

Program and Abstracts of the 68th Meeting of the American Malacological Society



Held at the
Lightsey
Conference Center
College of Charleston
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Editor

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Preface

It has been a great honor to serve as the 2001-02 President of the American Malacological Society, and a pleasure to Chair the program of the Society's 68th meeting in Charleston. Charleston is America's most beautifully preserved architectural treasure, featuring historic homes, restaurants, shops, museums, and tours. The College of Charleston's Lightsey Center is a modern facility with a complete range of conference services. A variety of special activities have been planned, including a reception in historic Alumni Hall, an endowment auction with musical entertainment, a dinner cruise on Charleston Harbor, and a variety of field trips.

The featured Symposium for 2002 is an especially timely one: **The Biology and Conservation of Freshwater Gastropods**. The North American fauna includes about 500 nominal species of freshwater gastropods. But the taxonomy of many groups predates the modern synthesis, and great confusion exists regarding the specific identity of even the most common populations. As a consequence, large regions of the continent have never been adequately surveyed, and fundamental aspects of the ecology of many freshwater gastropod groups remain obscure. Absent a recommitment to basic research on the biology of freshwater gastropods, a critical element of our biota is in danger of slipping away.

As a companion to the Symposium, Amy Wethington has organized a special session entitled **Pulmonates in the Laboratory**. Given their short life spans, proficient egg laying, genetic diversity, activity, and ease of culture, freshwater pulmonate gastropods make great organisms for experimental study. The special session is intended to address all aspects of experimental study using Pulmonates: behavior, life history, genetics (population as well as transmission), mating systems, reproductive biology, and much more.

A second special session has been organized by John Wise and Ellen Strong: **Multidisciplinary Approaches to Molluscan Phylogeny**. The intent is to provide a well rounded forum for discussing the unique challenges of analyzing multiple data sets in phylogenetic studies of mollusks. Case studies are offered and used as a framework to address theoretical and philosophical issues, e.g. of

separate vs. simultaneous analysis, (in)congruence of multiple data sets, and the reconciliation of disparate data sources. Such independent data sources include, but are not limited to, morphological, molecular, fossil, and biogeographic data.

In addition to the above, AMS 2002 features seven contributed paper sessions and a large poster session covering the entire spectrum of malacology.

I'd like to thank Tom Smith, Matt Rhett, Amy Wethington, John Wise, Dick & Liz Petit, Julian Harrison, and my wife Shary for contributions of time and talent invaluable in making this meeting a success. Special appreciation is due to our host institution, the College of Charleston, and especially to Ms. Leslie Whaley, Ms. Regina Semko, and all the Lightsey Center staff. Once again, **Welcome to Charleston!**

- Rob Dillon



Abbreviations used throughout this booklet:

P – Poster.

C1, C2, ..., C7 – Seven contributed paper sessions.

BCFG – Biology and Conservation of Freshwater Gastropods.

MAMP – Multidisciplinary Approaches to Molluscan Phylogeny.

PITL – Pulmonates in the Laboratory.

Asterisk* - Competing for a student award.

Saturday, August 3

9:30 – 6:00 Registration

10:00 – 12:00 Council Meeting, Room 217

1:20 – 3:00 Council Meeting continued, if needed.

7:00 President's Reception, Randolph Hall

Sunday, August 4

Plenary Session, Room 228

8:20 Introduction. R. T. Dillon

8:30 Welcome. Dr. James P. Deavor, Dean, School of Science and Math,
College of Charleston.

8:40 Kenneth M. Brown & Paul D. Johnson. The way they were versus the way
they are: comparative conservation ecology of pulmonate and pleurocerid
gastropods.

9:10 Jay Cordeiro. Nature Serve Explorer - An innovative tool for the
malacological community.

9:30 Amy R. Wethington. Pulmonate snails as models: Three case studies
involving sex allocation, life history, and phenotypic plasticity.

10:00 Break

Sunday, August 4. Room 228W

Symposium: Biology and Conservation of Freshwater Gastropods

- 10:20 John Alderman - Evolution of aquatic habitat conservation in North Carolina.
- 10:40 Brian Watson - Developing a successful freshwater snail inventory and conservation program within a State Resource Agency.
- 11:00 Timothy W. Stewart and Robert T. Dillon, Jr. - Geographic distribution and conservation status of Virginia's freshwater gastropods.
- 11:20 Douglas N. Shelton - The Freshwater Gastropods of Mississippi: Pioneer Survey Efforts in the 21st Century.
- 11:40 Robert Guralnick. - A Molluscan Informatics Utopia: Challenges and Approaches For Data Sharing and Data Use for Conservation and Biodiversity.
- 12:00 Lunch (On your own.)
- 1:20 E. Michel, P. McIntyre, Kristin France, and Jonathan Todd - Direct and Indirect Effects of Sedimentation on Rocky Littoral Gastropods of Lake Tanganyika.
- 1:40 Steven G. Johnson - Spatial patterns of genetic structure, armature and coloration in *Mexipyrghus churinceanus*.
- 2:00 E.L. Mihalcik, and F. G. Thompson - Interspecific and intraspecific assessment of mtDNA CO1 of the freshwater snail *Elimia curvicostata* complex with the southeastern rivers of Florida, Georgia, and Alabama (GASTROPODA: PLEUROCERIDAE).
- 2:20 Charles Lydeard - The Phylogenetic Species Concept and its application in the conservation of freshwater mollusks.
- 2:40 Matthias Glaubrecht - Leopold von Buch's legacy: treating species as dynamic natural entities, or Why geography matters.
- 3:00 Break

- 3:20 Eileen Jokinen - Mollusks of the Aquatic Communities of Miller Woods in the Indiana Dunes National Lakeshore.
- 3:40 Amy R. Wethington* - Conservation issues concerning the endangered *Physa (Physella) johnsoni*, the Banff Springs Snail.
- 4:00 Arthur E. Bogan, Morgan Raley, and Jay Levine - Conservation status of the Magnificent Ramshorn (*Planorbella magnifica* (Pilsbry, 1903), endemic to the lower Cape Fear River Basin, North Carolina (Mollusca, Gastropoda, Planorbidae).
- 4:20 Robert F. McMahon – A 15-year study of intrapopulation, interannual shell-shape variation in the freshwater pulmonate limpet, *Hebetancylus excentricus*.
- 4:40 Robert T. Dillon, Jr. – But a single step: The freshwater gastropods of South Carolina.
- 5:00 Dinner (on your own.)
- 7:00 Committee Meetings.
FWGNA in Room 228W.

Sunday, August 4. Room 228E

Contributed Session #1, José Leal chairs.

- 10:20 Benoît Dayrat - History of the Classification of Mollusks.
- 10:40 Gerhard Steiner, Hermann Dreyer and Elizabeth M. Harper - Molecular phylogeny of the anomalodesmatan Bivalvia inferred from 18S and 28S rDNA sequences.
- 11:00 David C. Campbell - Molecular insights on a traditional taxon: Heteroconchia and Suborder Venerina.
- 11:20 Alan J. Kohn - Biodiversity of *Conus*: How many species are there?
- 11:40 Fred E. Wells - Malacological Results of the Western Australian Marine Biological Workshop Series.
- 12:00 Lunch (On your own.)

Contributed Session #2, Ángel Valdés chairs.

- 1:20 Kenneth A. Hayes* - Evolution of the “*Corona Complex*” in the genus *Melongena* (Gastropoda: Melongenidae).
- 1:40 Caren E. Braby* - Environmental physiology and distribution of *Mytilus* as a model for understanding species invasions.
- 2:00 Fabio Moretzsohn* - More than just a pretty pattern: what the spots on the shell of *Cribrarula cribraria* tell us about its anatomy (Gastropoda: Cypraeidae).
- 2:20 Rebecca M. Price* - Is there a functional relationship between columellar folds and the columellar muscle in neogastropods?
- 2:40 Alan J. Kohn - Six-shooters of the mollusc world: Prey capture by molluscivorous *Conus*.
- 3:00 Break.

Contributed Session #3, Joe Thompson Chairs.

- 3:20 J. T. Thompson and J. R. Voight - Erectile tissue in the *Octopus* copulatory organ.
- 3:40 Roland C. Anderson and Jennifer A. Mather - Sleep behavior in octopuses *Enteroctopus dofleini* (Cephalopoda: Octopodidae).
- 4:00 Jochen Gerber & Esther Schechter - Mollusks from archaeological excavations in NW Papua New Guinea.
- 4:20 Lyle D. Campbell, Sarah C. Campbell, and Andrew K. Rindsberg - Fossils labeled "Prof. Tuomey" "Miocene, S. C." housed in the collections of the Alabama Geological Survey.
- 4:40 Matthew Campbell* - Systematics and Phylogenetics of late Paleozoic Streptacidae (Gastropoda, Heterostropha).
- 5:00 Dinner (On your own.)
- 7:00 Committee Meetings
FWGNA in Room 228W.

Monday, August 5. Room 228W.

Special Session: Multidisciplinary Approaches to Molluscan Phylogeny

Ellen Strong, Chair.

- 8:20 John Wise, M.G. Harasewych, and Robert T. Dillon - COI, allozyme, and morphological survey of the sinistral *Busycon* of North America.
- 8:40 António M. de Frias Martins & M. G. Harasewych - Phylogeny of the Ellobiidae.
- 9:00 Ángel Valdés - How many times has the radula been lost in dorid nudibranchs? Reconciliation of molecular and morphological data.
- 9:20 Terrence M. Gosliner, Rebecca Johnson & Shireen Fahey - Does color pattern provide phylogenetically informative characters?
- 9:40 M. G. Harasewych, Glenn A. Goodfriend & Stephen J. Gould - Relationships among *Cerion* snails on Long Island, Bahamas deduced from molecular (cytochrome c oxidase I) and morphological data.
- 10:00 Break.
- 10:20 Thomas von Rintelen & Matthias Glaubrecht - Gene trees and species trees – a case study from a species flock of viviparous freshwater gastropods (Caenogastropoda: Cerithioidea: Pachychilidae) from the ancient lakes of Sulawesi, Indonesia.
- 10:40 Mónica Medina, Yvonne Vallès, Terrence Gosliner, H. Mathew Fourcade and Jeffrey Boore - Mitochondrial gene order versus sequence data in heterobranch gastropods.
- 11:00 Kevin J. Roe - Historical biogeography in the Central Highlands region of North America: A comparison of the ability of analytical methods to resolve conflicting data.
- 11:20 Taehwan Lee, Andrea Walther & Diarmaid Ó Foighil - Polyploid Molluscs: Double the Phylogenetic Trouble?
- 11:40 George M. Davis and Thomas Wilke - The use and misuse of data sets in reconstructing phylogenies.

12:00 Lunch (On your own.)

Special Session Continued: Multidisciplinary Approaches to Molluscan Phylogeny

John Wise, Chair.

- 1:20 Ellen E. Strong, M. Glaubrecht, Charles Lydeard & Winston Ponder - A total evidence phylogeny of the Cerithioidea.
- 1:40 Patrick D. Reynolds & Gerhard Steiner - Using COI mtDNA sequences and morphological data in resolving relationships among the Scaphopoda.
- 2:00 Gerhard Steiner and Hermann Dreyer - Scaphopoda and Cephalopoda are sister taxa – an evolutionary scenario.
- 2:20 A.G. McArthur, M.G. Harasewych, R. Bieler, D. Colgan, T.M. Collins, J. Healy, G. Haszprunar, A. Kurabashi, D.R. Lindberg, S. Pacocha, W.F. Ponder, T.A. Rawlings, E.E. Strong, S. Tillier, R. Ueshima - Multidisciplinary Examinations of Gastropod Phylogeny.
- 2:40 Discussion.
- 3:00 Break.

Monday, August 5. Room 228E.

Contributed Session #4, Paul Callomon Chairs.

- 8:40 Fabio Moretzsohn - Making the best of museum specimens: a simple method to recover the radula, odontophore and DNA from dried tissues for taxonomic and phylogenetic studies.
- 9:00 Paul Callomon - Byne's disease in molluscan collections: detection and treatment strategies.
- 9:20 James H. McLean – Odostomiine genera reconsidered: shell characters versus spermatophore characters.
- 9:40 Robert H. Cowie, David G. Robinson, and Robert T. Dillon, Jr. - The AMS list of unwanted alien snails in the USA: progress report.
- 10:00 Break.

Contributed Session #5, Tim Pearce chairs.

- 10:20 Douglas Prasher, John Molongoski, Peggy Elder, and David Robinson - Identification of mollusk taxa at U.S. ports of entry: Help from molecular biology.
- 10:40 Somsak Panha, Piyoros Tongkerd, Chirasak Sutcharit, Sakbovon Tumpeesuwan, Pongpun Prasankok and John B. Burch - Distribution of Pupillid Micro Land Snails in Thailand and Adjacent Areas.
- 11:00 G. Thomas Watters - Land Snail Fauna of a Reclaimed Strip-Mined Land Site in the Midwest of the USA.
- 11:20 Timothy A. Pearce - When a snail dies in the forest, how long will the shell persist?
- 11:40 Piyoros Tongkerd* - Testing the Phylogenetic utility of taxonomic shell characters in Thai Pupillid Micro Land Snails.
- 12:00 Lunch (On your own.)

Contributed Session #6, Bob Prezant Chairs.

- 1:20 Thomas Wilke, Markus Pfenninger & George M. Davis - Shaken not stirred: phylogeography of *Oncomelania hupensis hupensis* in the Yangtze River.
- 1:40 Fred G. Thompson and E.L. Mihalcik - The freshwater snails of the *Elimia curvicostata* complex from the southeastern rivers of Florida, Georgia, and Alabama (GASTROPODA: PLEUROCERIDAE).
- 2:00 Jeffrey D. Sides* - Phylogenetic systematics and conservation status of the *Pleurocera* of the Mobile Basin.
- 2:20 David C. Richards, Dianne Cazier Shinn, and Billie L. Kerans - The invasive New Zealand mudsnail *Potamopyrgus antipodarum* in Western USA.
- 2:40 Russell L. Minton and Steven P. Savarese, Jr. - A new species of pleurocerid snail from the Harpeth River, Tennessee.
- 3:00 Steven J. Lysne* - Experimental studies on the substrate preference of two gastropods endemic to the middle Snake River, Idaho, USA.
- 3:20 Frida Ben-Ami* - Parthenogenesis: Red Queen vs. Reproductive Assurance.
- 3:20 Break

Monday, August 5. West Exhibit Hall

Poster Session. 3:40 – 5:00.

- [1] Ayana McCoy, Shirley Baker, Ruth Francis-Floyd & Anita Wright - Is *Mercenaria mercenaria* a host for Perkinsus species?
- [2] Isabella Kappner* – Effects of various fixation techniques on tissue of a marine bivalve, *Mercenaria mercenaria* (Linne 1758).
- [3] Rüdiger Bieler, Paula M. Mikkelsen, Russ Minton, Louise Crowley, and Isabella Kappner - Taxonomy on the Half-Shell: a “PEET” project investigating marine bivalves.
- [4] Rüdiger Bieler, Janet Voight, Jochen Gerber, Janeen Jones, Marty Pryzdia - Field Museum's Molluscan Collections.
- [5] Gregory P. Dietl & Gregory S. Herbert - Experiments with the predatory muricid *Chicoreus dilectus* and its bivalve prey *Chione elevata*: Does edge drilling decrease prey handling time?
- [6] Fabio Moretzsohn - Preliminary study of odontophore diversity in the Cypraeidae and the use of odontophores as a source of taxonomic characters.
- [7] Jennifer M. Walker and Thomas S. Hopkins - Preliminary Phylogenetic Analysis of *Melongena corona* Populations from the Gulf of Mexico.
- [8] José H. Leal - New edition of the FAO Identification Guide for Fisheries Purposes, Fishing Area 31 (Western Central Atlantic): Gastropoda and Bivalvia.
- [9] James H. McLean - Progress toward completion of taxonomic reference manual: Shell-bearing Gastropoda of the Northeastern Pacific.
- [10] Patricia Miloslavich, Pablo Penchaszadeh and Ana Karinna Carbonini - Embryonic development of *Crepidula aculeata* (Caenogastropoda, Calyptraeidae) from the Venezuelan Caribbean.
- [11] Diego César Luzzatto and Pablo E. Penchaszadeh - Intracapsular development and hatching in *Adelomelon brasiliiana* (Lamarck, 1819) (Gastropoda, Volutidae) from Northern Patagonia, Argentina.

- [12] Pablo Penchaszadeh, Gregorio Bigatti and Patricia Miloslavich - *Perna viridis* in La Restinga lagoon (Margarita Island, Venezuela): Is this population reproductively active?
- [13] Pablo E. Penchaszadeh, Guido R. Pastorino & Maximiliano Cledón - *Crepidula dilatata* (Gastropoda, Calyptraeidae) truly living in the SW Atlantic.
- [14] Neerupa Ramnath & Angela Fields - A Survey of the Land Snails of Four Islands in the Lesser Antilles: Dominica, St. Lucia, St. Vincent and Grenada.
- [15] Bridget Nicole Tiffany, Nann A. Fanguie, and Wayne A. Bennett - Probable extirpation of a unique endemic *Octopus* species from St. Joseph's Bay, Florida.
- [16] Barbara Gibbs - Molluscan benthic assemblages from potential sand borrow areas on the East Florida shelf.
- [17] Joseph H. Hartman and Arthur Bogan - Usual and Unusual Adaptations in Pre-K/T Impact Diverse Freshwater Molluscan Assemblages in the Northern Great Plains, USA.
- [18] Andrea Walther & John B. Burch - Biogeographic and phylogenetic studies of freshwater limpets.
- [19] Christian Albrecht, Kerstin Kuhn, Thomas Wilke & Bruno Streit - Anatomical and molecular character evolution in the Basommatophora: conflict or congruence?
- [20] ShuPing Wu* - Reproductive Biology and Accelerated Effect of Abnormal Embryos of fresh water snail Pleurocridae (Gastropoda: Prosobranchia) in N. E. Taiwan.
- [21] James W. Smith - Qualitative Pest Risk Analysis of the Channeled Applesnail, *Pomacea canaliculata*, and its Significance to Rice Production in the United States
- [22] Tamara K. Anderson - Where Are They Now? Current U. S. distribution of *Melanoides tuberculata*, an exotic freshwater snail.

