Program and Abstracts

American Malacological Society
78th Annual Meeting
Cherry Hill, New Jersey

June 16-21, 2012

Compiled and edited by Paul Callomon, Gary Rosenberg and Amanda S. Lawless

Contents

Schedule at a glance

Saturday, June 16

Registration starts, noon
AMS Council meeting, 2:00 - 4:30 pm
AMS Welcome Party, 6:30 - 9:00 pm

Sunday, June 17

Opening remarks, 10:00
Contributed talks, various subjects, 10:20 – 12:00, 1:40 - 4:20 pm
Publication committee meeting, 12:30 – 1:30
Developments at NSF, 4:20 - 5:00 pm

Monday, June 18

Session on cephalopods, 9:00 - 11:40 am
Contributed talks, land and freshwater, 9:00 - 12:00
Systematics committee meeting, noon
Symposium: invasive snails and slugs, 1:30 - 6:00 pm
Contributed talks, paleontology and marine, 1:40 - 4:20 pm
AMS Auction, 6:00 - 9:30 pm

Tuesday, June 19

Symposium on molluscan diversity, 8:40 - 12:00, 1:40 - 3:20 pm
North American mollusk conservation, 9:20 - 12:00
Conservation committee meeting, 12:30 – 1:30
Poster session, 3:00 - 5:00 pm
Bicentennial reception at ANSP, 6:30 - 9:30 pm (buses board at 6 pm)

Wednesday, June 20

Talks by COA grant winners, 8:30-12, 1:40 - 5:00 pm
Symposium on molluscan diversity (cont.), 8:40 - 12
Session on history of malacology, 1:40 - 5:20 pm
AMS business meeting, 5:20 - 6:00 pm
Joint AMS/COA banquet, 6:30 - 9:00 pm

Thursday, June 21

Talks by COA grant winners (cont.), 9:00 - 12:00
AMS ends at noon; talks for COA continue 2:00 - 5:00 pm

Welcome to AMS/COA!

Dear Friends and Colleagues,

On behalf of the Academy of Natural Sciences of Philadelphia and the Philadelphia Shell Club, I'm pleased to welcome you to Cherry Hill and Philadelphia for the 78th Annual Meeting of the American Malacological Society.

I've known for many years that I would one day host an AMS meeting. The bicentennial year of the Academy of Natural Sciences provides the ideal opportunity. Most of the activities will take place at the Crowne Plaza Hotel in Cherry Hill, New Jersey, since the Academy doesn't have the facilities needed to host such a large meeting—especially when it has evolved to become two meetings: AMS convenes joint sessions this year for the first time with the Conchologists of America. As the Academy is the birthplace of American Malacology and Conchology, it seems only fitting to bring amateur and professional together for a "conchlave" in celebration of all things molluscan!

Conchologists of America runs a program of grants to malacology, which has for many years been the main source of research funding for graduate students—who then end up attending AMS rather than COA meetings. This year's symposium for past winners of COA grants, convened by **Ellen Strong**, will let COA members see how important their funding has been in advancing research and careers in malacology. The keynote symposium on Molluscan Diversity, convened by **Philippe Bouchet** and **Ira Richling**, also promises to interest professional and amateur alike. **Rory Mc Donnell** organized the symposium on invasive slugs and snails in North America, and **Liz Shea, Jay Cordeiro** and **Paula Mikkelsen** organized special sessions on cephalopods, conservation, and history of malacology and conchology, respectively. My thanks to these conveners, whose success in recruiting speakers demanded three days of concurrent sessions to schedule all the talks.

In addition to the scientific sessions, most evenings there are social events, each of which provides dinner or the equivalent: the Welcome Party on Saturday, the notorious auction Monday, the bicentennial reception at the Academy Tuesday, and the joint AMS/COA banquet on Wednesday, with guest speaker **Toto Olivera**. The overlapping schedules of the AMS and COA meetings precluded the traditional Thursday field trips, but those of you staying through the weekend might want to join the excursions to the Wagner Free Institute, the Philadelphia Museum of Art and the Camden Aquarium on the Saturday following the meeting.

