Predators (mainly otter) actively chose larger individuals. Young, very small individuals are unprofitable prey for them, whereas larger, which are preferred, have to escape predation moving into deeper water.

It was also found, that young individuals, living in unpredictable environment (close to the bank), showed large mobility (they can move relatively quickly on large distances), whereas old individuals are practically motionless.

Marine bivalves of the Mljet National Park (Adriatic Sea, Croatia)

Tihana ŽERLIĆ

Thais - Society for Exploration and Conservation of Nature, Podgaj 11, 10 000
Zagreb, Croatia, tzerlic@hotmail.com

The fauna of bivalves in the Mljet National Park marine environment is not very widely known because it has rarely been the subject of scientific research. Therefore, within the framework of a student research project of the THAIS Society, special attention was paid to occurrence, vertical distribution and ecology of bivalve species in the Mljet National Park. Bivalve collections were made during summer vacations of 1995-1998. A total of 82 stations in the National Park and 2 stations just outside its borders were surveyed. Along transects, *in situ* observations and collections were made by skin and SCUBA diving to about 50 meters of depth. Underwater photography was also applied. At greater depth, live bivalves and/or their shells were sampled occasionally by Van Veen grab, commercial trawl and trammel bottom set.

A total of 134 bivalve species from 38 families were identified, 20 of them to genus level. More than two-thirds of the identified species (92) were not noted previously in the Mljet area.

Some species, rarely noted in previous Adriatic Sea literature, like *Anadara diluvii*, *Barbatia scabra*, *Camptonectes striatus*, *Chlamys bruei*, *Globivenus effosa*, *Clausinella brongniartii* and *Mysia undata* were found. Four species (*Nucula tumidula*, *Nucula hanleyi*, *Idasola simpsoni* and *Thyasira granulosa*) were recorded for the first time in the eastern Adriatic, as well as one juvenile individual of an Indo-Pacific species *Semipallium coruscans coruscans* (Hinds, 1845).

The most abundant and the most frequently noted species at stations surveyed were *Gastrochaena dubia* and *Arca noae*. Also, many individuals and shells of *Venus verrucosa*, *Lithophaga lithophaga*, *Chlamys varia*, *Plagiocardium papillosum*, *Barbatia barbata*, *Ctena decussata* and *Striarca lactea* were recorded, as well as numerous individuals of *Pinna nobilis*, a bivalve protected by law, in the lake-like inlet part of the National Park, the area of Veliko and Malo jezero.

Tolerance to starvation by the long-lived freshwater pearl mussel *Margaritifera margaritifera* (Bivalvia, Margaritiferidae)

Valery ZIUGANOV¹, Ekaterina POPKOVITCH¹, Viktor BELETSKY¹, and
Richard J. NEVES²

¹ Institute of Developmental Biology, Vavilov Street 26, Moscow 117808
Russia, vziug@ibrran.msk.su, valeryz@orc.ru

² Virginia Cooperative Fish and Wildlife Research Unit, Virginia Polytechnic Institute
and State University, Blacksburg, Virginia 24061 U.S.A., mussel@vt.edu

The freshwater pearl mussel (*Margaritifera margaritifera*) can attain ages exceeding 200 years in polar climates. During winter, these mussels experience a near starvation environment for the 6 months of polar night at near 0° C water temperature. During periodic droughts in summer, they are capable of anaerobic metabolism and high survival when emersed for at least 1 month. Because of their tolerance to environmental extremes, experiments were conducted with specimens collected from the Varzuga River, northwest Russia, to assess survival for long periods without food. In September 1997, 200 adult pearl mussels (length=110-140 mm, age=90-130 yr) were collected, marked, weighed, and transferred as two randomly assigned groups to the laboratory. In addition, 100 young mussels (length=10-30 mm, age=4-10 yr) also were collected and held with the second group of adults. Mussels were placed into tanks with aerated, charcoal-filtered tap water (12° C) mixed with distilled water to achieve 50 mg/l calcium hardness. The substratum consisted of a 12 cm layer of pebbles and sand. Group 1 (n=100) was kept in four tanks for 2 yr in total darkness without food. Mussels completely burrowed into the substratum, and after 2 yr, 86 mussels were recovered alive and transferred back to the Varzuga River. During the starvation period, mussels lost 20-24% of total weight, and shells became fragile. In September 2000, 57 (66%) of these marked specimens were re-collected alive from the river, and females contained viable glochidia. Group 2 (n=100) was kept in four tanks under a light regime of 12 hr light: 12 hr dark. In each tank, 500 g of plant material from the river was added to provide a potential food source or stimulus for feeding. These mussels partially burrowed into the substratum and exhibited filtration behavior. After 2 mo, mussels began to die at a rate of 20 specimens/wk. After 4 mo, all mussels were dead after losing roughly 30% of total body weight. Young mussels cohabiting with these adults showed high survival; 92% were recovered alive and returned to the Varzuga River. These young mussels were deeply burrowed in the substratum with no evidence of filtration behavior. The experiments show conclusively that environmental conditions that elicit filtration behavior result in subsequent mortality of mussels over several months. Adult and juvenile mussels that do not expend energy for filtration and associated metabolic activity can survive long periods without food and recover from their emaciated condition.