- [23] Nora Brinkmann* - Are there two distinct viviparous modes in *Balanocochlis*? On the reproductive anatomy and biogeography of an enigmatic Indopacific freshwater gastropod (Cerithioidea, Thiaridae).
- [24] James R. Cordeiro - Proliferation of the Chinese mystery snail, *Cipangopaludina chinensis malleata* (Reeve, 1863) (Gastropoda: Viviparidae), throughout Connecticut.
- [25] Steven J. Lysne and Peter Koetsier - Experimental studies on the temperature tolerance of two gastropods endemic to the middle Snake River, Idaho, USA.
- [26] Kathryn Perez, W. F. Ponder, D. J. Colgan, C. Lydeard, and Stephanie Walker - Evolutionary Radiation of Spring-Snails (Gastropoda: Hydrobiidae) of the Great Artesian Basin, Australia.
- [27] Robert S. Prezant, Eric J. Chapman & James A. Beemer - Comparative Molluscan Assemblages of West Point Military Academy Drainages.

7:30 – 10:00 Auction and entertainment, Stern Student Center

Tuesday, August 6. Room 228W.

Special Session: Pulmonates in the Laboratory

Amy Wethington, Chair.

- 8:20 Susan M. Bandoni - Planorbid laboratory stocks: Genetic variability, history and scientific communication.
- 8:40 Thomas P. Smith, Amy R. Wethington and R. T. Dillon - Evidence of social facilitation from interspecific crosses in *Physa*.
- 9:00 David K. Britton* - The influence of temperature and shell growth rate on shell shape in five inbred lines of the freshwater pulmonate snail, *Physella virgata*.
- 9:20 Thomas M. McCarthy - Effects of time, predation risk and relatedness on behavior during mating interactions.
- 9:40 Kenneth M. Brown, Kevin R. Carman, and Elizabeth K. Lotufo – What can radio-isotope methods tell us about grazing in *Physella*?
- 10:00 Break.
- 10:20 Andrew M. Turner - Nonlethal effects of predators on behavior and growth of *Physa integra*: comparing mesocosm and field experiments. Multivariate selection and emergent ecological impacts of multiple predators.
- 10:40 R. Brian Langerhans - Plasticity constrained: Overgeneralized induction cues cause maladaptive phenotypes.
- 11:00 Thomas J. DeWitt & R. Brian Langerhans - Multivariate selection and emergent ecological impacts of multiple predators.
- 11:20 Thomas J. DeWitt & R. Brian Langerhans - Morphometrics Workshop—A practical guide to the study of size & shape in ecology and evolution.
- 12:00 Business Lunch, Room 228.

Tuesday, August 6. Room 228E.

Contributed Session #7, Tom Watters chairs.

- 8:20 John E. Weinstein - Ultraviolet light enhances the toxicity of polycyclic aromatic hydrocarbons to glochidia of the paper pondshell, *Utterbackia imbecillis*.
- 8:40 Malcolm F. Vidrine, Dale D. Edwards, Arthur E. Bogan and Walter R. Hoeh - Gill mites and unionoid phylogeny.
- 9:00 Jeanne M. Serb* - The complete mitochondrial genome of the freshwater mussel *Lampsilis ornata* (Unionidae): Insight into the evolution of gene rearrangement in Mollusca.
- 9:20 Richard J. Neves, Jess W. Jones, and William F. Henley - Propagation of endangered freshwater mussels in the United States.
- 9:40 Daniel L. Graf - Phylogenetic Re-evaluation of the Systematics of the Nearctic Freshwater Mussels (Bivalvia: Unionidae).
- 10:00 Break.

**Anatomical and molecular character evolution in the Basommatophora:
conflict or congruence?**

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The Basommatophora represent a large group of predominantly limnic gastropods. They comprise about 15 families with several hundred assigned species. Many of them are of considerable importance for freshwater ecology and human health. Yet, systematics, phylogenetic relationships and character evolution are controversially discussed and poorly understood. In order to compare the performance of anatomical and molecular datasets and to study the degree of their congruence, we analyzed 72 soft body and shell traits as well as sequences of the COI mtDNA and 18S rRNA genes from the type species of 32 basommatophoran genera involving 10 families. Whereas the two genetic markers yielded rather well resolved and congruent phylogenies, a cladistic analysis of the anatomical data resulted in an unresolved polytomy. A comparison of phylogenetic signals showed a significant signal in the molecular dataset. However, the phylogenetic signal in the anatomical dataset was not significant, possibly indicating a high degree of homoplasy and ‘background noise’. We then mapped the anatomical character-states on to the molecular phylogeny, which was generated from the combined COI+18S dataset. The results show that many characters “evolved” independently, supporting the hypothesis of extensive homoplasies in the anatomical dataset. In order to find those anatomical characters that statistically discriminate among higher basommatophoran taxa, we performed discriminant analyses (DA) with DNA lineages as a grouping variable. Only few anatomical characters were retained in the DA. These characters and the problem of homoplasy are discussed in the context of basommatophoran evolution. [P]

Evolution of Aquatic Habitat Conservation in North Carolina

John Alderman

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Before states can set priorities for aquatic habitat conservation, inventories must be completed to determine significant aquatic biodiversity areas. Since the late 1970s, the federal Endangered Species Act has been a major driving force behind aquatic inventories. At first, surveys were completed within major river basins, such as the Tar and Waccamaw, for federal candidate species. Later, surveys were expanded into other river basins to ensure documentation and protection of unknown populations of federally listed species and to survey for populations of federal species of concern or candidate species. These efforts have been augmented for more than a decade by the state's Natural Heritage Trust Fund and Clean Water Management Trust Fund. Additionally, grants and other funds have been acquired to complete aquatic inventories in specific areas from the NC Department of Transportation, US Department of Energy, local governments, and other entities. Throughout the decades, public outreach was emphasized via various medias: newspapers, magazines, radio, television, presentations at meetings, and, most recently, the Internet. We have now completed enough inventory work to allow identification and conservation of numerous subbasins throughout North Carolina. Conservation of these subbasins is occurring via land purchases, conservation easements, localized restoration projects, state regulations, and public education. In addition to landowners, cooperators in this effort include the NC Wildlife Resources Commission, NC Natural Heritage Program, other state agencies within the NC Department of Environment and Natural Resources, NC Department of Transportation, US Fish and Wildlife Service, Natural Heritage Trust Fund, Clean Water Management Trust Fund, The Nature Conservancy, and local land trusts and conservation groups throughout North Carolina. Finally, because North Carolina is growing so rapidly, we have entered the era of secondary and cumulative impacts analysis and resolution for development projects. Although in its infancy, our goal is to sufficiently plan and manage development projects at the landscape scale to ensure future conservation of significant natural resource areas. Hopefully, all these efforts will help North Carolina maintain its globally significant aquatic habitats and populations for future generations. [BCFG]

**Sleep behavior in octopuses *Enteroctopus dofleini* (Cephalopoda:
Octopodidae)**

Roland C. Anderson
The Seattle Aquarium

Jennifer A. Mather
University of Lethbridge

Research on sleep has been dominated by the use of electronic measures to define it, despite the close correlation of EEG changes to sleep's behavioral aspects. Unfortunately, electrographic measures of sleep are only possible or useful in mammals and birds. In invertebrates, sleep can only be measured by their behavior. Within non-vertebrates, behavioral aspects of sleep have been looked for only in arthropodan bees and cockroaches and molluscan sea slugs. This first study on octopuses, made on *Enteroctopus dofleini*, shows possible sleep behaviors, including stereotypic postures and body patterns, behavioral quiescence, changed respiration rates and state reversibility with stimulation. Factor analysis isolated two clusters of behaviors changing across time, and neither factor clustered with arousability. This suggests a dual rather than a single sleep/arousal state in octopods. Such a system might be due to the semi-diurnal activity pattern of this species or to the distributed nervous system of the octopods. [C3]

**Where Are They Now? Current U. S. Distribution of *Melanoides tuberculata*,
an Exotic Freshwater Snail**

Tamara K. Anderson

Melanoides tuberculata is common in tropical to semi-tropical areas around the globe and is known to be a secondary host of several parasites that affect various fish and bird species. The species was first reported in the United States by Murray in 1964 in Texas. By 1977, their known U.S. distribution included Florida, Texas, Louisiana, Arizona, and Oregon (as summarized by Dundee 1974, 1977). The Fish and Wildlife Service indicates populations exist in scattered locations throughout the southern and western United States. A recent sighting in South Dakota (personal observation) prompted this review of the current distribution and a discussion of the factors contributing to their spread. [P]

**Planorbid laboratory stocks: Genetic variability, history
and scientific communication**

Susan M. Bandoni

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The M-line stock of *Biomphalaria glabrata* is widely used in research on trematodes, especially *Schistosoma mansoni*. The M-line stock was generated by hybridization of stocks from Brazil and Puerto Rico to produce a stock that is albino and highly susceptible to infection with *S. mansoni*. Genetic variability was examined in M-line snails from five laboratories engaged in research on snail-trematode interactions. Of the 24 enzymes examined, 9 were variable, some with three alleles, an observation inconsistent with the history of extensive selfing and inbreeding. Heterozygosity levels were higher than in some field populations of *Biomphalaria* species, although among-sample differentiation accounted for just 17% of the variation, somewhat lower than in field populations. A survey of maintenance histories revealed that cross-contamination with a similar laboratory stock offers a possible explanation for the unexpectedly high levels of genetic variability. The chief value of defined laboratory stocks is their uniformity, and maintenance of their integrity is an important component of their use as model systems. This study also points to a need for improved communication between malacologists and parasitologists. In spite of some problems, defined stocks of *Biomphalaria glabrata* have enormous potential as model systems for use in investigation of a variety of evolutionary phenomena. [PITL]

Parthenogenesis: Red Queen vs. Reproductive Assurance

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To explain the advantages of sexual versus asexual reproduction, the Red Queen theory suggests that sex generates variability; therefore, in very closely interacting species (such as hosts and their parasites) it enables ongoing reciprocal co-adaptation. This theory predicts that sex should be more common in populations heavily infested with parasites, than in those without.

The Reproductive Assurance theory suggests that sexual reproduction exposes the mate-searching individual to predators and disease; and to risks of no fertilization, if no mate is available. It predicts that sex should be more common in high-density populations than in low-density ones, and in stable rather than in disturbed habitats.

The aquatic snail *Melanooides tuberculata* (Thiaridae) reproduces both sexually and asexually, and some populations are heavily infested by trematodes. To investigate whether it supports the Red Queen theory four populations were studied: two with high initial parasite levels and two with low ones. To test whether it supports the Reproductive Assurance theory, these four populations were divided into those with low, high and fluctuating densities (as representing disturbed habitats). Densities, infestation and male frequencies were examined bi-monthly, during three years.

Results: 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 had no males at all. These results do not support the Red Queen theory. The low-density population had low male frequencies, the high-density population had high male frequencies and those with fluctuating densities had low male frequencies. These results corroborate the Reproductive Assurance theory. [C6*]

**Taxonomy on the Half-Shell:
a “PEET” project investigating marine bivalves**

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In partnership with academic institutions, botanical gardens, freshwater and marine laboratories, and natural history museums, the 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. The major components included, monographic products, training of new systematic biologists, and 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. We are using a wide range of 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 nominal genera). A phylogenetic definition of the family and its major subtaxa, based on carefully 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 subfamilies, the Pitarinae and the Venerinae. Pitarines, with 72 nominal genera, contribute 29% of all venerid genera, the most of any subfamily. The Venerinae currently comprise 15 genera with more than 400 nominal extant and fossil species. For more information about PEET, the Marine Bivalve Project and its products, see <<http://peet.fmnh.org>>. [P]

Field Museum's Molluscan Collections

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Widely recognized for its land snail collection with an estimated 3.5 million specimens in 210,000 specimen series representing 35,000 species, Field Museum's Invertebrates collections include a broad range of molluscan taxa plus a comparatively small representation of other phyla. 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 (1938-1959) and Alan Solem (1956-1990). Many former collections have been integrated in FMNH's holdings among them, to mention only one, Leslie Hubricht's 43,000-series collection of North American land snails. Support from the U.S. National Science Foundation allowed for retrospective data capture and archival rehousing of all land snail holdings – a project that is now complete. The data are searchable at http://www.fmnh.org/research_collections and currently provide the largest "virtual" gastropod collection accessible (freshwater and 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 provide loans of specimens to researchers unable to travel. For further information, see our web page at http://www.fieldmuseum.org/research_collections/scholarships/. [P]

Conservation status of the Magnificent Ramshorn (*Planorbella magnifica* (Pilsbry, 1903), endemic to the lower Cape Fear River Basin, North Carolina (Mollusca, Gastropoda, Planorbidae).

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The Planorbidae are a world-wide family of freshwater gastropods of medical importance. Many of the tropical species are the intermediate hosts of human and other vertebrate infectious trematodes. This family contains 48 species in 13 genera in North America. *Planorbella magnifica* is the largest of the North American native planorbids. Pilsbry listed the type locality as “Lower Cape Fear River in the vicinity of Wilmington, North Carolina.” This gigantic species is restricted to this area and historically found only in two ponds in this area, Greenfield Lake and Orton Pond. Recent work has confirmed that the species has disappeared from Greenfield Lake. Although conchologically different and anatomically separate from other species of the genus, the taxonomic status of The Magnificent Ramshorn was questioned. Some have suggested that *P. magnifica* was merely an ecophenotypic variation of *Planorbella trivolvis*, a sympatric species. We obtained 5 specimens of *Planorbella magnifica* for a comparison of the mitochondrial gene Cytochrome oxidase I (COI). The results of this analysis clearly place the species within the genus *Planorbella* and it is considered a valid species. Due to the reduced and very limited current range of this species, it should be considered a very endangered freshwater gastropod species. [BCFG]

Environmental physiology and distribution of *Mytilus* as a model for understanding species invasions

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The bay mussels *Mytilus trossulus* and *M. galloprovincialis* co-occur from Monterey to Cape Mendocino in a patchy hybrid zone. *Mytilus galloprovincialis* invaded Southern California before 1950 and is currently the only bay mussel south of Monterey. We are interested in whether small-scale physical conditions (temperature and salinity) and differential physiological adaptation can help explain patterns of species invasion and are using the California *Mytilus* hybrid zone as a model system. We surveyed adult and recruit populations, measured environmental parameters and are currently testing physiological limits of adults. Scoring individuals using multiple gene loci, we genetically identified adult and recruit populations in Monterey Bay (MBay) and San Francisco Bay (SFBay). In both systems, we found that adult *M. trossulus* increase in abundance as one moves up the estuarine gradient (towards higher temperature variability and lower salinity). However, *M. trossulus* has a lower heat tolerance than *M. galloprovincialis*, which implies that salinity variation - not temperature adaptation - is driving the observed distribution. We also found that recruit abundance does not match adult patterns in MBay but does match in SFBay, suggesting that MBay is an open system and SFBay is closed, with respect to recruitment. The mismatch in MBay is largely due to a delayed recruitment pulse of *M. trossulus*, at sites where *M. trossulus* adults are rare or absent. Finally, our results have implications for water resource use and management policies: these policies directly impact coastal communities and could facilitate species invasions when species distributions follow estuarine gradients. [C2*]

**Are there two distinct viviparous modes in *Balanocochlis*?
On the reproductive anatomy and biogeography of an enigmatic
Indopacific freshwater gastropod (Cerithioidea, Thiaridae)**

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The question of the existence of distinct developmental pathways in the same gastropod species (i.e. poecilogony sensu Giard, 1905) is still unresolved. Among Cerithioidea the various freshwater lineages display an amazing array of reproductive strategies. However, our understanding of their evolution is hampered by the lack of biological insight for many taxa. In this context, the present study of the thiarid genus *Balanocochlis* provides first detailed anatomical data on the reproductive biology. Based on a comprehensive review of shell material from major museum collections we document the geographic distribution of *Balanocochlis* verifying the occurrence of the described congeneric taxa in the Indopacific region from the Great Sunda Islands and the Philippines to the South Pacific islands in the east. In addition, we studied soft body anatomy, in particular brood pouch and oviduct morphology, of snails from several samples within the entire distributional range. Eventually, we aim at judging on the validity of cursory reports in the literature on the existence of two distinct reproductive modes in *Balanocochlis*. [P*]

The influence of temperature and shell growth rate on shell shape in five inbred lines of the freshwater pulmonate snail, *Physella virgata*

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The freshwater pulmonate genus, *Physella*, contains 34 species distinguished primarily by shell shape. However, gastropod shell shape is ecophenotypically influenced by biotic and abiotic factors, making its utility as a taxonomic character questionable. The influence of temperature, growth rate and genetics on shell shape was assessed in five different lines of *Physella virgata* inbred under controlled laboratory conditions through a minimum of five generations over two years. Hatchlings from these lines were randomly held in constant temperature regimes of 20°, 25° and 30°C and fed *ad libitum* with fish flake food until reaching a shell length of approximately 5 mm. Thereafter, growth rate, spire angle, and maximum shell length and width were recorded for each individual. Temperature impacts on growth rates varied significantly ($P < 0.05$) across lines, suggesting genetic regulation of shell growth. Temperature regime induced significant differences in shell shape uncorrelated with growth rate. The mean spire angle of snails reared at 20°C was approximately 5° less than that of those reared at 25°C or 30°C. Although all lines originated from the same natural population in north central Texas, remarkably different shell shapes were induced: the mean spire angle of a line held at 20°C was $<61^\circ$, while mean spire angle was $>72^\circ$ in a separate line held at 30°C. Thus, both genetic and environmental factors appear to influence shell shape in *P. virgata*, making its use as the sole species discriminating characteristic within *Physella* and other freshwater gastropod genera problematic. [PITL*]

What can radio-isotope methods tell us about grazing in *Physella*?