I want to thank the sponsors of various events at this year's meeting: the **Academy of Natural Sciences**, which waived the rental fee for the bicentennial reception, the **College of Arts and Sciences of Drexel University**, which helped fund the reception, and the American Malacological Society and

Richard E. Petit, who provided funding to defray travel expenses for symposium participants.

I've been fortunate to have on my staff at the Academy both the current and the former secretaries of AMS, **Amanda Lawless** and **Paul Callomon**. Their combined experience with AMS and tirelessness in keeping track of myriad details and deadlines has ensured the meetings' success. Many other volunteers also helped in essential ways: **Betty Lipe** ran the registration database and **Al Schilling** was treasurer for both meetings. **Anne Joffe** helped plan the overlapping of events with COA. **Marla Coppolino** designed the meeting logo and **Warren Graff** and **Amanda Lawless** worked with vendors who printed it on various swag.

Finally, thanks to you, the meeting registrants, 150 strong, for helping to celebrate the bicentennial of molluscan studies in America. I hope the meeting is stimulating and enjoyable, and leads to new ideas, friendships, and collaborations.

Gary Rosenberg
President, American Malacological Society, 2011-2012

Miscellanea

- From Sunday to Tuesday, all **coffee breaks** will be held on the Plaza Level; thereafter they are in the Promenade Foyer
- There will be a short presentation and Q&A by NSF program officer Charles Lydeard on "**Developments at the NSF**" on Sunday at 4:20 pm in the Terrace Room.
- The **AMS auction** of books and memorabilia is on Monday from 6: 00 pm in the Gallery. This event is catered, and there will be a bar.
- The **AMS/COA joint reception** is at the Academy of Natural Sciences on Tuesday from 7:00 pm. Buses will start leaving the hotel at 6 pm.
- Gather for the **group photo** at 12:00 on Wednesday in the Foyer
- The **AMS business meeting** is on Wednesday from 5:20 - 6:00 pm in Plaza Rooms 1&2.
- The **AMS/COA joint banquet** is on Wednesday from 6:30 in the Riverside Pavilion. The banquet speaker will be **Toto Olivera**.
- In the abstracts, an asterisk indicates the presenting author(s)

Sunday ● Contributed talks ● Terrace Room

10:00 am Welcome to AMS

10:20 am East meets west: trans-Pacific phylogeography of the rocky shore gastropods *Littorina sitkana* and *Nucella lima*
Peter B. Marko*, L. Nicole Cox & Nadezhda I. Zaslavskaya

10:40 am *Conus* of the southeastern United States and Caribbean region
Alan J. Kohn

11:00 am Teleplanic molluscan larvae, and the often specific substrata, hosts or prey of their postlarvae
Robert Robertson

11:20 am Causes of ecotypic variation in the dogwhelk *Nucella lapillus*
Katie E Vazquez* & Peter S. Petraitis

11:40 am Peeping through the keyhole: endoscopy of the mantle cavity of *Diodora aspera*
Janice Voltzow

12:00 – 1:40 Lunch

AMS Publication Committee meeting, Plaza Rooms 4&5, 12:30

1:40 pm "Keep your friends close and your enemies closer": behavioral ecology of invasive predators in Hawaii
Brenden S. Holland

2:00 pm Alternatives to expensive machinery: do what you can with what you have
Paul Callomon

2:20 pm Malacological contributions of Howard A. Bern (1920–2012)
Carole S. Hickman

2:40 pm Olof Olsson Nylander: malacologist of Maine's north woods
Scott Martin

3:00 pm Phylogeny incongruent with morphology in *Stagnicola* (Gastropoda: Lymnaeidae): historical factors driving present diversification?
Samantha Flowers

3:20 – 3:40 Coffee Break

3:40 pm Morphological and molecular analysis of the Andean land slugs *Colosius n. sp*., a newly recognized pest of cultivated flowers and coffee from Colombia and Ecuador, and *Colosius pulcher* (Colosi, 1921)
Suzete R. Gomes*, David G. Robinson, Frederick J. Zimmerman, Oscar Obregon & Norman B. Barr