Evolution vs. migration in Austrian Miocene marine mollusc communities

Martin ZUSCHIN¹, Mathias HARZHAUSER² and Oleg MANDIC¹

¹ Institute of Palaeontology, University of Vienna, Althanstrasse 14, 1090 Wien, Austria, martin.zuschin@univie.ac.at

² Museum of Natural History, Burgring 7, BOX 417, A-1014 Wien, Austria.

The aim of this project is to study migration and geographic isolation as controlling factors for the composition of marine paleocommunities in the Austrian Miocene. The mollusc assemblages of six time-slices are under investigation. Three of them represent mollusc faunas that developed under migration conditions, whereas the others contain isolated faunas with endemic evolution.

Seaways from the Paratethys to adjacent bioprovinces (Mediterranean, Atlantic and the Indo-Pacific) resulted in migration waves and highly diverse faunas with complex community patterns. Corresponding facies should host morphologically and taxonomically similar species in all migration-timeslices. Of particular interest is the influence of new immigrants on the established communities (*e.g.* influence of Mediterranean pectinids on the sublittoral faunas of the lower Miocene in Austria).

Geodynamic processes culminated in three distinct isolation periods of the Central Paratethys, accompanied by distinct changes in water chemistry. These conditions resulted in endemic evolution of certain molluscs and a fundamental shift in the composition of paleocommunities. In particular the extinction of stenohaline species caused drastic changes in the trophic structures and the take-over by adapted species. The investigated isolation-faunas differ clearly from each other because of the different ecological conditions that developed during each isolation. Nonetheless, analogies in paleocommunity-structures are expected because in all three time-slices similar taxa such as cardiids, congerias and melanopsids prevail.

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Palaeoecology and evolution of bivalve larvae – Evidence from stable isotopes

Nikolaus MALCHUS

Institut für Paläontologie, FU Berlin, Malteserstr. 74-100, D-12249 Berlin, Germany,
nikolaus.malchus@uab.es

The stable isotope ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) composition of fossil shells of marine bivalve larvae and their accompanying fauna can be an important source of independent information on larval palaeoecology and evolution (Malchus & Steuber 2001). 1) The data obtained from Jurassic fauna strongly suggest that benthic bivalves, ammonites and larval bivalves lived in a seasonally induced temperature/salinity-stratified water column. Larval bivalve shells show palaeotemperatures equal to or slightly higher than those of ammonites indicating that they were planktic-planktotrophic. 2) A planktic-planktotrophic life cycle cannot be induced with certainty from the prodissoconch I (P I) or the P I/P II-ratio. 3) With bakevelliid larval shells as an example we dispose of the first, preliminarily estimate of maximum shell size (850 μm), with which (fossil) bivalve larvae could have stood afloat. 4) Water density increases with either lower temperatures or higher salinities. The questions emerge, therefore, (a) whether these parameters would significantly influence the floating capacity of larvae, (b) whether this could be the reason for the appearance of extraordinarily large larvae in the past, and (c) whether the evolutionary size decrease found in some lineages could have been induced by temperature/salinity changes.

References

Malchus N & Steuber T. 2001. Stable isotope records (O, C) of Jurassic aragonitic shells from England and NW Poland: palaeoecologic and environmental implications. *Géobios*, in press.