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We have used ^{14}C -labeled periphyton to estimate grazing rates in the common southeastern pulmonate snail, *Physella virgata*. Grazing rates are density dependent, decreasing at densities above 4 snails/ 25 cm², although assimilation efficiency actually increases at higher densities. Constant replacement of water does not remove density-dependent effects, suggesting water-borne metabolites are not responsible. “Pre-grazed” periphyton actually stimulates grazing rates, suggesting cues are not substrate borne, and > 60 % of periphyton usually remained on tiles, negating resource limitation as a cause. Behavioral interference (shaking shells after contact with another snail) could limit feeding rates. To determine if snails can functionally respond to increasing periphyton biomass, we varied the times tiles were colonized in ponds. In most cases colonization period did not affect grazing rate, although snails could control periphyton biomass, especially larger snails at higher densities. Snail grazer impacts on periphyton assemblages can be complex and dependent on periphyton composition, and snail density and life history stage. We advocate a combination of ^{14}C -labeled periphyton and traditional techniques to best describe snail grazing impacts. [PITL]

The way they were versus the way they are: comparative conservation ecology of pulmonate and pleurocerid gastropods

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North American freshwater gastropods, especially riverine prosobranchs, are in peril, with over twice as many species in danger of extinction than in amphibians, fish or crayfish. I will compare the diversity, distributions and conservation status of pleurocerid gastropods with pulmonates, an out group selected because of differences in dispersal ability and ecology which should provide a “control” to judge the degree of species endangerment in pleurocerids. Using data from Burch’s monograph, pleurocerids are centered in south-eastern rivers, with a total of 100 taxa in Alabama, 36 in Tennessee, 20 in Georgia and 15 in Kentucky. Most species are found only in one state, and the Coosa River has the greatest diversity (45 taxa) , followed by the Tennessee (29), Cahaba (15) and Cumberland (15) Rivers. In comparison, pulmonate diversity is centered in the northern states, particularly in the mid-west and north-east, with from 14 - 41 species in most states. Most species are found in at least three states. For pleurocerids, the median conservation status was G2, while in pulmonates the value was G4, indicating pleurocerids are in more peril. However, conservation status in many cases is based on original distribution records, which predate the modern synthesis, and many taxa with restricted distributions could be eco-phenotypic variants, etc. We need to synthesize more recent collecting efforts, and fill in gaps where river systems have not been recently sampled. We also need to use modern molecular methods to determine how many real species are left. Once we have these data we should be able to formulate valid recovery plans for pleurocerids. [Plenary]

Byne's disease in molluscan collections: detection and treatment strategies

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'Byne's disease' is a corrosive acid/alkali reaction that takes place most commonly on the surface of molluscan shells and other specimens composed of calcium carbonate that are kept in wood-based storage environments. It affects marine, freshwater and terrestrial specimens equally. The chemistry and some aspects of the physical dynamics of its occurrence are presented. Current theories regarding some characteristics of the problem are reviewed, together with some new observations. Strategies for diagnosis and treatment are proposed, with illustrated case studies from the Academy of Natural Sciences and other museum collections. [C4]

**Molecular insights on a traditional taxon: Heteroconchia
and Suborder Venerina**

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Relationships among the superfamilies in the Heterodonta have been generally uncertain. For over a century, workers have divided the heterodont bivalves into two groups based on the presence or absence of arcticoid dentition (also called cyrenoid). Arcticoid dentition typically co-occurs with derived anatomical features. Molecular data suggests that the group with arcticoid dentition represents a clade, but also support morphological studies and paleontological data that indicate that neoteny or other secondary reduction can obscure typical characters. Multiple names exist for this clade; herein it is designated Venerina. Venerina originated by the Triassic and diversified rapidly in the Cretaceous and early Tertiary. It includes taxa traditionally assigned to Myoidea and Veneroidea, such as Veneridae, Myoidea, Mactridae, Pholadoidea, Dreissenoidea, Sphaerioidea, Ungulinidae, Arcticoidea, Corbiculoidea, and Vesicomidae. Relationships among heterodont superfamilies outside this clade remain poorly resolved. Molecular data resolve the basal branching order within Heteroconchia as (Palaeoheterodonta, (Carditoidea plus Astartidae, (Anomalodesmata, (Lucinoidea,(other Veneroidea and Myoidea))))), but do not clearly indicate a sister taxon for Venerina. [C1]

Fossils labeled "Prof. Tuomey" "Miocene, S. C." housed in the collections of the Alabama Geological Survey

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All investigations of the impact of Michael Tuomey on South Carolina Geology must begin with his *Report on the Geology of South Carolina* (1848) and the classic *Pleiocene Fossils of South Carolina* by Tuomey and Holmes (1855-1857). Incredibly, the 293 page *Report* was composed in two months. Tuomey accepted employment in Alabama in January 1847. Hence, most of his subsequent contributions to *Pleiocene Fossils* were by correspondence. Many South Carolina citizens contributed fossils to the ongoing study. Six of the taxa reported here are not documented in *Pleiocene Fossils*, so if the specimens are authentic, they must have come into Tuomey's possession shortly before his death in 1857. All Tuomey material was thought to have been lost when the University of Alabama was burned by Union troops. The authenticity of this rediscovered collection rests on the considerable integrity of Dr. E. A. Smith who was responsible for the oldest extant labels. Twenty-nine lots and twenty-seven species are present. Gastropoda include species of *Tegula*, *Crepidula*, *Neverita*, *Typhis*, *Conus*, *Terebra*, and *Polystira*. Bivalvia include species of *Nucula*, *Anadara*, *Glycymeris*, *Lithophaga*, *Anomia*, *Lopha*, *Radiolucina*, *Lucinisca*, *Cyclocardia*, *Astarte*, *Spisula*, *Mulinia*, *Chione*, *Pleiorytis*, and *Pholas*. Scaphopoda include *Dentalium* and *Cadulus*. Finally, there is a large Eocene bryozoan colony. Excluding the Eocene, three Pliocene to Early Pleistocene stratigraphic horizons are indicated by matrix, shell preservation, or range zones. All but two or three lots are compatible with South Carolina origins. [C3]

**Systematics and Phylogenetics of late Paleozoic Streptacidae
(Gastropoda, Heterostropha)**

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A diverse marine molluscan fauna has been collected at the Weller Falls locality, Warren County, Indiana, with 16 families and 34 genera of gastropods. Bivalves, rostroconchs, scaphopods, cephalopods, and polyplacophorans are also present. The fauna is lowest Desmoinesian (Carboniferous, Pennsylvanian) in age. Specimens are silicified and are as small as 0.15 mm. The silicified shells preserve not only the protoconchs and larval shells but also the microscopic morphological details of adult shells. Specimens from this locality will permit examination of populations of growth stages from juvenile to adult shells and study of their ontogeny.

Phylogenetic analysis of the family Streptacidae Knight 1931 will resolve how they evolved and the degree of relationship with Recent Pyramidellidae and other Euthyneura. Some authors have placed the Streptacidae in the same superfamily as the Recent Pyramidellidae, and other authors have placed them in their own superfamily and said that the oldest true member of the superfamily Pyramidelloidea is Jurassic. The Streptacidae range in age from Devonian to Triassic, and are known from the USA, Europe, China, and Australia. The Devonian taxa are poorly preserved and of uncertain affinity. The genus *Donaldina* has 11 species and the genus *Streptacis* has 8 species reported from the Mississippian to Permian of the USA. Phylogenetic analyses will elucidate the origin and early evolution of the Streptacidae, its rates and mechanisms of evolution, the development of a parasitic feeding strategy, and how this group survived the Permo-Triassic extinction. [C3*]

Proliferation of the Chinese mystery snail, *Cipangopaludina chinensis malleata* (Reeve, 1863) (Gastropoda: Viviparidae), throughout Connecticut

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The Chinese mystery snail, *Cipangopaludina chinensis malleata* (Reeve, 1863) and Japanese mystery snail *Cipangopaludina japonica* (von Martens, 1861) [both recently placed in the genus *Bellamya*], are southeast Asian invasives occurring throughout North America that have been implicated in aquatic vegetation decline and are reported hosts for certain helminth parasites. *C. chinensis malleata* was introduced into North America as a food item in the 1890s by sailors returning from Yokohama, Japan, to San Francisco's Chinatown. A second invasion was reported in a Chinese market in Victoria, British Columbia, although it is unclear which species was found. The first positive occurrence of *C. japonica* was in 1911 long after *C. chinensis malleata* had become well established. The first east coast population of *C. chinensis* was collected in Massachusetts from the Muddy River, Boston, in 1914. By 1940, the species was sufficiently widespread to be sold in markets in Boston's Chinatown. Since that time, both species have spread throughout New England and New York arriving in Connecticut in 1982. Increase from 8 Connecticut sites in 1982 (of 215 surveyed) to 20 (of 140 sites surveyed) randomly distributed localities today represents rapid proliferation of what are likely human-induced introductions. Not only are the snails often seen as a food item in Chinese markets in major cities, they have also been observed by the author for sale in several aquarium shops across the state. Present habitat conditions are presented for both species in Connecticut as is documentation of their spread in the last 20 years. [P]

Nature Serve Explorer - An Innovative Tool for the Malacological Community

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NatureServe Explorer (www.natureserve.org/explorer) is an acclaimed website providing authoritative conservation information in a searchable database for more than 50,000 plants, animals, and ecological communities of the United States and Canada. NatureServe-an online encyclopedia of life-provides the most comprehensive, in-depth information on rare and endangered species currently available, and also includes extensive information on common plants and animals.

NatureServe Explorer represents a "snapshot" of dynamic data that are continually being refined by the input of hundreds of Natural Heritage scientists and collaborators into NatureServe's central databases. NatureServe Explorer is updated from the central databases three times each year to reflect new data from refined geographic surveys, the latest taxonomic treatments, and any new conservation status assessments. Data for additional taxonomic groups can be expected with each update.

The AMS list of unwanted alien snails in the USA: progress report

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Alien species cost the USA billions of dollars annually in damage and in efforts to control them. Agriculture, the environment, human health and well-being, and commerce are all affected. At the request of the United States Department of Agriculture, the American Malacological Society is creating a list, with associated factsheets, of “America’s least wanted” snails and slugs. This list included those species either not yet present in the USA or present but as yet highly localized, that authorities should be especially aware of and whose introduction to and spread within the USA authorities should make every effort to prevent. The list includes 15 taxa, of which some are individual species and others are groups of related species. These taxa were selected based on criteria that in general are thought to correlate with potential invasiveness. These criteria include biological features of the taxa (e.g., reproductive rate, body size) as well as features reflecting their interaction with humans (e.g., pest status elsewhere, frequency of interception by quarantine officials). The list is to be reviewed by AMS members and other malacological specialists worldwide. [C4]

The use and misuse of data sets in reconstructing phylogenies

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As Cain and Harrison pointed out many years ago (the 50s), to construct and interpret a credible phylogeny one must 1) point out the timing and direction of evolution, 2) find sufficient suitable character-states to enable constructing a phylogeny, and 3) one must be able to detect and rid from the data sets homoplasies. In the Rissooidea, we demonstrate where exhaustive use of anatomical characters yields chaos in a phylogeny due to overwhelming homoplasy and random noise; then use multiple molecular data (DNA and Isoenzymes) sets to demonstrate anatomical character suites that exhibit considerable homoplasy, while at the same time clarifying monophyly for some families, notably the Amnicolidae, Hydrobiidae and Pomatiopsidae. Finally, understanding the basis of homoplasy for two character suites, and knowing the origin, timing and direction of evolution, we can explain the evolution and phylogeny of a major rissooidean family, the Pomatiopsidae with its two subfamilies Pomatiopsinae and Triculinae. [MAMP]

History of the classification of mollusks

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It is quite well accepted today that the Phylum Mollusca comprises nine higher taxa, even if their relationships are still debated. Modern history of the classification of Mollusks started with Cuvier who introduced the term Mollusca in its modern sense in 1795. After Cuvier, it took more than one hundred years to obtain the higher groups we accept today: 1) new organisms have only been discovered during the mid nineteenth century, like chaetoderms or solenogasters; 2) zoologists had to get rid of affinities inherited from much older classifications, like the close relationships between Ascidians and Bivalves first suggested by Aristotle. The main changes that occurred in the classification of Mollusks, from Aristotle up to the beginning of the twentieth century, will be given. These changes will be explained through the study of the successive — and very different — historical contexts in which scientists worked. [C1]

Multivariate selection and emergent ecological impacts of multiple predators

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We examined natural selection on defensive traits of a prey species having functionally diverse predators. We additionally measured community ecological impacts of the predators and sought mechanistic explanations in our phenotypic selection analyses. Freshwater snails, *Physa virgata*, were exposed in 250-L mesocosms to molluscivorous crayfish, *Procambarus clarkii*, redear sunfish, *Lepomis microlophus* and combined predator treatments. Directional selection differentials and gradients were calculated for prey morphology (shell size and shape) and behavior (use of covered or near-surface habitats). Quadratic selection on body size and correlational selection between size and behavioral traits were also examined. Predation intensity in the presence of both predators was greater than expected based on the additive effects of individual predators. A common mechanism believed to generate such emergent impacts involves conflicting prey defenses. We discovered two traits for which the directional selection gradients differed in sign for the two predators: shell shape and use of covered habitats. The combined predator treatment produced nonadditive selection for these traits. We believe the primary cause of the emergent impact was that fish presence induced similar habitat shifts for both crayfish and snails, facilitating intense predation on snails by crayfish. [PITL]

Morphometrics Workshop—A practical guide to the study of size & shape in ecology and evolution

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Given the foundational importance of phenotypic variation in biological research, it is important to have powerful, economical, and intuitive methods for measuring phenotypes. Several approaches to morphometrics (the study of size and shape) exist. Each approach tends to have unique strengths, yet the newer geometric techniques often prove superior to traditional approaches. Unfortunately, most organismal scientists have shyed away from geometric morphometrics because they view it (and somewhat justifiably so) as too mathematically complex and too technically demanding. As yet there are no good entry-level materials to assist people who wish to learn about this field. Thus I will attempt to present an overview here, the likes of which I think could have eased my entry into the world of modern morphometric analysis. This workshop first discusses the several alternative approaches to morphometrics and culminates in a focused demonstration of thin-plate-spline analyses using software available free of charge on the internet. [PITL]

Experiments with the predatory muricid *Chicoreus dilectus* and its bivalve prey *Chione elevata*: Does edge drilling decrease prey handling time?

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Predatory activity by drilling gastropods is a time consuming behavior with inherent risks – exposure to enemies, interruption, giving up – that can translate into unsuccessful feeding and even death. A behavior proposed to reduce the amount of time the gastropod is exposed to these attendant factors is selection of thinner drilling sites, such as along the ventral edge of bivalve prey. Preliminary evidence indicates that drilling at the edge results in higher success rates than drilling elsewhere through the shell wall, but there is no evidence that the behavior decreases drilling time of the prey.

We tested the hypothesis that handling time (a function of drilling time) is reduced when prey are edge drilled using the *Chicoreus dilectus*-*Chione elevata* predator-prey system common in seagrass habitats of Florida. Handling time of the prey was defined as the time from initiation of the predation process to abandonment after the prey was consumed. A total of 31 observations were recorded (7 edge and 24 wall drillholes). The average time for edge drilling was more than two times faster than wall drilling (1.9 vs. 5.1 days; $t=10.1$, $p<0.0001$). Shell thickness is the most important factor contributing to the decreased handling time. Mean shell thickness (measured at the site of boring) was significantly thinner for edge (1.4mm) versus wall (2.6mm) drilling sites ($t= 8.51$, $p<0.0001$). Our results are the first to indicate that prey handling time is reduced significantly when a predator selects drilling sites at the edge rather than the wall of its prey. [P]

Mollusks from archaeological excavations in NW Papua New Guinea

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As part of the New Guinea Research Program at the Field Museum, John Terrell, together with Robert Welsch, Baiva Ivuyo, Alois Kuaso and Robert Mondol of the Papua New Guinea National Museum, conducted the first archaeological excavations in the Aitape district of NW Papua New Guinea. Excavations took place at two sites in the Aitape hills and on Tumleo Island off the Aitape coast.

Alongside with artifacts and bones, numerous molluscan shells and fragments were found. Radiocarbon dating determined the age of the shells from the Aitape hill sites as ca. 1280-1330 years b.p. At the three sites, more than 50 marine, fresh- and brackish-water, and terrestrial (not on Tumleo) molluscan taxa were identified, belonging to the classes Polyplacophora, Gastropoda and Bivalvia. While the terrestrial species from the Aitape hill sites may have lived where their shells were eventually embedded, the marine as well as the fresh- and brackish-water mollusks were brought to the hill sites from the seashore, rivers and lagoons in the surrounding lowlands, probably as food supply and possibly in part for other reasons (tools, ornaments). The composition of the molluscan samples is discussed in relation to the ecology of the species found and their possible use by the ancient people of Aitape and Tumleo. [C3]

Molluscan benthic assemblages from potential sand borrow areas on the East Florida shelf.

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As part of a baseline study on potential sand mining in OCS waters offshore East Florida, Vittor and Associates analyzed molluscan benthic assemblages from Jupiter inlet to Cape Canaveral. Spatial and temporal changes in assemblage composition varied with sediment grain size, latitude, and sampling date. Benthic assemblages were affected mostly by the amount of very fine sediments in the benthic grabs, primarily silts and to a lesser degree clays. Fine sediment stations yielded mostly deposit feeding bivalves and the scaphopod *Dentalium texasianum*. Vittor and Associates found a species change from north to south for the gastropod, *Caecum*. *Caecum johnsoni* was found primarily in the north sampling areas whereas *C. imbricatum* and *C. cooperi* were found in the southern areas. There were differences in assemblages between sampling dates for samples collected at gravelly sand stations during September and May. These differences were due mainly to presence of September species that were largely or completely absent in May such as the bivalves *Anomia simplex*, *Chione cancellata*, *Crassinella martinicensis*, and *Ervilia concentrica*. This project was funded by the U.S. Department of Interior, Minerals Management Service, International Activities and Marine Minerals Division, under contract #1435-010-00-CT-31044. [P]

**Leopold von Buch's legacy: treating species as dynamic natural entities,
or Why geography matters**

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Although not unknown but largely underutilized during the 19th century and the first half of the 20th century, the idea of reproductive isolation (RI) - or its converse, the potential to interbreed - as species criterion goes back to the German naturalist, geologist and paleontologist Christian Leopold von Buch (1774-1853). In his accounts on the natural history of the Canary Islands, von Buch (1819, 1825) perceived RI as the defining property of species. As "Darwinian before Darwin" he adopted for the first time (i) the modern (i.e. non-essentialistic) concept that species are not types but populations consisting of individuals or groups of such populations, and (ii) a model of geographical speciation. However, it was only much later - in particular as a consequence of Mayr's (1942, 1963) synthetic works - that RI was widely accepted as most valuable for defining biological species, including the notion of geographical variation, separation and the non-applicability of the degree of (phenotypic) distinctness. The last decades have seen an active phase of debate about how to define and delineate species (with only few active contributions from malacology, though). While the Biological Species Concept (BSC) is often criticized, alternative suggestions - such as e.g. the Phylogenetic Species Concept (PSC) - are either nebulous, vague, and artificial (non-biological) or as much operational-oriented (serving only diagnosability) as the 19th century typological approach resulting in ballooning species numbers. After briefly outlining the historical development of the species concept debate, three case studies from malacology will be discussed. Utilizing freshwater gastropods of the former "melaniid species basket", ongoing studies on the "species question" in (i) Pleuroceridae, (ii) Melanopsidae, and (iii) Thiaridae will illustrate some of the implications when conceiving species as representing dynamic entities in a historical and geographical context. [BCFG]

Does color pattern provide phylogenetically informative characters?