4:00 pm Phylogenetics and evolution of Jamaican Pleurodontidae
Makiri Sei* and Gary Rosenberg

4:20 pm Developments at the National Science Foundation, a special Q&A session hosted by **Dr. Charles Lydeard**

Monday ● Contributed talks ● Land and freshwater
Plaza Rooms 1&2

9:00 am Are Pennsylvania land snails susceptible to climate change?
Timothy A. Pearce* & Megan E. Paustian

9:20 am The slugs of Pennsylvania: Analysis of species distributions and ecological correlates
Megan E. Paustian* and Timothy A. Pearce

9:40 am Land mollusks in northern South America: biogeographic and ecological studies in megadiverse hotspots
Francisco J. Borrero* & Timothy A. Pearce

10:00 am Populations of abnormally-shelled giant African snails *Lissachatina fulica* (Bowdich) in Barbados
Anton Norville and Angela Fields*

10:20 – 10:40 Coffee Break

10:40 am Diversity, phylogeography and relationships of the *Cerion* (Gastropoda: Cerionidae) of the Dutch Leeward Islands
M. G. Harasewych

11:00 am Evolution of asymmetrical larvae in freshwater mussels (Bivalvia: Unionoida: Unionidae)
John M. Pfeiffer III

11:20 am Distributional differences in the freshwater pulmonate snails *Physa gyrina* and *P. acuta*
Amy R. Wethington

11:40 am *Pleurocera acuta* (Raf. 1824) and *P. pyrenellum* (Conrad 1834) are small-stream ecophenotypic morphs of *P. canaliculata* (Say 1821)
Robert T. Dillon, Jr.*, Stephen Jacquemin & Mark Pyron

12:00 – 1:40 Lunch

AMS Systematics Committee meeting, Plaza Rooms 4&5, 12:30

Monday ● Cephalopod session ● Terrace Room (am.)

9:00 am Cephalopod observations during the 2012 cruise of the *Okeanos Explorer* in the Gulf of Mexico
Michael Vecchione

9:20 am Reflections on the current status of living populations of *Nautilus* and *Allonautilus*
W. Bruce Saunders* & Peter D. Ward

9:40 am Non-invasive imaging techniques provide new pathways to discovery in cephalopod biology
Alexander Ziegler, Elizabeth Shea*, Darlene R. Ketten, Ross Mair, Cornelius Faber, T. Aran Mooney, Christian Bock, Rachel Berquist, Lawrence R. Frank & Gonzalo Giribet

10:00 am Size-based predation on shortfin squid *Illex illecebrosus* in the northwest Atlantic Ocean
Michelle Staudinger

10:20 – 10:40 Coffee Break

10:40 am Systematics, phylogeny and ecology of the Octopoteuthidae Berry, 1912 (Cephalopoda: Oegopsida)
Jesse T. Kelly

11:00 am How octopuses choose their prey
David Scheel* & Diana Stanley

11:20 am Characterizing arm autotomy: an octopus mode of defense
Jean S. Alupay* & Roy L. Caldwell

12:00 – 1:40 Lunch
AMS Systematics Committee meeting, Plaza Rooms 4&5, 12:30

Monday ● Contributed talks ● Land and freshwater
Plaza Rooms 1&2

1:40 pm Late Pleistocene molluscan provinciality in the Western Atlantic: a test case for genus richness
Lyle D. Campbell*, Sarah C. Campbell & Matthew R. Campbell

2:00 pm Prehistoric coastal shell midden research in Maine
Scott Martin

2:20 pm Vermeij Crushing Analysis: analyzing crushing predation in Miocene mollusk communities
Emily S. Stafford* & Lindsey R. Leighton

2:40 pm Significance of *Kuphus* tube morphology and microstructure for understanding the growth, taxonomy and ecology of a poorly known teredinid bivalve
John A. Sime* & Gary Rosenberg