Early ontogeny, heterochrony and evolution in pteriomorphian bivalves

Nikolaus MALCHUS

Institut für Paläontologie, FU Berlin, Malteserstr. 74-100, D-12249 Berlin, Germany,
nikolaus.malchus@uab.es

Early ontogenetic shell stages of pteriomorph bivalves from the Jurassic of Poland and England, from the NW Mediterranean and the Red Sea show: 1) that the larval soft body of Middle Jurassic bakevelliids and oysters, Lower Cretaceous inoceramids and living pterioids – *Pteria*, *Electroma*, *Pinctada*, *Malleus* – grows anteriorly, along a helicospiral path, and that the ligament-secreting mantle cells rotate in the same sense. 2) The post-metamorphic ligament of bakevelliids, inoceramids and living pterioids, however, grows posteriorly, which is not the case in post-larval oysters. 3) Pteriidae (including the type species), *Malleus* and oysters (atavistically) are multivincular in early post-metamorphic stages. Tertiary and recent Spondylidae and Plicatulidae possess multiple resilifers as adults. A model is presented, which assumes that the number of resilifers in adult specimens is largely a function of space on the hinge area. 4) The model of ligament growth-constraints involves that the position of the larval ligament cannot be used to distinguish between left and right valves. 5) The larval postero-dorsal notch of oysters and the postero-dorsal outlet (new feature) of pterioids are homologous. However, in oysters the character forms much earlier in ontogeny due to heterochronic processes. The offset time of helicoidal-spiral growth in oysters appears to be delayed, therefore. 6) The similarity in larval shell characters of Bakevelliidae, Pteriidae, and Ostreoidea, and the plesiomorphic existence of multivincularity in the latter two taxa indicate close phylogenetic relationship. Larval opisthogyry is very likely a much older (at least Silurian), plesiomorphic trait within the Pteriomorphia.

**Separating historic events from recurrent processes in cryptic species:
phylogeography of *Hydrobia* (Gastropoda, Hydrobiidae)**

Thomas WILKE¹ and Markus PFENNINGER²

¹ Department of Microbiology and Tropical Medicine, George Washington University
Medical Center, 2300 Eye Street NW, Washington DC 20037, USA,
mtmtxw@gwumc.edu

² J.W. Goethe-Universität Frankfurt am Main, Abteilung Ökologie & Evolution,
BioCampus, Siesmayerstraße, D-60054 Frankfurt am Main, Germany.

The molecular revolution of phylogenetics has provided powerful tools for species-level studies based on the reconstruction of past population events and geographic modes. Coalescent theory, which makes use of the historic information contained in gene genealogies, is a promising framework for studying population history and dynamic structure.

We use the two mudsnail species *Hydrobia acuta* and *H. glyca* as a paradigm for investigating the role of biogeography and past geographic events in speciation based on nested clade, mismatch distribution, and maximum likelihood gene flow analyses of mitochondrial haplotypes. A recent study of phylogenetic relationships within the genus *Hydrobia* has revealed interesting distribution patterns for these two brackish-water species: *H. glyca* occurs in the northern Atlantic from northwest Africa to Brittany and divides the distribution of *H. acuta* into two segments. *Hydrobia acuta acuta* occurs in the Mediterranean and *H. acuta neglecta* occurs in the eastern part of the English Channel, the North Sea, the Baltic Sea, and the Norwegian Sea.

Our analyses of mitochondrial sequencing data for 141 specimens from 25 populations revealed the distinctness of *H. glyca* and *H. acuta*. Nested clade and gene flow analyses indicate a past fragmentation among four groups of haplotypes in *H. glyca* with a considerable degree of gene flow from northern Spain to Brittany. The two subspecies of *H. acuta* have likely evolved as a result of past fragmentation. Within *H. acuta neglecta*, a fair degree of gene flow from the North Sea to the Baltic Sea could be observed, indicating that the Baltic Sea populations are secondary. Within *H. acuta acuta*, a past fragmentation of the westernmost population from Tarifa from all other Mediterranean populations could be detected.

Based on our analyses, we hypothesize that a range shift and/or range expansion of *H. glyca* from northwestern Africa to the Iberian Peninsula as a result of the post-glacial warming caused the separation of *H. acuta acuta* and *H. acuta neglecta*. The fact that *H. glyca* has a higher tolerance for the potentially superior competitor *Peringia ulvae* (Hydrobiidae) than *H. acuta* may have contributed to the observed distribution patterns.