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Color pattern has been used extensively to provide a basis for differentiation of opisthobranch mollusk species. The value of these characters has been well established for alpha taxonomic methodology, but their utility in phylogenetic studies has been largely discounted. Phylogenetic studies based on morphological data sets were undertaken for several opisthobranch taxa, including members of the distantly related taxa *Hypselodoris*, *Thuridilla* and *Halgerda*. Subsequent phylogenetic analysis of these data sets yielded phylogenetic trees containing several well-defined clades, with relatively poor resolution within these clades. Addition of color pattern characters did not fundamentally alter tree topology and increased resolution of multichotomies within well-defined clades. Inclusion of color characters into combined data sets does provide robust, phylogenetically informative characters and increases overall resolution of phylogenies. Homoplasy in color pattern, as a result selection pressure for Müllerian mimicry complexes, does not appear to mask phylogenetic signal in several of the examples that have been studied thus far. [MAMP]

**Phylogenetic Re-evaluation of the Systematics of the Nearctic Freshwater
Mussels (Bivalvia: Unionidae)**

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The recent application of analytical methods with diverse datasets has clarified and improved our understanding of the intergeneric relationships of the Nearctic freshwater mussels. However, the genera *Unio* and *Gonidea* have traditionally been difficult to place, and they provide a context for discussion of troublesome areas in the classification of the Unionidae. I have applied a phylogenetic analysis of a fragment of large nuclear ribosomal subunit DNA (28S rDNA, domain 2) to this problem. The results indicate that conservative revisions to the “accepted” classification of the Unionidae are warranted. [C7]

A Molluscan Informatics Utopia Challenges and Approaches For Data Sharing and Data Use for Conservation and Biodiversity

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Molluscan collections in museums are the main repository for past and current baseline molluscan biodiversity information. A crucial task in the coming century will be utilizing that baseline biodiversity information as fully as possible for research and management decisions. This is especially critical in bioregions like the American West - experiencing rapid environmental changes due to factors such as population growth, land development, and climate change. I will present models for how we can most effectively use molluscan museum data showing examples from current work on a larger National Science Foundation bioinformatics grant. In particular, I will focus on methods for linking databases together and then submitting those linked databases to further processing in Geographic Information Systems. Ultimately, on-the-fly maps can be made available for further visualization and analysis on-line. For example, from a computer a user could simultaneously visualize species diversity and land-use over the last one hundred years. That user could then use spatial statistics tools to determine if there is statistically significant covariation between the two datasets and how that relationship has changed over time. In the longer-term all metadata collected from specimens (e.g. morphometric measurements, sequence data) need to be stored in museum databases along with more traditional information. With this data, researchers and managers will be able to more fully understand true measures of genetic and species diversity as well as phenotypic disparity (units of morphology). With proper collaborations and data/data infrastructure models, we can create a molluscan informatics utopia. [BCFG]

Relationships among *Cerion* snails on Long Island, Bahamas deduced from molecular (cytochrome c oxidase I) and morphological data

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The *Cerion* fauna of Long Island is the most morphologically diverse within the Bahaman Archipelago. A significant portion of this morphological diversity is concentrated along a 12 km section along the central east coast of the Island, where five taxa occur sequentially along the coastline.

In connection with a larger study on the origins of Holocene geographic diversity and the evolution of *Cerion* shell form, we analyzed patterns of morphological and DNA sequence variation in representative populations of modern *Cerion* collected along this section of coastline. At selected localities, we assessed morphological changes in shell form over time intervals spanning up to 4000 years using fossil shells dated by amino acid racemization analysis.

Although *Cerion* taxa have been based exclusively on morphological features of the shell, these data have not previously been used to produce hypotheses of relationships among them. Phylogenetic hypotheses based on cytochrome c oxidase sequences from multiple individuals from each population were used to evaluate morphology-based hypotheses, and to assess the genetic distinctiveness of neighboring populations. The substantial sequence differences among many of the geographically proximal taxa are compared to published data on other molluscan lineages spanning a variety of taxonomic and geographic levels. Phylogeographic patterns are assessed and evaluated in the context of several alternative scenarios for the origin of the observed patterns. [MAMP]

Usual and Unusual Adaptations in Pre-K/T Impact Diverse Freshwater Molluscan Assemblages in the Northern Great Plains, USA

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Detailed stratigraphic control and comprehensive collecting of freshwater mollusks of the uppermost Cretaceous Hell Creek Formation of the Williston Basin of Montana and North Dakota document a diverse assemblage of bivalves (Unionidae and Sphaeriidae) and gastropods (Viviparidae and Pleuroceridae), along with fewer numbers of Hydrobiidae and Physidae. Recent collecting in the type area of the Hell Creek Formation in Montana adds rare representation of a terrestrial gastropod (Cerionidae) and new bivalve taxa including a *Pleiodon*-like species and a new genus of Unionioida. The discovery of more complete specimens of the taxodont-hinged, iridiniid-looking taxa provides the opportunity to explore new interpretations of previously undocumented freshwater ecological adaptation and convergent evolution in a radiation likely distinct from the African Iridinidae. The taxon is easily distinguished from any other bivalves in the Western Interior of North America by possessing a distinctively raised hinge platform that forms a vertical wall on the interior of an otherwise edentulous valve. The hinge plate appears rotated from a standard-type taxodont tooth position (e.g., *Pleiodon*) to where the hinge plate is raised above the dorsal commissure in a series of ridges and grooves on either side of the beak. The presumed life orientation of the taxon would have the valves completely open, cojoined along the dorsal margin. This shell configuration is similar to the life mode of the living marine galeommatid *Ehippodonta*. Galeommatids are known to crawl with valves dorsal and live in somewhat protected cavities. An obvious freshwater analog may not be possible, as other Hell Creek unionoid bivalves were active burrowers. [P]

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

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Gastropods in the genus *Melongena* are common marine snails found on the intertidal shores of southeastern Alabama, Florida, both coasts of Mexico, and the Caribbean. Due to their intriguing biogeography and outstanding fossil record these snails 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. Eight microsatellite loci have been developed and characterization of these loci in several populations from the Southeastern United States has been completed. 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. [C2*]

**Spatial patterns of genetic structure, armature and coloration in
*Mexipyrgus churinceanus***

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An important component of conservation genetics is to examine spatial patterns of genetic and phenotypic variation. By combining molecular analysis of nuclear and mitochondrial markers with patterns of phenotypic variation, we can gain considerable insight into phenotypic diversification and speciation. Banded spring snails (*Mexipyrgus churinceanus*), endemic to Cuatro Ciénegas in northern Coahuila Mexico, exhibit remarkable local variation in shell structure and coloration, perhaps in response to a molariform cichlid morph. In this study, I examine population structure in mtDNA and nuclear intron markers to assess conservation units among the major drainages in the basin. I also develop quantitative measures of shell morphology and coloration in an attempt to assess the correlation between shell load strength and shell characters. Preliminary analysis reveals the independent evolution of different shell and color morphs in genetically distinct *Mexipyrgus* lineages, and considerable variation among populations in load strength. I discuss these patterns in relation to coevolutionary interactions with the molariform cichlid and responses to abiotic variation in temperature and water chemistry. [BCFG]

Mollusks of the Aquatic Communities of Miller Woods in the Indiana Dunes National Lakeshore

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Four aquatic habitats were sampled for mollusks in the Indiana Dunes: 1) pannes (formed 500 YBP) adjacent to Lake Michigan, 2) intradunal ponds (2000 YBP), 3) interdunal ponds (3000 to 2100 YBP), and 4) intermittent ditches and ponds. The first three habitats are in rows parallel to Lake Michigan's south shore, those nearest the shore being the pannes. Only two species were in the pannes, *Fossaria exigua* and *Helisoma trivolvis*. Intradunal ponds were in two parallel rows south of the pannes. The five ponds of row 1 still had *F. exigua* and *H. trivolvis* but also had four sphaeriids plus *Stagnicola reflexa*, *Physa gyrina*, and *Gyraulus parvus*. The second row had only *M. securis*, *F. exigua*, *S. reflexa*, *P. gyrina* and *H. trivolvis*. The limpets *Ferrissia parallela* and *Laevapex fuscus* lived in one pond. The five interdunal ponds were in three parallel rows south of the intradunals. *F. exigua* was gone. The one pond in row 3 was limited to four species. The three ponds in row 4 had three species of *Musculium* spp., plus *S. reflexa*, *P. gyrina*, *Planorbula armigera*, *Promenetus exacuus*, and *F. parallela*. The one pond of row five was marshy, and four species of the previous row had dropped out. Mollusks of intermittent habitats formed a unique community. *S. reflexa* was replaced by *S. elodes*, and *P. gyrina* gave way to *Aplexa elongata*. *Sphaerium occidentale* was present. Except for *P. armigera*, *M. partumeium*, and *P. casertanum*, no species of the dune habitats were present. [BCFG]

**Effects of various fixation techniques on tissue of a marine bivalve,
Mercenaria mercenaria (Linné, 1758)**

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Study of marine bivalve anatomy and fine structure from preserved animals, essential for taxonomic work, requires successful fixation of soft body tissue. For optimal fixation, thin (1-5 mm) tissue samples are required. During fieldwork and for long-term museum storage, however, it is not always possible or advisable to dissect the animals, and methods are needed to preserve the whole organism. It is thus of special interest how fast and deep different fixatives penetrate into the tissues and result in best longer-term preservation. In this study various preservation techniques (e.g., alcohol in various concentrations, formalin, Bouin's fixative), are tested for their effects on *Mercenaria* tissue. Selected tissues (ctenidia, mantle, foot and labial palps) have been examined. Results from tested fixation procedures are compared using various microscopical techniques; a ranking of methods will be presented. [P*]

Biodiversity of *Conus*: How many species are there?

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Conus is generally recognized as the most diverse genus of marine molluscs, and probably of all marine invertebrates. I report on current efforts to update an electronic database cataloguing all available species-group names not listed in the catalogue published by Tomlin in 1937, that have come to my attention. The present version contains 810 names published through 2000, bringing the total number of available species-group names in *Conus* to nearly 4,000. Of these, 710 names were published after 1936, 404 after 1976, and 174 after 1989. The database allows examination of trends in the rate of new species descriptions (average of 16/year over the past decade). I also address recent efforts to assess the number of valid extant species in different regions of the world, the morphological characters currently being used in species descriptions and determinations, and the use of molecular genetic data to test hypotheses of species identity and to detect morphologically cryptic species. [C1]

Six-shooters of the mollusc world: Prey capture by molluscivorous *Conus*

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Each radular tooth in *Conus* functions independently, typically as a hypodermic needle that is forcibly injected into the prey organism and carries conotoxins, neurotoxic venoms that paralyze the victim 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 each predation event employs a single radular tooth that 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, pulled into the rhynchodaeum by contraction of longitudinal proboscis muscles, and swallowed whole. The tooth passes through the *Conus* alimentary tract with the prey. In contrast, molluscivorous species of *Conus* are shown to shoot up to six radular teeth into a single prey gastropod before swallowing it. Their feeding process is thus behaviorally much more complex. Each tooth is released from the proboscis into the prey; it 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, and the passage of the prey body through the *Conus* digestive tract is traced. [C2]

Plasticity constrained: Overgeneralized induction cues cause maladaptive phenotypes

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The adaptive value of phenotypic plasticity depends upon the degree of match achieved between phenotype and environment. This degree of match is governed in part by how well organisms discern environmental states (e.g. presence or absence of particular predators). To examine the specificity with which organisms use cues to induce defensive phenotypes, we raised freshwater snails, *Physella virgata*, with either molluscivorous or nonmolluscivorous sunfish species (*Lepomis cyanellus*, *L. gibbosus*, *L. macrochirus*, *L. megalotis*, *L. microlophus*, *Micropterus salmoides*). Regardless of the predator class with which they were raised, snails exhibited two induced responses: (1) reduced growth, and (2) development of rotund shells. Reduced growth typically results from predator avoidance behaviors and so is associated with a net survival benefit in environments containing molluscivores. Rotund shells increase crush resistance and so increase both handling time and rejection rates by molluscivorous sunfish. Despite the adaptive nature of these responses to molluscivorous species, responding unnecessarily to nonmolluscivores is maladaptive. Growth reduction limits fecundity and prevents snails from attaining size refugia for most predators. Rotund shells increase vulnerability to shell-entry predators, which are typically more common than shell crushing predators. Thus, the induced responses entail costs but award no advantages in the presence of nonmolluscivorous sunfish. Lack of specificity in use of cues (e.g. all sunfish treated alike) may be a major constraint on the evolution of phenotypic plasticity. Furthermore, these induced responses may produce trait-mediated indirect effects that cascade throughout the food web. [PITL]

New edition of the FAO Identification Guide for Fisheries Purposes, Fishing Area 31 (Western Central Atlantic): Gastropoda and Bivalvia

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The Food and Agriculture Organization of the United Nations (FAO) publishes identification guides of terrestrial and aquatic animals and plants used as food worldwide. The FAO guides target a global audience of field and fisheries biologists, farmers, government officials and other professionals that are not necessarily specialists in the taxonomic groups treated. One of the many subdivisions of the world's oceans adopted by FAO, Fishing Area 31 ranges from North Carolina, south along the US eastern seaboard, Gulf of Mexico, the Antilles, and the Caribbean to Venezuela. The original version of the Bivalvia and Gastropoda volume for Fishing Area 31, authored by R. T. Abbott, was published in 1978. The new edition includes 40 species (17 families) of bivalves and 23 species (11 families) of gastropods. Relevant families are diagnosed and compared to morphologically similar ones. The species sections provide updates on systematics and nomenclature and common names in English (including those reviewed by the American Fisheries Society in 1998), Spanish, and French. Diagnostic characters, maximum shell size, and distribution help define the different species. Additionally, notes on habitat, biology and fisheries are provided, as well as references to relevant literature, when available. Distribution maps and line drawings emphasizing diagnostic, mostly shell, characters are included. Glossaries for each class explain terms used in the morphological descriptions of bivalves and gastropods. The volume, now at the proofreading stage, is scheduled for publication by late 2002. [P]

Polyploid Molluscs: Double the Phylogenetic Trouble?

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Although rare in marine molluscs, polyploidization is prevalent in some freshwater lineages and may have played an important role in shaping their diversification patterns. Such taxa can pose significant challenges to phylogeneticists as they may have qualitatively distinct origins (allo/auto) that have implications for our ability to accurately infer genealogies. Other issues include the evolutionary timescale of genome duplications relative to the cladogenic events of interest, the genetic/reproductive consequences of polyploidization and the differential utility of mitochondrial, nuclear ribosomal and nuclear single-copy genes in reconstructing comprehensive genealogies. We address these issues with examples from our work on polyploid freshwater (Sphaeriidae, *Corbicula*, Ancyliidae) and marine (*Lasaea*) taxa. [MAMP]

Intracapsular development and hatching in *Adelomelon brasiliana* (Lamarck, 1819) (Gastropoda, Volutidae) from Northern Patagonia, Argentina.

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The snail *Adelomelon brasiliana* (Lamarck, 1819) has an increasing demand on the market. It is a common inhabitant on sandy shallow bottoms (10 – 20 m). It ranges from the state of Río Grande do Sul, Brazil, to Río Negro province, Argentina. Monthly samples were collected by trawling during two years at Mar del Plata, Buenos Aires (~38°S, 57°W).

The spawn consists of free capsules of 72 ml of average volume, containing between 1 to 27 embryos without nurse eggs. Egg capsules are produced during the whole year except for the coldest months (June-August). This observation together with the massive spawn occurred every early spring, marking the beginning of the reproductive season, and the recorded first hatchlings in early summer, allow us to estimate a development time of 90 days.

During the sampling period, a progressive decrease in the abundance sampled was observed. We estimate that during the third summer the abundance of egg capsules in the field decreased 85%.