3:00 pm Symbiosis in *Kuphus polythalamia* (Bivalvia: Teredinidae).
Daniel L. Distel*, Julie Albano, Marvin Altamia, Rowena Antemano, Gisela Concepcion, Rande Dechavez, Imelda Forteza, Andrew Han, Margo Haygood, Gwen Limbaco & Roberta O'Connor

3:20 – 3:40 Coffee Break

3:40 pm Phylogenetic analysis of four protein-encoding genes largely corroborates the traditional classification of Bivalvia (Mollusca)
Prashant P. Sharma, Vanessa L. González*, Gisele Y. Kawauchi, Sónia C. S. Andrade, Alejandra Guzmán, Timothy M. Collins, Emily A. Glover, Elizabeth M. Harper, John M. Healy, Paula M. Mikkelsen, John D. Taylor, Rüdiger Bieler & Gonzalo Giribet

4:00 pm Grades are as important as clades for understanding hyperdiversity of skeneiform microgastropods
Carole S. Hickman

AMS Auction, 6:00 – 9:30 pm, Gallery

Monday ● Status, impacts and management of invasive slugs and snails in North America ● Terrace Room (p.m.)

1: 30 pm Introduction by symposium chairs **Rory McDonnell** and **James Harwood**

1:40 pm Facing the onslaught of invasive snails and slugs: one country's defenses against the introduction and establishment of non-native agricultural and environmental pests
David G. Robinson

2:00 pm The USDA's response to the latest south Florida Giant African Snail infestation
Frederick J. Zimmerman*, David G. Robinson & Amy Roda

2:20 pm Giant African Land Snail in Florida: introduction and state response
Paul E. Skelley

2:40 pm Impact and pest status of *Parmarion cf. martensi* and *Veronicella cubensis* in the Pacific region, and tools to prevent damage and spread
Robert Hollingsworth* and David Robinson

3:00 pm Elucidation of an invasive slug species complex in California with comments on the source location of introductions
Rory Mc Donnell*, Paul Rugman-Jones, Thierry Backeljau, Karin Breugelmans, Kurt Jordaens, Richard Stouthamer, Tim Paine & Mike Gormally

3:20 – 3:40 Coffee Break

3:40 pm Maintaining snail-free status in California nurseries with emphasis on the European Brown Snail
Cheryl Wilen

4:00 pm Amber Snail management in Pacific Northwest nurseries
Robin Rosetta* & James Coupland

4:20 pm Slugs and other grower concerns in no-till production systems in the Midwest
Ronald B. Hammond

4:40 pm Insights on the ecology and management of slugs in Pennsylvania no-till crop fields
Margaret R. Douglas* and John F. Tooker

5:00 pm Reduced tillage systems for slug management in no-till field corn
Joanne Whalen* and William Cissel

5:20 pm Slugs in North America: options for biological control
James D. Harwood

5:40 pm Open discussion

AMS Auction, 6:00 – 9:30 pm, Gallery

Tuesday ● North American Mollusk Conservation
Plaza Rooms 1&2 (a.m.)

Poster setup will take place all day in the Terrace Room

9:20 am An introduction and brief history of 20th-century molluscan conservation issues in North America
Jay Cordeiro

9:40 am Changes in the freshwater mussel (Unionoidea) fauna of Illinois over the past 100 years as an exemplar for North America.
Kevin S. Cummings*, Sarah A. Bales, Alison L. Price & Diane K. Shasteen

10:00 am Western American perspectives on molluscan conservation
Robert Hershler

10:20 – 10:40 Coffee Break

10:40 am Conservation status of North American freshwater limpets (Ancylinae) clarified by molecular systematics
Diarmaid Ó Foighil* & Andrea C. Walther

11:00 am Conservation considerations for North American land snails
Jeffrey C. Nekola

11:20 am Conservation issues of terrestrial slugs
Megan E. Paustian

12:00 – 1:40 Lunch

AMS Conservation Committee meeting, Plaza Rooms 4&5, 12:30

Tuesday ● Magnitude of molluscan diversity – the known and the unknown ● Terrace Room