The intracapsular fluid contains a high protein concentration that varies during development. Also the pH decreases during development time. The capsule wall open always on a predetermined area which is more hyaline during the whole development period. The dissolution of the egg capsule at this predetermined area is apparently an enzymatic process at the end of the development. [P]

The Phylogenetic Species Concept and its application in the conservation of freshwater mollusks

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Species richness is often used as an indicator to locate biological hotspots for prioritizing conservation efforts. Species are the invertebrate focus for the United States Endangered Species Act. In short, species are the fundamental units in biodiversity studies. Despite the central role species play in conservation biology, biologists, especially systematists, still debate about species and how best to define and/or delineate one. The Phylogenetic Species Concept (PSC) is actually comprised of at least two different concepts of species. The first one is the diagnosable version and the second one is based on monophyly. Here, I present data from freshwater mollusks illustrating the value of the Phylogenetic Species Concept (monophyly version) for delineating species boundaries and why this is important for conserving imperiled freshwater mollusks. [BCFG]

Experimental studies on the substrate preference of two gastropods endemic to the middle Snake River, Idaho, USA

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We investigated the substrate preference of two federally protected gastropods, Utah valvata (*Valvata utahensis*; Call) and Idaho springsnail (*Pyrgulopsis idahoensis*; Pilsbry), in custom aquaria designed to present four substrate types simultaneously. *V. utahensis* and *P. idahoensis* were protected by federal law in 1992 in response to declining population numbers due to habitat alteration and degradation. Our objective was to begin investigating the theoretical niche that these snails exploit by conducting laboratory experiments designed to determine preferred habitat type. Snails were introduced individually to the 1L aquaria and left for 24h at which time the substrate occupied was recorded. Additionally, a sub-set of substrate preference tests (SPT) were videotaped using a Sentinel video surveillance system (n = 23). From the videos, proportions of time spent in each substrate type were calculated and used as verification of the substrate preference assigned to each snail from the >snapshot= collected at 24h. Results from this study are intended to provide basic life history information for these snails which is presently lacking, and to provide resource managers with information useful in the conservation and recovery of *V. utahensis* and *P. idahoensis*. [C6*]

**Experimental studies on the temperature tolerance of two gastropods
endemic to the middle Snake River, Idaho, USA**

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We studied the theoretical tolerance to extreme temperatures of two federally endangered gastropods endemic to the Snake River in south-central Idaho, USA. The Utah valvata (*Valvata utahensis*) and the Idaho springsnail (*Pyrgulopsis idahoensis*) were protected by federal law in 1992 in response to declining population numbers due to habitat alteration and degradation. Our objective was to begin investigating the theoretical niche that these snails exploit by conducting laboratory experiments designed to define the limits of the snails' physiological tolerances to temperature. In tightly controlled laboratory tests, we subjected experimental animals to incremental increases and decreases in water temperature until the thermal maxima and minima temperatures respectively, were realized. The average maximum temperature tolerable for *V. utahensis* was 31.77 ° C, the average minimum 7.39 ° C. The average maximum temperature tolerable for *P. idahoensis* was 33.70 ° C, the average minimum 9.34 ° C. Results of this work are intended to provide basic life history information which is currently unavailable for either species of Snake River gastropod, and to stimulate further research into the biology and ecology of these unique organisms. [P]

Phylogeny of the Ellobiidae

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The family Ellobiidae (Gastropoda: Archaeopulmonata) is currently subdivided into six subfamilies on the basis of relatively few characters of the reproductive and nervous systems. In this study, an anatomical survey of 20 species representing 20 of the 23 currently recognized genera, and spanning the six subfamilies of the Ellobiidae was conducted, and a cladistic approach to classification was attempted. External anatomy (tentacles, foot, border of mantle), protoconch (heterostrophy, anastrophy, orthostrophy), mandible and radula, and a number of characters of the internal anatomy (pallial organs, digestive system, reproductive system and nervous system) were analyzed to produce a cladogram. The previously established basic subfamilial layout was generally supported: the Melampodinae and the Ellobiinae are clearly separated from the remaining subfamilies; the more closely related Pythiinae and Pedipedinae include problematic genera; the identity of the recently revived Cassidulinae is questioned. A molecular approach using COI was attempted for 8 genera and, although corroborating the identity of the Melampodinae, was not decisive in resolving the grouping of the remaining genera. A clear subfamilial classification is hindered by the accentuated mosaic pattern of evolution in the Ellobiidae, which creates polythetic situations of difficult taxonomic resolution. [MAMP]

Multidisciplinary Examinations of Gastropod Phylogeny

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Gastropod phylogeny has come under considerable scrutiny in the last few decades, but both anatomical and molecular approaches have yet to provide a clear model of basal phylogenetic relationships. A renewed interest in gastropod phylogeny has been fueled by the discoveries of numerous new, higher taxa, especially at hydrothermal vents and sulphide seeps; the rapid increase in the amount of new data provided by new morphological and molecular techniques; and, perhaps most importantly, by the application of increasingly rigorous methodologies for analyzing the data and generating phylogenetic hypotheses. We here present a meta-analysis of 11 previously published studies, a preliminary Bayesian analysis of an 81 taxon small subunit (18S) ribosomal RNA gene (rDNA) alignment, and detailed maximum parsimony, minimum evolution, maximum likelihood, and Bayesian analyses of a focused 33 taxon 18S rDNA alignment. Each of these studies support nine major clades within the Gastropoda: Patellogastropoda, Cocculinoidea, Lepetelloidea, Neritopsina, Neomphalina, Vetigastropoda, Pleurotomarioidea, Caenogastropoda, and Heterobranchia. There was very significant support for the Apogastropoda (Caenogastropoda + Heterobranchia). Little support was found for the Cocculiniformia (Cocculinoidea + Lepetelloidea). Molecular and morphological data provided very different results for the placement of the Neomphalina, Neritopsina, Cocculinoidea, Lepetelloidea, and Pleurotomarioidea. As such, we examine consensus via a supertree analysis of combined morphological, gene sequence, and mitochondrial gene order data. We also discuss sources of noise, variation, and bias in these data. [MAMP]

**Effects of time, predation risk and relatedness on
behavior during mating interactions**

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Behavioral tendencies during mating interactions can have important effects on mating patterns within populations. Factors hypothesized to influence mating behavior include recent experience, predation risk and relatedness. The genetic similarity of mates could affect fitness due to inbreeding or outbreeding effects. Predation risk and sexual motivation could also differentially affect fitness consequences of particular mating behaviors. Two experiments tested for effects of these factors on mating interactions of snails (*Physa gyrina*). Pairs of snails experienced different temporal patterns of interaction, different levels of predation risk, and the genetic similarities of individuals within pairs was varied. I recorded behaviors leading to copulations, error rates, rejection behaviors, and the number of matings. Evidence suggests isolation time increased reproductive motivation. Predation risk influenced mating behavior and decreased mating frequency. Mating interactions were also influenced by the degree of genetic similarity of the potential mates within a pair. Further studies are needed to identify general patterns for how these and other factors influence mating behavior and fitness. [PITL]

Is *Mercenaria mercenaria* a host for *Perkinsus* species?

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Perkinsus marinus is an endoparasitic protistan that infects the Eastern oyster, *Crassostrea virginica*. This parasite has caused mass mortalities of oysters along the Atlantic and Gulf coasts. The commercially important *Mercenaria mercenaria* is cultured in areas naturally populated by *C. virginica*. Whether the hard clam, *M. mercenaria* is susceptible to *Perkinsus* infection or serves as an intermediate host has not been well studied. Therefore, the objectives for this study were (1) to examine the diversity of *Perkinsus* species associated with *M. mercenaria* and *C. virginica* in the environment, and (2) to experimentally test the susceptibility of hard clams to *P. marinus* and *P. andrewsi* infections. *M. mercenaria* and *C. virginica* were collected from the Cedar Key area on the Gulf Coast of Florida. Both species-specific PCR assays and standard Fluid Thioglycollate Media assays were used in this study to identify associated parasites and determine levels of infection. PCR assays suggest that *P. marinus* infects *M. mercenaria* collected from Gulf coast waters. Laboratory studies are in progress to determine virulence of *Perkinsus* species in *M. mercenaria*. This project should help to provide an indication of virulence potential of *Perkinsus* species for the hard clams on Florida's Gulf Coast and the possible threat of these parasites to the rapidly growing aquaculture industry in the region. [P]

**Progress toward completion of taxonomic reference manual:
*Shell-bearing Gastropoda of the Northeastern Pacific***

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Two volumes on shelled gastropods comparable to the highly acclaimed *Bivalve Seashells of Western North America*, by Coan, Scott and Bernard, published in 2000, are in late stages of preparation, to be published by the LACMNH. In order to provide reasonable geographic limits and to emphasize faunal distinctions and provincial radiations, the first volume treats the species of British Columbia to central Baja California and the second treats the more northern species of Arctic Alaska, south to British Columbia and west to the Kurile Islands, Russia. Type localities and type specimen repositories for nominal taxa and all synonyms, and citations of subsequent illustrations of type specimens are included, for the databasing purposes of future workers. Most groups are subjected to major revision, bringing them into conformity with recent taxonomic advances. The format is sufficiently detailed to allow the descriptions of approximately 350 new species to be included in the text. Shells are to be illustrated in black and white on a white background, close to the text and with full captions. Although there has long been a demand for the Eastern Pacific gastropod book, and its importance to resource managers and modern systematists is evident, there are no calls for proposals from NSF or other federal agencies for the preparation of taxonomic manuals. However, I am pleased to report that the Packard Foundation has provided me with funding for an imaging technician, who is now preparing the plates from my negatives taken over many years. I do not have the benefit of a co-author, and the fauna is three times the number of bivalves, but with this help, there is now the expectation that the books will be completed. [P]

**Odostomiine genera reconsidered: shell characters
versus spermatophore characters**

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Robertson (1978, Biol. Bull. 155: 360-382, and subsequent papers) studied the biology of six species of Western Atlantic odostomiine pyramidellids of diverse shell morphology, finding that three species had large, shell-attached spermatophores and that another three species had smaller spermatophores positioned within the mantle cavity. Robertson (1978) used the genus *Fargoa* Bartsch, 1955, for the former group and proposed the new genus *Boonea* for the latter group, basing the classification chiefly on distinctions in the spermatophores. At the same time, he declared shell sculpture to be “unreliable in pyramidellid systematics.” Robertson’s classification has been followed by Wise in a series of recent papers and to some extent by Hori and his collaborators, whereas other recent authors have based odostomiine genera on shell characters, not commenting on the usage of *Boonea* and *Fargoa* for western Atlantic species. Using traditional methodology, in which I compare shell characters to those of the type species, my allocations for the species assigned by Robertson to *Fargoa* are: *Chrysallida dianthophila* (Wells & Wells 1961), in which genus the beaded axial ribs strongly project; *Fargoa bushiana* (Bartsch 1909), with clathrate, beaded sculpture in which the spiral cord above the suture is smooth and strongly projecting; “*Odostomia*” *bartschi* (Winkley 1909), with nearly smooth sculpture. For those species assigned to *Boonea* by Robertson, my allocations are: *Boonea seminuda* (C. B. Adams 1839), with evenly clathrate, beaded sculpture; *Oscilla impressa* (Say 1822), with strongly projecting spiral cords; *Odetta bisuturalis* (Say 1822), with deeply incised spiral sculpture. The genera are broadly distributed and speciose. I argue that shell characters provide a multi-character data-set that is just as reliable for systematics in odostomiine pyramidellids as it is in any other family of shell-bearing marine gastropods. My hypothesis is that spermatophore differences serve as isolating mechanisms that enhance speciation within genera. [C4]

A 15-year study of intrapopulation, interannual shell-shape variation in the freshwater, pulmonate limpet, *Hebetancylus excentricus*

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A population of the pulmonate limpet, *Hebetancylus excentricus*, inhabiting a natural impoundment of a small stream in southeastern Oklahoma, was sampled every fall from 1973-1987 and every spring from 1978 to 1987 to assess intrapopulation, interannual variation its shell morphology. The population was semelparous, thus, successive fall and spring samples contained individuals from the same cohort after 5-6 and 11-12 months growth, respectively. Aperture length (AL), shell height (SH) and aperture width (AW) were determined for all specimens. Multiple factor ANOVA, with AL as a covariant, indicated that 36 and 49 of 105 pair-wise comparisons (Scheffe Test) of sample mean SH and AW were respectively different ($P < 0.05$), among fall samples. Similarly, 28 and 26 of 55 possible pair-wise comparisons of mean SH and AW were respectively different among 11 spring samples. ANOVA tests with AL as a covariant indicated that mean SH and AW varied significantly in seven of 11 fall versus spring samples within the same generation. Little correlation occurred between shell morphometry and mean monthly air temperature or total precipitation during a six-month period preceding fall or spring samples. Such extensive intrapopulation, interannual variation suggests that shell shape is labile in freshwater gastropods. Thus, within genus species designations based on gross shell morphology could lead to conservation efforts directed at ecophenotypes rather than species. [BCFG]

Mitochondrial gene order versus sequence data in heterobranch gastropods

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Crown gastropods exhibit remarkable evolutionary trends such as convergent body plan evolution, as well as adaptations to new environments (e.g. freshwater and land). They also show interesting patterns of evolution at the molecular level. In the particular case of their mitochondrial DNA, and based on the few genomes available, heterobranch gastropods (i.e. hetrostrophan snails, pulmonates and opisthobranchs) are found to have small genomes compared to other invertebrate taxa. More importantly, they present major gene rearrangements that have occurred multiple times throughout the evolutionary history of this clade. We are obtaining complete mtDNA sequences from additional key taxa, which already show that rearrangements are rather common in this group. Having a detailed phylogenetic reconstruction of multiple genomes should help us identify when and how these rearrangements started taking place in gastropod evolution. We will be comparing the gene order data with phylogenetic trees obtained with amino acids and nucleotide for the complete genomes. Additionally, we also have a more complete data set (large taxon sampling) for the mitochondrial large ribosomal subunit (16S), and we will be assessing how these different types of phylogenetic characters complement each other. [MAMP]

Direct and Indirect Effects of Sedimentation on Rocky Littoral Gastropods of Lake Tanganyika

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Endemic gastropods are the dominant benthic macroinvertebrates on the faunally diverse, rocky substrates of Lake Tanganyika. As grazing herbivores, they form a critical focal group for monitoring the effects of increased anthropogenic sedimentation in the clear waters of Lake Tanganyika.

Habitat disruption may have a suite of effects on the resident fauna, including changes in diversity, abundance, life history characters, parasites and predators. We assessed these factors for gastropods in a paired sample design of sites that were differentially impacted by increased sedimentation from erosion in surrounding watersheds (5 replicated quadrat samples at each of 4 depths, total 80 quadrats).

Sedimentation had no significant effect on snail species richness or abundance. The evenness of community composition was lower at sedimented sites, particularly below 1 m. Overall variation between sites, within sites, and within depths was higher at sedimented sites than undisturbed ones. Frequencies of parasitism and shell scarring were lower at sedimented sites, and generally increased with depth. *Lavigeria nassa* adult size at reproduction was smaller at sedimented sites, suggesting that snail nutrition is affected by sediments.

Our results demonstrate the importance of spatial replication and detailed response measures in conservation surveys. Many of the most easily measured responses to disturbance (e.g. diversity, abundance) were unaffected by sedimentation in our survey, whereas more time-consuming analyses (evenness, parasitism, predation, size at reproduction) revealed strong patterns. The differences in parasitism and predation reflect the influence of indirect effects of sedimentation on snails, mediated by sediment impacts on predatory and parasitic taxa. [BCFG]

Interspecific and intraspecific assessment of mtDNA CO1 of the freshwater snail *Elimia curvicastrata* complex with the southeastern rivers of Florida, Georgia, and Alabama (GASTROPODA: PLEUROCERIDAE)

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Using a 385 bp sequence of mtDNA CO1 gene this study compared 20 species. Phylogenetic trees generated by parsimony and distance data revealed that *Elimia curvicastrata* of previous authors is polyphyletic and that the complex includes 5 distinct species clusters. The first cluster includes an undescribed species from the Escambia and undescribed species from the upper Choctawhatchee. The second cluster includes *E. ucheensis* from the Chattahoochee and *E. mutabilis* from the Ocmulgee. The third cluster includes *E. viennaensis* from the Flint River and an undescribed species from the Oconee River system. The fourth cluster includes *E. curvicastrata* of the Chipola, Choctawhatchee and Flint Rivers. The final cluster includes *E. timidia* from the Ocmulgee River system, *E. induta* from the Flint River and an undescribed species from upper Choctawhatchee River. Our study reveals 4 distinct genetic species from the Escambia drainage, 3 from the Choctawhatchee, 4 from the Apalachicola, and 3 from the Altamaha totaling 14 species plus 6 extralimital species. Interspecific variation among these species yielded a 4-17% difference within the genetic sequences. Using morphological analysis of shell characters to establish intraspecific variation, the genetic distances reveal a 0.005 –6% difference in sequence divergence. [BCFG]

Embryonic development of *Crepidula aculeata* (Caenogastropoda, Calyptraeidae) from the Venezuelan Caribbean

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Brooding specimens of *Crepidula aculeata* were collected at the intake channel of the Planta Centro power plant in Puerto Cabello, Venezuela between 1 and 3 m depth. Individuals were attached to flat, large rocks at both sides of the channel entrance. A total of 58 brooding females of *C. aculeata* were collected. The shells of brooding females measured between 15-36 mm in length. Each female broods between 4 -19 egg capsules. The egg capsules, thin and transparent had the typical shape among calyptraeids, triangular, with one corner extending to form a stalk by which all the egg capsules were attached to the substrate at a common point. Egg capsules measured between 1.5-5.3 mm both lengthwise (without the stalk) and in width. The number of eggs per capsule varied from 12-65. The uncleaved egg measured about 417 μm . About 60 % of the eggs do not develop and constitute nurse eggs. Between the trochophore stage and the hatching stage, the mean number of embryos per capsule decreases significantly possibly due to cannibalism among sibling embryos. An intracapsular veliger develops measuring about 690 μm in shell length, the foot also develops and has a round, transparent operculum. Hatching occurred as crawling juveniles measuring about 860 μm in shell length, this calcified shell is white and has vertical lines. No relationship was found between female size and reproductive parameters such as size and number of egg capsules per female, size and number of eggs per capsule nor hatchling number and size. [P]

A new species of pleurocerid snail from the Harpeth River, Tennessee

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The continued loss of aquatic species richness and diversity can be attributed to widespread anthropogenic elimination and degradation of freshwater habitats. One group that exemplifies both a loss of diversity and a poor understanding of systematic relationships is the Pleuroceridae of North America, a family of gill-breathing operculate snails that reaches its greatest diversity in the southeastern United States. *Lithasia armigera* is a widespread pleurocerid species found throughout the Cumberland, Ohio, and Tennessee River drainages. Previous phylogenetic analyses of 16S rDNA sequences revealed a potential sister relationship of *L. armigera* from the Harpeth River, TN to *Leptoxis*, while COI sequences suggested it represented a valid species within *Lithasia*. Here we analyze both extant Harpeth River populations using COI data, along with other representative pleurocerid species. Our data suggests that *L. armigera* in the Harpeth River represents two distinct phylogenetic species: one recognized as *L. armigera* and one new undescribed species. Here we describe the new species, illustrate differences between it and other taxa in the Harpeth, and discuss potential conservation implications. This study highlights the potential for intergeneric similarity and cryptic diversity in the Pleuroceridae and highlights the need for continued systematic studies of the family. [C6]

More than just a pretty pattern: what the spots on the shell of *Cribrarula cribraria* tell us about its anatomy (Gastropoda: Cypraeidae)

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Cowrie shells are considered to have few informative characters, with their glossy, involute shells bearing little or no sculpture. Nor is the protoconch visible. When fully exposed, the mantle covers the entire shell. The mantle is stationary relative to the shell, that is, it returns to the same position on each exposure. Shells in the *Cribrarula cribraria* complex have characteristic white dorsal spots (DS), which are non-pigmented oval “windows” through which the white background of the dorsum is seen. I suggest, based on observation and photographs of live cowries, that there is a direct correspondence between DS and mantle papillae in the *C. cribraria* complex: the white DS are the record of each papilla at the time the pigmented layer was deposited by the mantle. The number of DS or papillae may have an adaptive value in cowries. DS counts from 371 shells assumed to represent all ten species in the *cribraria* complex show species-specific ranges. Other DS-related taxonomically useful characters include: dorsal line position; dorsal papillae number on each mantle lobe; relative size and density of DS, etc. These novel conchological characters reflect anatomical features previously only available from study of live or preserved animals. Thus, museum shells can help tell a story about the animal’s anatomy. Combined with anatomical and molecular data, the non-traditional conchological characters used here may provide a higher level of taxonomic resolution than traditional conchological characters in cowries. [C2*]

Making the best of museum specimens: a simple method to recover the radula, odontophore and DNA from dried tissues for taxonomic and phylogenetic studies

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Most museum specimens are essentially used for morphometric studies. The vast museum collections, obtained at great cost over a long period of time, and from diverse localities, are also valuable resources for evolutionary and ecological research. Many specimens have dried or preserved tissue that can be a source of DNA. Although DNA extraction is destructive, it is possible to maximize information from museum specimens. A simple method for digesting dried tissue *in situ* from gastropod shells is described, whereby the shell is preserved and the radula and odontophore are retrieved for taxonomic purposes, and DNA is available for molecular systematics. The shell is covered with nail polish to protect the external surface from etching by the lysing buffer (NET buffer and proteinase K), which digests the tissue inside the shell. The chitinous radula and odontophore are not digested but cleaned and can be used for SEM without further cleaning. The supernatant is used for DNA extraction, yielding DNA that may vary from degraded to high molecular weight. Some samples may be PCR amplifiable and used for sequencing. Common problems associated with DNA from dried tissue include PCR inhibitors and contamination with extraneous DNA. Addition of bovine serum albumin and Hot Start PCR are among the best strategies used to curb PCR inhibition. In the absence of fresh tissues museum specimens can be a viable source of DNA, as well as radulae and odontophore. [C4]

Preliminary study of odontophore diversity in the Cypraeidae and the use of odontophores as a source of taxonomic characters

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The significance of the taxonomic value of radulae has long been recognized by malacologists, first using optical microscopes, and later at the scanning microscopic level. Today, radulae are among the standard characters used in molluscan taxonomic studies. Odontophore cartilages (or bolsters), on the other hand, are often only briefly mentioned in anatomical studies, but not in taxonomic papers. In this poster I present a preliminary study of the diversity of odontophores in the Cypraeidae, and investigate the utility of odontophores as a source of additional taxonomic characters. Both the radula and odontophores can be easily obtained by dissection of the buccal mass, or through digestion of the whole body by a lysing buffer and proteinase K in the case of dried tissues. The odontophores can be whole-mounted to be studied under the optical microscope, or critical-point dried for scanning electron microscopy. Ideally, both approaches should be used for maximum recovery of characters. If odontophores vary in shape, size and texture even in closely related species in cowries with similar feeding preferences, then odontophores likely vary more widely in other groups with more diverse feeding specializations. Further studies are needed to explore the variation of odontophores in other molluscan groups to assess the taxonomic and phylogenetic utility of odontophores. [P]

Propagation of endangered freshwater mussels in the United States

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Propagation facilities for the production, culture, and release of endangered juvenile mussels have been established in several states to serve the conservation needs of 70 federally threatened and endangered species. The Freshwater Mollusk Conservation Center at Virginia Tech was the first to release endangered juveniles in 1997, and subsequent facility in at least 6 other states have followed suit, using either recirculating or flow-through culture systems for their propagation work. Approximately 15 species have benefited thus far from this expanding effort, supported by the U.S. Fish and Wildlife Service and fish and wildlife agencies of the respective states. More than half a million mussels have been released thus far, and several additional states are developing their own propagation centers. Mussel biologists now have reason for optimism in saving this beleaguered faunal group. [C7]

Distribution of Pupillid Micro Land Snails in Thailand and Adjacent Areas

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Distribution data of approximately 100 species of pupillid micro land snails of Thailand and Peninsular Malaysia were examined at 62 sites representing 22 latitudinal zones. Similarity coefficients were calculated between each zone. A cluster analysis determined the groupings were significant. The analysis confirmed the significance of a transition between northern Indochinese and southern Indomalay(Sundaic) micro land snail fauna assemblages at the Isthmus of Kra area (close to 10 ° N). *Hypselostoma khaowongensis* is the dominant morphotype for northern species and *Gyliotrachela khaochongensis* is for the south. (This research was supported by The Thailand Research Fund, TRF/13/2001). [C5]

When a snail dies in the forest, how long will the shell persist?

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After snails die, their shells persist in the environment. Although some shells survive as fossils for hundreds of millions of years, most shells decompose more quickly than that, probably on the order of months or years.

We know very little about the rate at which shells decompose, and the little we know is anecdotal. Nevertheless, many studies make assumptions about the rate of shell decomposition. Endangered species biologists need to know how long ago a species was living at a site having an empty shell. Biologists conducting biodiversity surveys commonly use empty shells to signal the presence of a species at a site, but using empty shells to calculate abundances requires assuming that all species, robust or fragile, decompose at the same rate, and in some studies, that shells at different sites decompose at the same rate.

In order to determine how long empty shells persist in the forest, and to test for differences in decomposition rate among species and among sites, I put shells in mesh litter bags at one site in Delaware and at two sites in northern Michigan, and monitored shell weight annually for 3 and 4 years.

Preliminary results from 1 and 2 years indicate that shell weight decreased 8-10% per year, with no apparent difference in weight loss among species. In this talk I present results of shell decomposition over 3 and 4 years, examining differences among species and among sites. [C5]

***Perna viridis* in La Restinga lagoon (Margarita Island, Venezuela):
Is this population reproductively active?**

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The Indo-Pacific green mussel *Perna viridis* has been recorded in South America since 1992 (in Trinidad Island). In 1995 it was observed in the north coast of Sucre state in Venezuela. Specimens of *P. viridis* were collected from *Rizophora mangle* roots during February 2002 in the coastal lagoon “La Restinga” (Margarita Island, Venezuela).

The aim of this work is: To generate knowledge concerning the sexual differentiation size and the first maturation size in this mussel. Does the recruitment depends on the exogenous larval supply, or is the population of *P. viridis* inside the lagoon reproductively active? We collected specimens between 18 mm and 91.2mm of total length. Sexual differentiation starts at a size of 23 mm with incipient follicular formation. In the mantle of individuals of a total shell length of 20mm or less no gonad development was observed. Specimens larger than 30mm presented developed gonads, while males were all mature and females had developed gonads with different maturity stages (50% to 100% of follicle development in the mantle). First maturity stages are discussed in relation to other localities, cited by several authors. We concluded that the population of *P. viridis* in La Restinga lagoon is reproductively active. Larval supply could come from outside or inside the lagoon, assuring the recruitment of new spat and the dispersion of this species. [P]

***Crepidula dilatata* (Gastropoda, Calyptraeidae) truly living in the SW Atlantic.**

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Crepidula fecunda Gallardo, 1979, was described from Bahía Chinquihue (41°31'S-73°03'W) in the Chilean Pacific. *C. dilatata* Lamarck, 1822, is differentiated by its direct development and the presence of embryos consuming nurse eggs. Adult morphological features are identical. Therefore, earlier records referring to the presence of *C. dilatata* in the Atlantic coast of South America need validation. The type locality of *C. dilatata* remains unknown but the Western coast of South America as a probable type locality has been mentioned in a commented list of the types from Lamarck's collection. Egg capsules and adult, males and females were collected from Bahía Ensenada, Ushuaia (~55°S) to Golfo Nuevo (~42°30'S) in Chubut province. Collections were during February 2000. We studied more than 100 brooding females. Most females were brooding egg masses at advanced stages of embryonic development, containing embryos and uncleaved nurse eggs or crawling juveniles.

The observed material was completely homogeneous, with only one developmental mode characterized by the presence of nurse eggs. Each egg capsule (n= 150) contains 203-375 eggs (mean = 303, SD = 54) with only 2 to 12 developing embryos, representing as an average, the 2.4% of the initial egg number. The average uncleaved egg diameter was 214 μ m (SD = 13 μ m, n=72). Hatching occurs at a crawling juvenile stage. Brooding females measured 11-32 mm (mean = 22 mm) in shell length, but in this protandric species the loss of penis can be already observed at 11 mm of shell length. Males (with a penis) measured 7-19 mm of shell length. This study confirms the presence of *C. dilatata* in the Southern Atlantic and, up to our knowledge and as far as we observed, restricts *C. fecunda* to the Pacific. [P]

Evolutionary Radiation of Spring-Snails (Gastropoda: Hydrobiidae) of the Great Artesian Basin, Australia

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Freshwater snails of the family Hydrobiidae are increasingly recognized as a prominent component of artesian springs of the Great Artesian Basin (GAB) of Australia, with most species having been discovered and described during the past 15 years. The GAB drains 22 percent of the continent and its borders are outlined with several “permanent” super-group artesian spring systems each containing an endemic spring-snail fauna. Although considerable research has been done within individual spring systems, little is known of the evolutionary and biogeographic relationships among super-group taxa. Here, we present a preliminary phylogenetic hypothesis of the GAB spring-snail fauna based on partial mitochondrial cytochrome oxidase c subunit I and 16S rRNA gene sequences. The hypotheses examined include (1) is each spring system’s hydrobiid fauna monophyletic; (2) what are the phylogenetic relationships among super-group taxa; and (3) is the GAB fauna monophyletic? Our goal is to understand the spring-snail species’ evolutionary response to fragmentation due to increasing aridity since the Tertiary. [P]

**Identification of mollusk taxa at U.S. ports of entry:
Help from molecular biology.**

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Plant Protection and Quarantine of the USDA is responsible for preventing the importation of exotic agriculture pests including terrestrial mollusks. Pests that are ‘exotic’ and found associated with imported commodities are considered ‘actionable’ requiring the commodity to be either rejected for importation or it must undergo a ‘quarantine treatment’. This generally involves fumigation for most of mollusk-associated commodities. Unfortunately, approximately 40% of slug interceptions and 20% snail interceptions at U.S. ports are juveniles and cannot be identified by dissection as they have yet to develop adult genitalia or other diagnostic characters. This results in 200-300 fumigations per year, 70% of which are probably unnecessary if they could be identified by other means. To reach the goal of developing a robust method of taxon identification for use at ports-of-entry, a ‘molecular taxonomic key’ has been developed using the PCR-RFLP patterns of the 16S rRNA and COI genes of the mitochondrial DNA from mollusks. We have generated the DNA sequences of these genes from 61 taxa of slugs and 33 of snails serving as our baseline data set from which to compare intercepted ‘unknowns’. In these groups are a number of apparent cryptic species which are morphologically and anatomically identical to described species but yield significantly different mitochondrial DNA sequences. The molecular phylogenetics of these taxa will also be discussed. [C5]

Comparative Molluscan Assemblages of West Point Military Academy Drainages

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The molluscs of five drainages on West Point Military Academy property in New York were surveyed. The different areas sampled were variously impacted by training activities on the military base including periodic drawdowns. About 35 species of molluscs were collected, including one very rare and presumed new species of small planorbid gastropod. Only two species of unionids were found (*Elliptio complanata* and *Pyganodon cataracta*). The hydrobid *Amnicola limosus* was the most abundant mollusc recovered, commonly found in shallow, weedy areas of ponds and lakes. Shallow, ditches with temporary stands of water, held diverse communities that included *Aplexa elongata*, *Gyraulus circumstriatus*, *Pseudosuccinea columella*, *Pisidium casertanum* and *Pisidium rotundatum*. Additionally, two species of freshwater limpet (*Ferrissia walkeri* and *F. fragilis*), previously unreported from West Point, were found sympatrically on twigs in a slow moving elbow of one stream. The Popolopen drainage system held the highest diversity of molluscs in strong correlation with the overall size of this watershed.

Bray-Curtis similarities revealed that Popolopen and Cragston drainages had a 47% similarity in molluscan taxa. An overall comparison of habitat type found on the base proper demonstrated that lakes/ponds compared most favorably with streams/brooks at 64%. Comparisons with other New York freshwater surveys found a similarity coefficient of 53 to 55% for lakes/ponds and streams/brooks respectively, but a similarity of 66.7% for comparable ditch habitats. This higher index likely reflects selection of more restricted physiologies required for these ephemeral habitats. [P]

Is there a functional relationship between columellar folds and the columellar muscle in neogastropods?

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Malacologists traditionally assume that the function of columellar folds is intimately related to the columellar muscle because the muscle has grooves that surround each fold. Two commonly cited functional hypotheses state that folds increase the surface area of columellar muscle attachment, which in turn increases the animal's ability to maneuver its shell, and folds guide the muscle during retraction and protraction, as railroad tracks guide a train. To begin testing these hypotheses, I explore the relationship between the presence of columellar folds, the position and length of muscle attachment, and the proportion of muscle in contact with the columella. I quantified these aspects of attachment morphology in 7 neogastropod species with folds and 4 species without them, supplementing these data with qualitative descriptions of another 10 species. Measurements were taken from photographs documenting dissections. Since photographs collapse three-dimensional data into two-dimensions, I have developed a method to calculate true surface area and lengths. Species with and without folds show no significant differences in any of the variables measured. Thus, the function of columellar folds is not to increase surface area of muscle attachment, and it may not be to guide the columellar muscle. The remarkable similarity in morphology of the columellar folds and the columellar muscle may be a non-functional artifact of the muscle conforming to the shape of an adjacent surface. Future work will document convergence in columellar fold morphology to determine whether independent derivations of similar fold shapes corroborate the supposition that folds are adaptive. [C2*]

**A Survey of the Land Snails of Four Islands in the Lesser Antilles:
Dominica, St. Lucia, St. Vincent and Grenada**

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The terrestrial molluscan fauna of the Lesser Antilles is poorly known and much of the literature on the molluscs dates back to the late 1800's and early 1900's. Thus, most islands are in critical need of surveys to document their current molluscan faunas. The islands surveyed, Dominica, St. Lucia, St. Vincent and Grenada, are almost entirely volcanic, dominated by steep mountainous topography. Natural lowland habitats have been extirpated or severely restricted by intensive cultivation. A minimum of ten sites on each island was examined for the presence of snails. Specimens were collected and preserved in 70% ethanol. After preservation the soft parts of the snails were removed and the shells were air-dried. The malacological collections at the Florida Museum of Natural History were used in the identification the snails. A total of 40 species of snails from 10 families were found. Twenty-two species were recorded from Dominica, 13 species were found in Grenada, 11 species in St. Lucia and 7 species in St. Vincent. Three new species were found, *Austroselenites* sp. nova and *Lithacaspis* sp. nova in Dominica and *Lucidella* sp. nova in Grenada. A high degree of endemism was observed. Of the snails found, only two species, *Subulina octona* and *Leptinaria lamellata*, were common to all the islands. The results of this preliminary survey of the molluscan fauna of the four islands emphasize the need and urgency for more detailed surveys of these and other islands within the region. [P]

Using COI mtDNA sequences and morphological data in resolving relationships among the Scaphopoda

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In continuing to expand the set of informative characters and increase the taxa represented in analyses of scaphopod phylogeny, we have compiled a matrix of 22 partial sequences (687 bp) of COI mtDNA from 15 scaphopod species. Taxonomic sampling is uneven, providing a test of monophyly for only a subset of taxa represented; this is also a problem in recent morphological analyses, and renders reconciliation of disparate datasets difficult. Nevertheless, COI nucleotides and amino acids support some morphological results and provide new, if in some cases limited, tests of family and genus monophyly. The two scaphopod orders based on morphology, the Dentaliida and Gadilida, are strongly supported. Within the Gadilida, monophyly of the family Gadilidae is supported, with *Gadila aberrans* and *Polyschides carolinensis* representing subfamilies Gadilinae and Siphonodentaliinae respectively. *Entalina tetragona*, however, is resolved sister to the Gadilinae, thereby questioning the monophyly of the suborder Gadilimorpha. Neither is monophyly supported for the family Dentaliidae, with the placement of *Fissidentalium candidum* as sister to a clade including *Rhabdus rectius*. *Antalis* is the best-sampled genus in this analysis, being represented by 6 species; *A. entalis*, however, emerges sister to the single *Dentalium* species, *D. majorinum*, thereby rendering the genus paraphyletic. The taxonomic history of the genus *Dentalium*, once widely inclusive but narrowed considerably by the elevation of recognized subtaxa, also indicates a need for systematic review. But until more complete taxonomic sampling across both morphological and molecular datasets is available, little resolution can be brought to this and other uncertainties in scaphopod systematics. [MAMP]

**The invasive New Zealand mudsnail *Potamopyrgus antipodarum*
in Western USA**

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The exotic New Zealand Mudsnail, *Potamopyrgus antipodarum* (Gray) has invaded portions of most of the major river systems in the Western USA, including the Columbia, Colorado, and Missouri. It is a live bearing, parthenogenic hydrobiid with high reproductive potential and can often exceed densities $>300,000/m^2$. *Potamopyrgus antipodarum*'s potential impacts on native aquatic ecosystems in the western USA appear to be great, depending on conditions. Several researchers have documented decreases in native invertebrates, changes in primary production, and competitive effects between *P. antipodarum* and native threatened snails. I will give an overview of basic life history, ecology, distribution, impacts and research findings concerning *P. antipodarum* in the western USA. [C6]

Historical biogeography in the Central Highlands region of North America: A comparison of the ability of analytical methods to resolve conflicting data.