8:40 am Introduction by symposium chairs Philippe Bouchet & Ira Richling

9:00 am What is the magnitude of known diversity of Recent mollusks?
Gary Rosenberg

9:20 am Exploration of a "well known" marine fauna: mollusks of the Florida Keys
Rüdiger Bieler* & Paula M. Mikkelsen

9:40 am Overview of North American land snail biodiversity
Jeffrey C. Nekola

10:00 am Biodiversity of continental molluscs in the western Palaearctic
Eike Neubert

10:20 – 10:40 Coffee Break

10:40 am Continuing species discovery at hydrothermal vents and comparable habitats
Janet R. Voight

11:00 am Chemosymbiosis feeds diversification of Lucinidae from the intertidal to the deep sea: new discoveries of the last 20 years
John D. Taylor & Emily A. Glover

11:20 am Freshwater molluscan biodiversity: distribution, extinction and the future
Arthur E. Bogan

11:40 am The tropical Indo-Pacific: the ultimate frontier, a world of small and rare species
Philippe Bouchet

12:00 – 1:40 Lunch

AMS Conservation Committee meeting, Plaza Rooms 4&5, 12:30

1:40 pm Housekeeping through the Carychiidae (Eupulmonata, Ellobioidea) - DNA barcoding scours the rust of species splitters, lumpers and synonomies
Alexander M. Weigand & Adrienne Jochum*

2:00 pm Discovering land snail diversity faster than a snail's pace: DNA barcoding helps reveal secrets hidden within the shell
John Slapcinsky

2:20 pm The glass half empty: frontiers in the exploration of Australia's non-marine molluscs
Frank Köhler

2:40 pm Cowries: how well inventoried is the best-known seashell family?
Fabio Moretzsohn

3:00 pm How over-named are the ceriths? New species *vs*. digging in the graveyard of synonymy
Ellen E. Strong

Poster session ● Tuesday 3:00 – 5:00 pm, Terrace Room

Mitogenomes of *Nerita versicolor* and *Nerita tessellata* and phylogenetic analysis with gastropods
Moises Arques, Lyda Castro* & Donald Colgan

University of Kansas Fitch Natural History Reservation mollusks: then and now.
Elizabeth C. Davis-Berg

Rare freshwater mussels (Unionidae) in the urban corridor of the Delaware estuary
Danielle Kreeger, Roger Thomas*, Sylvan Klein, Angela Padeletti, Melanie Mills, William Lellis & William Whalon

Essential oils as novel tools in the management of snails and slugs in potted plants
Rory Mc Donnell*, Robert Hollingsworth* &Tim Paine

The BioGoMx Database as a tool for conservation
Fabio Moretzsohn* and J. Wes Tunnell, Jr.

Spawn and larval development in *Siphonaria lessoni* (Siphonariidae: Gastropoda) from Buenos Aires, Argentina
Mariel Ojeda, Maria Eugenia Torroglosa* & Juliana Giménez

Comparative shell and shell microstructure of *Laternula truncata* and *L. cf. corrugata*
Robert S. Prezant*, Rebecca Shell & Laying Wu

Gastropods of caves in the Grand Duchy of Luxembourg
Carsten Renker*, Dieter Weber & Andrea Pohl

Sepiola atlantica: the mating behavior
Marcelo Rodrigues, Angel Guerra & Jesús S. Troncoso*

The influence of diphenhydramine HCl and caffeine on embryonic development and reproductive success of *Helisoma trivolvis*
Diana Sanchez

The role of terrestrial mollusks in phoresis and vectoring of plant parasites, bacteria and fungal pathogens
Kristi Sanchez*, S. Nadler, & E. P. Caswell-Chen

Novel insights on the prevalence of gender conflict in *Biomphalaria glabrata*: autosperm buildup not a likely factor
Jonathan Schultz* and Jeffrey Hollinger*