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One of the central tenets of historical biogeography is that the observation of congruent distributions of organisms is *prima facie* evidence for a vicariant event. In practice however, the analysis of a variety of endemic taxa that share similar distributions often produces disparate biogeographic hypotheses. Reconciling incongruent area cladograms has been problematic for biogeographers. Incongruent area relationships can result from a variety of causes including accurate phylogenies that correctly depict different responses of organisms to the same historical events. The Central Highlands region of North America is home to a large number of endemic vertebrate and invertebrate taxa. As such it has been the focus of several recent biogeographic studies. These include mitochondrial DNA based phylogenies for fishes, freshwater mussels and crayfishes. In this presentation I will examine the utility of methods for combining data typically applied in phylogenetic analyses of taxa to resolve incongruence among the different area cladograms produced by these data sets. [MAMP]

The complete mitochondrial genome of the freshwater mussel *Lampsilis ornata* (Unionidae): Insight into the evolution of gene rearrangement in Mollusca

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The complete mitochondrial (mt) genome was sequenced and characterized for the freshwater mussel *Lampsilis ornata* (Unionidae). Gene arrangement, genome content, and nucleotide frequency seen in *L. ornata* was compared to other bivalve and gastropod taxa. Trends among these lineages were assessed. For all available molluscan mt genomes, gene order was coded phylogenetically to reconstruct history of gene translocation and to determine whether gene arrangement has phylogenetic signal across the phylum. Mapping gene order characters on an independently derived, morphological- and molecular-based phylogeny of Mollusca revealed several synapomorphies uniting members at the level of phylum, class, and family. Interestingly, although members of Bivalvia experience extraordinary variation in gene arrangement, gene order characters provide support for monophyletic groups within the class. Bivalve gene content also provides support for the duplication/random loss model for gene translocation of this lineage. An hypothesis to explain the high levels of gene rearrangement within the Bivalvia is proposed. [C7*]

**The Freshwater Gastropods of Mississippi:
Pioneer Survey Efforts in the 21st Century**

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The freshwater gastropods of Mississippi are poorly known. Very little work has been done on this group within the state. Museum records are scarce. Current studies are ongoing under the auspices of the Mississippi Wildlife Heritage Checkoff Grant Program and as part of the national Freshwater Gastropods of North America Project. Recent surveys have recovered 51 species; including two that appear to be unknown in current literature and not recognized in standardized lists. At least one of these species has a name and needs to be officially recognized. This study is a multi year effort which will culminate in a published monograph once the entire state is covered. [BCFG]

Phylogenetic Systematics and Conservation Status of the *Pleurocera* of the Mobile Basin

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Over the last century, North America has seen the loss of 76 species of freshwater mollusks, all of which were endemic to the southeastern U.S. The Mobile River basin is distinguished by having the greatest freshwater snail diversity in North America, second only to rivers of Southeast Asia. In order to effectively conserve and manage remaining imperiled molluscan biodiversity, one must first delineate phylogenetic species boundaries. Species of the gastropod genus *Pleurocera* have traditionally been based on a morpho-species concept, whereby each shell morph was described as a distinct species. Later, taxonomists interpreted shell variation to reflect largely intraspecific variation and reduced the number of species to the five currently recognized *Pleurocera* species in the Mobile basin. I constructed a preliminary molecular phylogeny of Mobile basin *Pleurocera* based on a portion of the mitochondrial cytochrome oxidase c subunit I gene to delimit phylogenetic species boundaries. Specimens for this analysis were found at 46 of 121 locales surveyed throughout the Mobile basin from September 1999 to November 2001. Specimens were sorted by shell morpho-type and DNA was extracted, amplified, and sequenced using an ABI 3100 Genetic Analyzer. The molecular phylogeny of *Pleurocera* specimens revealed clades associated largely with drainage basin and not necessarily traditional morphological groupings. For example, the morpho-species *Pleurocera vestitum* inhabits the Cahaba River and tributaries of the Black Warrior and Coosa Rivers in the Mobile basin. However, the molecular phylogeny shows no evidence for such a species. These findings will undoubtedly alter the conservation status of each species. [C6*]

Qualitative Pest Risk Analysis of the Channeled Applesnail, *Pomacea canaliculata*, and its Significance to Rice Production in the United States

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The channeled applesnail (CAS), *Pomacea canaliculata*, has been introduced into the U. S. through the pet trade industry, and continues to be sold in aquarium shops and via the internet, *e. g.*: eBay. The CAS has devastated large areas of rice production in countries such as the Philippines and demonstrates a preference for rice over weeds. It also has been implicated in vectoring eosinophilic meningitis, a brain disease in humans; it tends to eliminate native snail competitors where established; and it has limited value as an aquarium species because it consumes aquarium plants and grows to the size of a baseball. It has already been found in California near a major rice growing area, and in Texas in two rice growing areas. The rice industry in Texas has a net worth of \$1 billion. In the Philippines, within five years of introduction, that country went from rice exporting to rice importing. Therefore, it is important to keep the same from happening to the U. S. rice industry and to provide the pet trade industry both education and alternatives so that *P. canaliculata* will disappear from aquarium shops and the internet marketplaces nationwide. Known infestations in Lake MiraMar, CA and in Houston, TX have not been exterminated due to either public use of the facility [Lake MiraMar serves as a public recreation area and as a water source for San Diego, CA] or due to the presence of endangered native species of bivalve mollusks [American Canal in Houston, TX]. Both California and Texas seek an APHIS response to this species as a model for future infestations of mollusks that threaten agriculture, the environment, and in the case of *P. canaliculata*, human health, so APHIS-PPQ undertook this PRA to determine and communicate the risks represented by this snail. [P]

Evidence of social facilitation from interspecific crosses in *Physa*

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In August 2001 we initiated a series of no-choice mating experiments involving populations of *Physa* with Type-B penial morphology: *Physa gyrina gyrina* from Council Bluffs, Iowa, *Physa gyrina aurea* from Hot Springs, Virginia, and *Physa microstriata* from Fish lake, Utah. We also included one population with Type-C penial morphology as a negative control: *Physa acuta* from Charleston. Surprisingly, reproduction was initiated in Virginia x Charleston pairs simultaneously with the onset of reproduction in VxV and CxC controls. Allozyme electrophoresis demonstrated that all progeny from the VxC pairs were the product of self-fertilization by the Charleston population. Since our prior research has shown self fertilization to be delayed about 6 weeks after the onset of ordinary (outcross) fertility in *P. acuta*, we interpret the present findings to be evidence that self-fertilization in *P. acuta* is “socially facilitated” by *P. gyrina*. Experiments currently ongoing will verify this phenomenon and establish whether such facilitation may be due to physical or chemical stimulus. [PITL]

Molecular phylogeny of the anomalodesmatan Bivalvia inferred from 18S and 28S rDNA sequences

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Anomalodesmata unites 14 morphologically highly divergent families with controversial phylogenetic relationships. Their position within the Bivalvia is as enigmatic as the group itself, and their proposed sistergroups range from the remaining Autobranchia, to the pteriomorph Mytiloidea, the Heterodonta or, within the Heterodonta, the Myoidea. We present initial results from parsimony and maximum likelihood analyses of a 18S rDNA and 28S rDNA (domains D1-D3) dataset containing 20 and 16 anomalodesmatan species respectively. Both genes support similar topologies. The monophylum Anomalodesmata and its origin within the basal heterodonts is robustly confirmed. We found no support for a sistergroup relationship with the apparently diphyletic Myoidea. Branching order at the base of the Anomalodesmata is unstable, leaving some inter-familial relationships unresolved. Monophyly of the families Poromyidae, Laternulidae and Cuspidariidae is well supported. Other robustly supported clades within the Anomalodesmata are [Lyonsiidae, *Pandora* (Pandoridae), *Brechites* (Clavagellidae)] and [Thraciidae, *Myadora* (Myochamidae), *Cleidothaerus* (Cleidothaeridae)]. These two clades share homologous elongations of the E 10 insertion in the 18S rDNA and the D 3 domain of the 28S rDNA. There is some evidence for a clade uniting Cuspidariidae, Poromyidae and Lyonsiellidae close to the base of the anomalodesmatan tree which may become better resolved when additional species become available. Despite the limited taxon sample, several discrepancies to recent morphological trees are evident and indicate extensive convergent evolution in several character complexes like, e.g. shell microstructure and hinge morphology. Supported by the Austrian Science Fund (FWF) project P14356-BIO, and the Royal Society, London. [C1]

Scaphopoda and Cephalopoda are sister taxa – an evolutionary scenario

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Each of the higher conchiferan classes have been proposed as a sistergroup to Scaphopoda. They are either recognized as sistertaxon to Bivalvia (Diasoma/Loboconcha concept), or to a Gastropoda-Cephalopoda clade, or to Cephalopoda (“Helcionelloida” concept). Neither hypothesis comes without homoplastic morphological interpretations, particularly regarding to the Scaphopoda. The Diasoma concept results in convergent evolution of elongated dorsoventral body axes in Scaphopoda and Cyrtosoma (Gastropoda, Cephalopoda), of multiple cephalic tentacles and ring-shaped muscle attachment in Scaphopoda and Cephalopoda. The "helcionelloid" concept has to account for convergences in the development of the mantle-shell, the burrowing foot, and the nervous system in Bivalvia and Scaphopoda. Testing these hypotheses against independent molecular data, we analyzed an 18S rDNA data set containing all relevant taxa. All resulting trees show Cephalopoda and Scaphopoda as sistergroups and the Gastropoda connecting to their common stem. Spectral analysis and likelihood-mapping show much higher signal for a Cephalopoda-Scaphopoda clade than for any competing topology. Key characters of molluscan morphology plotted onto the molecular tree, reveal a possible scenario for the evolution of higher conchiferan taxa. Accordingly, infaunal adaptations occurred independently in the early Rostrochonchia-Bivalvia lineage and in Scaphopoda. The dorsoventrally elongated helcionellids with a deep mantle cavity and a circular muscle attachment are a likely stem-group of Scaphopoda and Cephalopoda. While shell-chambering for buoyancy led to the first cephalopods, anterior mantle elongation and posterior shell slits or snorkels in response to an increasingly infaunal habit gave rise to the tube-shelled scaphopods. Supported by Austrian Science Fund (FWF) projects 14356-BIO and 14846-GEN. [MAMP]

Geographic distribution and conservation status of Virginia's freshwater gastropods

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We reviewed collection records from museum databases and published manuscripts to provide a comprehensive summary of the geographic distribution and conservation status of Virginia's freshwater gastropods. Sixty eight species of freshwater gastropods have been reported from Virginia, with 10 families represented, including Valvatidae (1 species), Viviparidae (4 species), Bithyniidae (1 species), Hydrobiidae (14 species), Pomatiopsidae (2 species), Pleuroceridae (20 species), Lymnaeidae (10 species), Physidae (5 species), Planorbidae (7 species), and Ancyliidae (4 species). Of these snails, four are non-indigenous species that have successfully invaded Virginia (*Bithynia tentaculata*, *Cipangopaludina chinensis*, *Viviparus georgianus*, *Radix auricularia*). Although no Virginia freshwater gastropod species are on the federal list of endangered species, at least five Hydrobiidae (*Somatogyrus virginicus*, *Fontigens bottimeri*, *Fontigens morrisoni*, *Holsingeria unthankensis*, and a recently described, unnamed species of *Holsingeria*) one Pomatiopsidae (*Pomatiopsis cincinnatiensis*), two Pleuroceridae (*Io fluvialis*, *Leptoxis praerosa*), and one Lymnaeidae (*Stagnicola neopalustris*) are threatened with statewide, if not global, extinction. Relatively little attention has been directed toward preserving these threatened species. However, transplantations have resulted in reestablishment of spiny river snail (*Io fluvialis*) populations in the Holston River following their extirpation from this system in the early 20th century. Unfortunately, assessment of conservation status of most species, and efforts to preserve threatened species, are hindered by inadequate knowledge of their geographic distribution, population sizes, and ecological requirements. In Virginia, only populations of cave and spring snails (Hydrobiidae; genera *Fontigens* and *Holsingeria*), and river snails (Pleuroceridae) in the southwest region of the state, have been extensively surveyed and studied. [BCFG]

A total evidence phylogeny of the Cerithioidea

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The Cerithioidea Ferussac, 1819 is one of the most diverse superfamilies of caenogastropods, including about 14 families, 200 genera, and several thousand extant species. Cerithioideans are distributed worldwide in a diversity of marine, brackish water and freshwater habitats, often representing a significant component of the communities where they are found. Recent studies have generated two hypotheses of relationships within the superfamily. One is based on a morphological data set comprising a total of 180 characters, for shell (including protoconch), operculum, radular, alimentary tract, kidney, nerve, sperm ultrastructure and reproductive anatomy for 44 taxa; the other is based on a data set comprising 40 nearly full-length mitochondrial large subunit rRNA and flanking tRNA gene sequences (total aligned length of 1873 bp). These two hypotheses differ significantly regarding the monophyly and systematic placement of several families. This uncertainty surrounding our understanding of evolutionary relationships within the Cerithioidea effectively prevents efforts to evaluate biogeographic and ecological hypotheses. Combining all available morphological and molecular data (or total evidence) yields yet another hypothesis of relationships for the group. Possible causes for the topological discrepancy between the separate morphological and molecular analyses will be explored with the aid of congruence metrics. The role of congruence in assessing the combinability of data sets, as well as the implications of the separate and combined analyses for biogeographic and ecologic interpretations will be discussed. [MAMP]

**The freshwater snails of the *Elimia curvicostata* complex from the southeastern rivers of Florida, Georgia, and Alabama
(GASTROPODA: PLEUROCERIDAE)**

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Previous literature recognized a single species, *Elimia curvicostata* (Reeve, 1861) distributed from the Escambia River system at the Florida – Alabama border east to the Flint River system in Georgia. Ten names were synonymized with *E. curvicostata*. A systematic analysis based on shell and opercular morphology of populations from throughout the purported range of *E. curvicostata*, as well as related but extra-limited species necessitate the recognition of fourteen species in this complex, including five new species and two new subspecies. Juvenile shell characters are of primary importance for purposes of species discrimination as well as showing group relationships. Adult shell characters are less useful because of convergent evolution. Species boundaries and relationships were confirmed by mtDNA CO1 gene sequencing. [C6]

Erectile tissue in the *Octopus* copulatory organ

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Erectile tissue is known most familiarly from mammal genitalia, notably the penis and clitoris. Among the soft-bodied invertebrates that constitute the majority of the animal kingdom, erectile tissue is uncommon and erectile sexual organs discontinuous with the reproductive tract are unknown. Here we report erectile tissue composes the ligula, the copulatory organ, of *Octopus bimaculatus* and *O. bimaculoides*. The ligula is derived from the tip of the third right arm in immature males and is thought to insert a spermatophore into the female's oviduct. Like the mammal penis, it contains extensive interconnected spaces surrounded by robust collagen fibers. The collagen fibers bounding the ligula are arrayed at 66 degrees to the organ's long axis, an orientation that likely allows it to retain sufficient flexibility to manipulate the spermatophore into the female's oviduct. Like the mammal penis, the ligula is also highly vascularized; this contrasts with the relatively few blood vessels in the opposite and presumably homologous third left arm. Because the ligula of these diurnal species lacks chromatophore organs and is bounded by a layer of opaque collagen, it may be conspicuous to visual predators. The evolution of erectile tissue may allow the ligula to both be physically minimized, and therefore less visible, and to maintain its function. [C3]

**Probable Extirpation of a Unique Endemic *Octopus* Species
from St. Joseph's Bay, Florida**

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Harmful algal blooms (HAB) have been a well-documented event along the west coast of Florida since the 1800's. From August 17th to October 22nd, 1999 St. Joseph's Bay, Florida experienced a severe and prolonged HAB with cell counts ranging from 10,000 to 1,000,000 cells/L, causing discolored water, shell bed closure, and notable invertebrate mortality. Prior to the HAB of 1999 an endemic and possibly undescribed species of octopus (probably *Octopus mercatoris*, but often misidentified as *Octopus joubini*) inhabited grass beds at densities as high as 1 per 30m². The proclivity of *O. mercatoris* for shallow sea grass habitats and sedentary lifestyle made the mollusk especially vulnerable to the 1999 HAB. Extensive and repeated sampling since 1999 has failed to turn up any *O. mercatoris* in St. Joseph's bay. It may be difficult for *O. mercatoris* populations from other locations to re-colonize St. Joseph's Bay due to the relatively small number of benthic hatchlings produced. Even assuming a high emigration rate, plans for extensive development of St. Joseph's Bay and the associated loss of critical habitat may further interfere or prevent re-colonization of this unique endemic species. [P]

**Testing the Phylogenetic utility of taxonomic shell characters in
Thai Pupillid Micro Land Snails**

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A combined approach of 16s mt and 28s nuclear ribosomal DNA sequence analysis of Thai pupillid micro land snails was used in an effort to test the previous proposed taxonomic shell characters of certain taxa within the land snail family Pupillidae. There was a good agreement among apertural tooth-based taxonomic groupings and the combined gene tree. Best for *Gyliotrachela* spp., less so for *Hypselostoma* spp. and *Anauchen* spp. Geographic proximate taxa tend to share recent ancestry and evolutionary transitions in ecology and shell morphology may occur rapidly in some pupillid lineages. Baker (1935) arranged the five sub-family but the present results show that Gastrocoptinae and Vertigininae are arranged in the same clade which separated by Pupillinae. More data from appropriate nuclear genes and from anatomical analyses are required to construct a robust phylogeny of Thai pupillids. (This research was supported by The Thailand Research under The Royal Golden Jubilee Ph. D. Program). [C5*]

**Nonlethal effects of predators on behavior and growth of *Physa integra*:
comparing mesocosm and field experiments.**

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A number of mesocosm and laboratory studies show that predators can induce shifts in snail morphology, life-history, and behavior. The overall importance of trait shifts in mediating evolutionary and ecological processes depends on the spatial and temporal scales over which predators induce trait shifts in the field, but most studies of phenotypic plasticity are laboratory based. Thus, the importance of trait shifts in the field is largely unassessed. I determined the spatial scale of predator avoidance by snails in a lake by measuring the habitat use and growth rate of *Physa integra* held at varying distances from a caged pumpkinseed sunfish (*Lepomis gibbosus*). Refuge use was highest near the fish and gradually decayed to background levels at distances ≥ 3.2 m from the predator. Snail growth rates were negligible near the predator, but increased with greater separation from fish. The dependence of behavior on the age of chemical cues was measured in a experiment in which water was withdrawn from a tank holding pumpkinseeds and held for varying lengths of time before being added to experimental mesocosms with snails. Fresh cues elicited the strongest habitat shifts relative to well water controls, and avoidance behavior decayed in an exponential manner with increasing cue age. The mean lifetime of avoidance behavior was 41 hours. Combined with field estimates of predator density and movement rates, these results suggest that trait shifts are ubiquitous in the field. Finally, I use these data to describe the behavioral landscape created by mobile predators. [PITL]

**How many times has the radula been lost in dorid nudibranchs?
Reconciliation of molecular and morphological data.**

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Maximum-parsimony analysis of the nucleotide sequence of the 16S mtDNA gene, obtained from several dorid nudibranch taxa, shows that the radula-less dorids are a monophyletic group. In addition, most of the traditional groups within this nudibranch clade are also monophyletic. However, in the gene tree obtained, the family Dendrodorididae and the genus *Phyllidiopsis* are paraphyletic, which contradicts previous morphological results. Branch support for the traditional groups is very high, whereas all those arrangements that differ from the topology of previously published morphological trees are not well supported. Maximum-likelihood analysis offers a different topology which disagrees with both previously published morphological analyses and maximum-parsimony results. In this case, the radula-less dorids are not monophyletic. Total evidence and supertree techniques are used to combine the morphological and molecular data, and the results are discussed. [MAMP]

Gill mites and unionoid phylogeny

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Water mites (Acari: Unionicolidae: *Unionicola*) represent a diverse collection of more than 200 species distributed in freshwater habitats on all continents except Antarctica. More than half of the known species are parasites of freshwater mollusks, especially freshwater mussels (Bivalvia: Unionoida). The mites oviposit in different regions of the mussels, *e. g.*, gills, and this correlates with their current phylogeny. The gill mites, those that use the gills for oviposition, comprise more than twelve subgenera readily separable into two divergent clades. The most ancient and least derived members of these mites, the subgenus *Australatax*, inhabit hyriid mussels, both in Australia and South America. Derived members of one clade are distributed among iridinids, mycetopodids, and North American unionids (excluding anodontines), while the members of the other clade are distributed among North American anodontines and Eurasian mussels. Recent papers regarding the higher systematics of Unionoida, evaluated using both morphological and biochemical data, provide a different view from previous systematic groupings for the mussels by suggesting the hyriids to be most ancient. General hypotheses regarding coevolution imply that there exist specific host preferences among the phylogenetic groups of parasites and that those preferences might support or refute general hypotheses regarding host phylogenies. The new systematic groupings of mussels and especially the ancientness of the hyriids appear to be supported by the preferences of the parasitic gill mites. However, mites have never been reported from several significant mussel groups, namely margaritiferids, *Gonidea*, *Coelatura*, and *Etheria*, thus limiting the scope of phylogenetic evaluation of mussels using mite preferences. [C7]

Gene trees and species trees – a case study from a species flock of viviparous freshwater gastropods (Caenogastropoda: Cerithioidea: Pachychilidae) from the ancient lakes of Sulawesi, Indonesia

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Molecular phylogenies have become an important standard tool in systematic and evolutionary research, in particular those based on mitochondrial genes. The gene trees thus gained are usually assumed to represent species trees or population genealogy. In a case study on a radiation of pachychilid gastropods in the central ancient lakes on Sulawesi, Indonesia, we compared gene trees obtained by sequencing two mitochondrial gene fragments with patterns of morphological variation. The molecular phylogeny shows the lake species to fall into four well supported clades. While molecular and morphological data are largely congruent at this species-group level, the same is not true for the species level. Several morphologically highly distinct species appear to be polyphyletic. Often incomplete lineage sorting is invoked to explain inconsistencies of this kind, and it cannot be ruled out in this case as well. Striking ‘misplacements’ of some species or populations, respectively, in the gene trees lead us to assume, though, that hybridization might be a widespread phenomenon in the Sulawesi pachychilids. Accepting this hypothesis has a profound impact on the interpretation of the molecular phylogeny in terms of species and character evolution. [MAMP]

Preliminary phylogenetic analysis of *Melongena corona* populations from the Gulf of Mexico

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Current taxonomic classification recognizes two species of *Melongena* along the gulf coasts of Alabama and Florida. Within the *M. corona* species, three subspecies are currently recognized. Two subspecies are found within the Gulf of Mexico (*M. c. corona* and *M. c. johnstonei*) while the third is located along the Atlantic coast of Florida (*M. c. altispira*). The second species, *M. bicolor*, is restricted to the Florida Keys. The current analysis utilizes an 895 bp fragment of CO I to investigate the relationships represented in this genus. To date, sequences have been obtained from 78 *M. corona* individuals representing two subspecies (*M. c. corona* and *M. c. johnstonei*) and 9 populations (6 *M. c. corona* and 3 *M. c. johnstonei*). Outgroup taxa used include *Fasciolaria tulipa*, *Strombus alatus*, and *Busycon contrarium*. An analysis of this sequence data using PAUP 4.0b10 shows little resolution between the subspecies represented in this study thus far. A previous sheared PCA analysis of the 6 shell characters originally used to define the subspecies also provides little support for the current subspecific classification. Continuing analysis of populations from Alabama and Florida is in progress. [P]

Biogeographic and phylogenetic studies of freshwater limpets

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Freshwater pulmonate limpets (Basommatophora) have nearly bilaterally symmetrical, cap-shaped shells that lack the coil which is so distinctive of the great majority of gastropods. Believed to have evolved several times from coiled ancestors, freshwater limpets exist in both lentic and lotic habitats, and their geographic range includes all but one continent (Antarctica). Three families containing freshwater limpets occur in North America. The Lymnaeidae have mostly high-spired and coiled shells, but *Lanx* and *Fisherola* of the west coast have limpet-shaped shells. Taxa of the other two families, Acroloxidae and Ancyliidae, have exclusively limpet-shaped shells. *Acroloxus coloradensis* is dextral in body organization, while all species of the Ancyliidae are sinistral. Of the genera in the family Ancyliidae, *Ferrissia* has the widest range and is found almost worldwide. Old World taxa include *Ancylus* (Europe/Africa) and *Burnupia* (southern Africa), whereas New World genera incorporate *Rhodacmea* (southeastern United States), *Hebetancylus* (southern North/Central America), and *Gundlachia*, *Uncancylus*, and *Anisancylus* (South America). All freshwater limpets are hermaphroditic and some seemingly are polyploid. Chromosome numbers among the ancyliids range from haploid 15 in *Rhodacmea cahawbensis* to haploid 30 and 60 in two *Ancylus* species. These fascinating little snails have not been intensively studied for a generation, and many questions concerning their evolution and biogeography remain unaddressed. We are now revisiting their systematic relationships using anatomical, karyological and molecular characters. [P]

Developing a Successful Freshwater Snail Inventory and Conservation Program within a State Resource Agency

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Over the past decade, the North Carolina Wildlife Resources Commission has sought out and obtained funding that has allowed the agency to complete significant aquatic surveys statewide. While all the projects have not been specifically geared towards freshwater gastropods, the diversity of the nongame staff along with the utilization of flexible sampling protocols has allowed us to constantly collect snail data regardless of the project's goal. An initial major step is to make sure all inventory biologists are familiar with the local freshwater snail fauna. Local museums should be thoroughly utilized to achieve this goal. Within each project, survey sites should be chosen by analyzing the focus area rather than at random. This should involve techniques such as identifying the major waterways and their tributaries or hydrological unit analysis in ArcView. Reconnaissance of potential survey sites also is worthwhile. A combination of survey techniques should be implemented at all sites, and some sites should be surveyed over long reaches (miles) rather than short distances or just at bridge crossings. Data collection should be standardized on data sheets and include information such as habitat, relative abundance, and reproduction information. Once gathered, it is critical that the data are maintained in a database. The NCWRC Nongame Program has developed an aquatics database (Access) that currently contains over 3000 freshwater snail entries. This information has been imperative for various land trusts and conservation organizations in order to target significant aquatic habitats for preservation. The data also play a significant role in the permitting process and the development of North Carolina's landscape. Our database is currently housed online, which allows real-time entry and access capabilities for multiple users within North Carolina. This format also provides us the capability to expand the database outside of the state. [BCFG]

**Land Snail Fauna of a Reclaimed Strip-Mined Land Site
in the Midwest of the USA**

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A survey of terrestrial snails and slugs was made at The Wilds, a large tract of reclaimed strip-mined land in Muskingum County, Ohio. The study area was reclaimed between 1949 and 1972 and left as either forest or fields. The purpose of the study was to map the distribution of snails using GPS technology and compare the faunas of deciduous woods, coniferous woods, and open fields. Four hundred thirty-six 0.25m² leaf litter samples were taken from ~1,800 hectares. Sixty taxa were found, including three species new to Ohio and two exotic slugs. The mean species richness was 2.7 species/sample; the mean density was 7.1 individuals/sample. Density and diversity (H) in deciduous woods were statistically different from those of fields; woods had nearly twice the density and diversity of fields. There was no difference between deciduous and coniferous woods. Most species were either woodland or field species with very few taxa occurring in both. However, even strictly field species rarely occurred beyond a 200m buffer zone from a woods. Many taxa had ranges of only a few hectares and some species were found in only a single sample. This study suggests that most surveys will miss the majority of species and that faunal lists for a given area may be greatly underestimated. [C5]

Ultraviolet light enhances the toxicity of polycyclic aromatic hydrocarbons to glochidia of the paper pondshell, *Utterbackia imbecillis*

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Polycyclic aromatic hydrocarbons (PAHs) represent a class of ubiquitous environmental contaminants primarily derived from petroleum products and their combustion. In this study, the acute toxicity of three PAHs (fluoranthene, anthracene and pyrene) to the glochidia of the paper pondshell, *Utterbackia imbecillis* was characterized in the laboratory using two sets of experiments. Acute toxicity tests designed to determine the overall sensitivity of glochidia to these three PAHs were conducted under ambient laboratory lighting (UV-A = $< 2.0 \mu\text{W}/\text{cm}^2$) and under simulated sunlight (UV-A = $69 \pm 1.0 \mu\text{W}/\text{cm}^2$) (mean \pm SD). For all three compounds, toxicity was greater in the presence of simulated sunlight. 24-h median lethal concentration (LC50) values for fluoranthene, anthracene, and pyrene under simulated sunlight were 2.45, 1.93, and 2.63 $\mu\text{g}/\text{L}$, respectively. Acute toxicity tests designed to delineate the relationship between the rate of mortality and UV intensity were conducted under one of four different UV intensities (UV-A=15, 31, 50, and 68 $\mu\text{W}/\text{cm}^2$) for each PAH. Regression analyses revealed that time to death decreased as tissue residue concentrations and UV intensity increased for all three compounds. These findings suggest that 1) glochidia of freshwater mussels are sensitive to photoactivated PAHs at environmentally-relevant concentrations, and 2) the time-dependent mortality of glochidia can accurately be predicted through evaluation of the product of tissue residue and light intensity. [C7]

Malacological Results of the Western Australian Marine Biological Workshop Series

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The State of Western Australia is larger than the United States east of the Mississippi and has a coastline of 12,000 km. The south coast of WA has a temperate biota; the north coast is tropical; and the west coast is an overlap region between the two. About 10% of the shallow water molluscs are endemic to the State; these are concentrated on the west coast. European settlement started only in 1827 and many areas are still inaccessible. Aside from the aquaculture industry there are fewer than six malacologists, and all except one occupy positions created since the 1960s. To help overcome this isolation, a series of six marine biological workshops has been conducted in Western Australia and the Northern Territory, including workshops in the tropical, temperate and overlap zones. The workshops are field intensive, lasting for 17 days. It takes three years to write up and publish the workshop proceedings. Participants have included many leading marine malacologists of the present generation. Eight volumes of results have been published to date, and about half of the papers have dealt with molluscs. Malacological results include basic research such as substantial documentation of species present in WA, biogeography, systematics (including new species, and a new family), ecology (diets, reproduction, ecological separation, episodic mortalities, growth rates), and physiology (evaporative heat stress, tolerances). Practical results include the first report of imposex in Western Australia and information used in marine management programs. The Dampier workshop proceedings will be published in mid 2003 and there will be a workshop in Esperance on the south coast in February 2003. [C1]

Pulmonate snails as models: 3 case studies involving sex allocation, life history, and phenotypic plasticity

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Pulmonates have been used and continue to serve as models to study big ecological and evolutionary questions which I explore in this talk and give a brief overview of what I feel are some of the major contributions. Their short life spans, high fecundity, ease of culture, and prominence in a variety of ecosystems make pulmonates invaluable as lab organisms. As hermaphrodites that can self-fertilize, pulmonates have several choices in a sexual encounter: don't mate, mate as male, mate as female, or switch sexual roles in an encounter. Size as well as reproductive history play important roles in decisions made in mating encounters. Also important in terms of sex allocation is how much an individual chooses to put into self-fertilization versus cross-fertilization. If an individual can control the degree of self-fertilized eggs it lays, then a mixed-mating strategy may be present in some populations. Pulmonates have also been used in life history studies. In addition to physical factors, competition (or shifts in niche space) can lead to shifts in life history parameters as well as predator and parasite presence. And finally, pulmonates have been used to study phenotypic plasticity. Shell and behavior characters are affected by predator cue as well as by water chemistry. Given the large degree of plasticity in shell characters, delineating species (many of which were described solely on shell characters) can become troublesome. Currently, we are trying to work out species boundaries within the family Physidae using both the Biological Species Concept and Phylogenetic Species Concept. [Plenary]

**Conservation issues concerning the endangered *Physa (Physella) johnsoni*,
the Banff Springs Snail.**

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Physa johnsoni Clench was described in 1926 based solely on shell characters. Te (1978) examined internal anatomical structures and placed *P. johnsoni* into the *acuta* species complex, *Physella (Costatella)*. Clarke (1973, 1981) re-examined *P. johnsoni* and suggested that it was closely related to *P. gyrina*, which would place it in *Physella (Physella)*. Recently, a genetic analysis of the Banff Springs snail by Remigio and colleagues have reported that it is genetically distinct from *P. gyrina* and worthy of protection, however, no members of the *P. acuta* group were included in the study. Here, I present a more extensive comparative genetic analysis of the Banff Springs snail including multiple physid species and several representatives from the *P. acuta* and *gyrina* groups. The molecular phylogeny, which was based on partial DNA sequences of the mitochondrial cytochrome oxidase c subunit I and 16S rRNA genes, placed *P. johnsoni* in the *gyrina* group, indistinguishable from other members of the Western United States within the *gyrina* group. These findings call into question the identity and/or validity of the taxon currently referred to as *P. johnsoni*. [PITL]

Shaken not stirred: phylogeography of *Oncomelania hupensis hupensis* in the Yangtze River

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The rissooidean taxon *Oncomelania h. hupensis* is the intermediate host for Asian schistosomiasis in central and eastern China. Its distribution is mainly associated with the floodplains and tributaries of the Yangtze River downstream of the Three Gorges. Due to closely co-evolved relationships with the human blood fluke *Schistosoma japonicum*, information on the phylogeography and genetic diversity of the snail host might be very useful for predicting parasite genetic diversity and infectivity, particularly in the light of the Red Queen hypothesis.

We used COI mtDNA sequences from a total of 251 specimens from 26 sites and methods that were designed to infer intraspecific relationships (*e.g.* nested clade analysis, mismatch distributions, ML gene flow analysis, and analyses of molecular variance) to study phylogeographic pattern and population structures in *O. h. hupensis*. We found a total of 113 haplotypes and an overall high rate of heterogeneity within and among populations. The nested clade analysis revealed a considerable degree of restricted gene flow (isolation by distance) along the Yangtze River, but also several events of past fragmentation. Interestingly, the ML gene flow analysis suggests a fair degree of upstream dispersal. Analyses of molecular variance involving upstream and downstream populations as well as populations from three major endemic schistosomiasis areas in eastern China indicate an overall low population structure. However, there are significant differences between populations affected by the annual flooding of the Yangtze River and populations outside the floodplains. In summary, the phylogeography and population structure of *O. h. hupensis* can be characterized with the three famous words: “shaken not stirred”. The work is funded in part by NIH grant AI 39461 (TMRC, Shanghai, China). [C6]

**COI, allozyme, and morphological survey of the
sinistral *Busycon* of North America**

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We examined the gene frequencies of eight polymorphic enzyme loci, shell and soft-part morphology, and the COI gene for eight populations of left-handed *Busycon*, as well as a *Busycon carica* control population. The maximum COI sequence divergence we observed among 32 individuals was 2%, which together with a general homogeneity of soft-part anatomy supports the hypothesis of a single species. Much of the significant variability in radula and shell morphology, both within and among the eight populations can be correlated with systematic trends in overall body size (e.g., shells of both Atlantic and Gulf sinistral populations generally change in color and spinosity with growth in a similar fashion). High levels of allozyme frequency divergence between the allopatric western Atlantic and Gulf of Mexico *Busycon* seemed attributable to isolation by distance and not reproductive isolation. Our combined data suggest all living North American populations of sinistral *Busycon* be relegated to the oldest available nomen, *B. perversum*, to which we assign 3 subspecies. [MAMP]

Reproductive Biology and Accelerated Effect of Abnormal Embryos of fresh water snail Pleurocridae (Gastropoda: Prosobranchia) in N. E. Taiwan

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An investigation of reproductive biology of the ovoviviparous fresh water snail *Semisulcospira libertina* was proceeded for 14 months in Ha-Pen natural reserve of northeast Taiwan. The reproductive cycle of *S. libertina* in this population was comprehended by exploiting embryo abundance and measuring development stages from the brood pouch of adult female snails. In this study, *S. libertina* was found to achieve maturity when their body length reached 9 mm. Adult females are fertile entire year but have a major consecutive reproductive period from spring to summer. Brood size showed significant correlation with water temperature. Female snails also showed smaller brood size, longer reproductive period and smaller mean body length when compared with *S. libertina* population in Japan. Environmental fluctuation might affect abnormal embryo ratio. In this study, we also found that abnormal embryo rate rose with water turbidity. [P*]

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