A re-description of the du Pont Trophy (Shell Show Award: Outstanding Exhibit), with notes on distribution and ontogeny
Elizabeth K. Shea* and Leslie Skibinski

Conservation Status of Freshwater Snails of the United States and Canada
Jeremy S. Tiemann

Spermatozoa morphology of *Brachidontes rodriguezii* (d'Orbigny, 1846) (Bivalvia)
María E. Torroglosa* & Juliana Giménez

Ecology of *Gouldia californica* Dall, 1917, and *Olivella cocosensis* Olsson, 1956 in Isla del Coco
Jesús S. Troncoso* & Jeffrey A. Sibaja-Cordero

A sixth species within the scorched mussel (*Brachidontes exustus*) cryptic species complex
Jessica K. Wadleigh, Theresinha M. Absher & Kyle F. Bennett*

Undergraduate research in Malacology
Norine W. Yeung*, Kelsey Coleman, Torsten Durken, Ashley Kong, Dylan Ressler, Taryn Takebayashi, Kenneth A. Hayes, and Robert H. Cowie

Phenotypic structure of the land snail *Ponsadenia duplocincta* in the Tian-shan Mountains
Asel Busuioc Zhetigenova

The Bailey-Matthews Shell Museum: a museum for Malacology
José H. Leal

Evening reception at the Academy of Natural Sciences.
Please gather in Foyer at 6:00 pm to board buses.

Wednesday ● Magnitude of molluscan diversity – the known and the unknown (continued) ● Ballroom C (a.m.)

8:40 am The nudibranch revolution: are they evolving faster than we can find them?
Terrence Gosliner

9:00 am Small mollusks - big insights: the mesopsammic contribution to Malacology
Timea P. Neusser*, Bastian Brenzinger, Katharina M. Jörger & Michael Schrödl.

9:20 am Revision of living and fossil Liotiidae and Areneidae of the world: the beaded operculum synapomorphy
James H. McLean

9:40 am The vast frontier: exploring the unusual world of galeommatoidean bivalves
Paul Valentich-Scott

10:00 am Exploration at the verge of extinction – estimating diversity in the tropical land snail family Helicinidae (Neritopsina)
Ira Richling

10:20 – 10:40 Coffee Break

10:40 am Exploring cockles: where do we stand and who gets it done? A European perspective from a non-professional
Jan Johan ter Poorten*

11:00 am Our sea of "sp."s—the non-professional to the rescue
Philip J. Fallon, Jr.

11:20 am Status of cataloguing the megadiverse marine gastropod family Pyramidellidae
Patrick I. LaFollette

11:40 am Sound nomenclature: how to find reliable names for the diversity
Francisco Welter-Schultes

12:00 Open discussion

12:00: AMS/COA Group Photograph – please gather in Foyer

12:00 – 1:40 Lunch

Wednesday ● COA Grant Winners ● Plaza Rooms 1&2

8:30 am Introduction by symposium chairs Ellen Strong and José Leal

8:40 am Beauty and the Beast – diversity, research history, and ongoing challenges in two families of marine gastropods, Architectonicidae and Vermetidae
Rüdiger Bieler

9:00 am Characterizing the molecular basis of dispersed photoreception in the cephalopod *Octopus bimaculoides*
Desmond Ramirez* & Todd H. Oakley

9:20 am A phylogenetic and transcriptomic study of convergent evolution in bioluminescent squids
M. Sabrina Pankey* & Todd H. Oakley

9:40 am Do scallops see in color? Understanding the visual capabilities of scallops
Anita J. Krause* & Jeanne M. Serb

10:00 am Biological determinants of extinction risk in the marine bivalve fossil record
Paul Harnik

10:20 – 10:40 Coffee Break

10:40 am Equatorward increase in naticid gastropod drilling on bivalves across four ecoregions in Brazil
Christy C. Visaggi* & Patricia H. Kelley

11:00 am Possible alternative strategies for nudibranchs navigating in variable flow
Russell Wyeth

11:20 am The rhinophores are sufficient and necessary during odor-gated rheotaxis in the nudibranch *Tritonia diomedea*
Gregory B. McCullagh*, Cory Bishop & Russell C. Wyeth

11:40 am Developing a model system for investigating how circadian clocks produce circadian behavior
James M. Newcomb

12:00: AMS/COA Group Photograph – please gather in Foyer
12:00 – 1:40 Lunch

Wednesday ● History of Malacology in the Americas ● Ballroom C (p.m.)

1:40 pm AMS-WSM-COA: a brief history of shell societies in the U. S.
Paula M. Mikkelsen* and Thomas E. Eichorst*

2:00 pm Ideas on biological evolution in the writings of early American malacologists
Aydin Örstan

2:20 pm Audubon's shells
Harry G. Lee

2:40 pm Edward Sylvester Morse: quintessential malacologist – and more
Scott Martin

3:00 pm H. J. Krebs and the earliest survey of West Indian mollusks
Alan J. Kohn

3:20 – 3:40 Coffee Break

3:40 pm A brief history of Malacology at the Academy of Natural Sciences of Philadelphia
Gary Rosenberg

4:00 pm The Academy of Natural Sciences of Philadelphia: driver of 19th century Neogene molluscan paleontology and foundation for subsequent centuries
Lyle D. Campbell* and Sarah C. Campbell

4:20 pm History of Malacology at the Museum of Comparative Zoology, Harvard University
Adam J. Baldinger

4:40 pm Molluscan paleontologists at the National Museum of Natural History in the late 20th century
John Pojeta, Jr.

5:00 pm The age of the molluscan monograph series in America - legacies of R. Tucker Abbott.
Leslie A. Crnkovic

5:20 – 6:00 AMS Business Meeting, Plaza Rooms 1&2

6:30 – 9:00 AMS/COA Banquet, Riverside Pavilion

Wednesday ● COA Grant Winners (continued) ● Plaza Rooms 1&2

1:40 pm How can extant species of molluscs help us understand the evolution of life on Earth?
Manuel António E. Malaquias

2:00 pm Diversity and diversification in a group of tropical gastropods (genus *Nerita*)
Melissa A. Frey*, Geerat J. Vermeij & Thomas Eichorst

2:20 pm Habitat preferences and intertidal zonation of *Cittarium pica*: what rocks their world
Erin L. Meyer

2:40 pm Systematics and egg laying evolution of Pleuroceridae (Gastropoda: Cerithioidea)
Nathan Whelan

3:00 pm Description of gonad development in a pleurocerid snail (*Leptoxis carinata*)
Serena Ciparis*, William F. Henley & J. Reese Voshell

3:20 – 3:40 Coffee Break

3:40 pm Conchologists of America: fostering the future of Malacology and supporting student research through grants to Malacology
Kenneth A. Hayes

4:00 pm Investigations into the systematics and conservation genetics of freshwater mussels
Kevin J. Roe

4:20 pm Galápagos bulimulids: diversification amongst a vanishing tribe
Christine E. Parent

4:40 pm Geographic mosaics in biotic interactions drive evolution: patterns of variation of venom genes tightly associated with prey diversity
Dan Chang, Amy M. Olenzek & Thomas F. Duda Jr.*

5:20 – 6:00 AMS Business Meeting, Plaza Rooms 1&2

6:30 – 9:00 AMS/COA Banquet, Riverside Pavilion

Thursday ● COA Grant Winners (continued) ● Ballroom C

9:00 am Structure and function of the fused tentacles in ommastrephid squids: dissertation research funded by the Conchologists of America
Elizabeth K. Shea

9:20 am The Pterioidea: diversity and disparity
Ilya Tëmkin

9:40 am Damn those dams - their negative effects on stream ecosystems
Jeremy S. Tiemann

10:00 am The role of predation risk in mating system expression: avoiding inbreeding when death is on the line
Josh R. Auld

10:20 – 10:40 Coffee Break

10:40 am The influence of litter species, chemistry and diversity on snail communities
Aaron B Stoler* & Rick Relyea

11:00 am Hawaiian land snail biodiversity: conservation status of a vanishing fauna
Norine W. Yeung* & Kenneth A. Hayes

11:20 am Land snail compositional changes and the functioning of ecosystems
Wallace M. Meyer III* and Robert H. Cowie

Characterizing arm autotomy: an octopus mode of defense

Jean S. Alupay & Roy L. Caldwell

Department of Integrative Biology, University of California, Berkeley CA, USA

Animals have evolved a diverse set of defense mechanisms, including cryptic and startling displays, flight response, and inking. Arguably one of the most extreme tactics is autotomy, the voluntary shedding of a limb or body part. This behavior provides immediate benefits that allow the organism to escape from predators, while simultaneously incurring long-term costs including inefficient locomotion and foraging. A taxonomically diverse set of organisms exhibit this ability despite its being studied almost exclusively in jointed animals such as reptiles, echinoderms, and crustaceans. Many of these studies provide evidence for increased survival in autotomizing individuals, yet little is known about how this defense mechanism compares in soft bodied animals.

A few species of octopus have anecdotally been reported to exhibit arm autotomy. We studied one species, *Abdopus aculeatus*, to determine the mechanism by which arms were lost and quantify the costs of autotomy to locomotion. Histological sections were performed on the arms to locate the presence of cleavage planes where autotomy is predicted to occur. Autotomy often occurred at the base, though arm loss has been observed elsewhere along the length of the arm. The cloven ends displayed a clean break with minimal blood loss, indicative of voluntary dropping. Thrashing and sucker attachment of the newly autotomized limb persisted for nearly an hour upon stimulation, likely functioning as predator distraction. Signs of arm regeneration were evident as early as three weeks after the arm was lost.

Surveys in the Philippines indicate high frequency of autotomy in the field. Preliminary locomotion studies to quantify gait were performed to use as a comparison for autotomized individuals. With these data, more quantitative analyses of the costs and benefits of autotomy may be determined along with the evolution of this extreme tactic among cephalopods.

Arquez, M., Castro, L. &
Colgan, D.

Poster

Mitogenomes of *Nerita versicolor* and *Nerita tessellata* and phylogenetic analysis with gastropods

Moises Arques, Lyda Castro* & Donald Colgan

Universidad del Magdalena, Santa Marta, Colombia

In 2010 the complete mt genome of *Nerita melanotragus* was published and a phylogenetic analysis was performed including all the available gastropod mt genomes that were available to that date. Although a very close relationship was found between Caenogastropoda, Vetigastropoda and Neritimorpha, the sister group of Neritimorpha varied in the phylogenetic analyses. In this study we sequenced the mt genomes of two other nerites, *Nerita versicolor* and *Nerita tessellata*, and performed a preliminary phylogenetic analysis including an updated gastropod mt genome dataset that also included four Vetigastropoda mt genomes that were not available for the previous analysis.

DNA was extracted using the DNAeasy tissue extraction kit (QIAGEN). Two PCR fragments comprising nearly the entire mt genomes were successfully amplified using the primers designed by Castro and Colgan (2010). The amplified products were sequenced using a Genome Sequencer 454 FLX instrument (Roche) at the "Center of genome sequencing" at the Universidad de Antioquia in Medellin, Colombia. Verification of genes and joining of contigs were performed by PCR and Sanger sequencing of the resulting PCR products. Phylogenetic analyses of the DNA alignment were conducted using MrBayes and PAUP.

The *N. versicolor* and *N. tessellata* mitochondrial genome are similar in size and organization to the *N. melanotragus* mt genome. The intergenic regions were generally short, and all the genes share the same size, initiation and stop codons, with the exception of nd2 of *N. tessellata*. Phylogenetic analysis using parsimony and Bayesian analyses suggested a very strong relationship of Neritimorpha with Caenogastropoda.

The role of predation risk in mating system expression: avoiding inbreeding when death is on the line

Josh R. Auld

Department of Biology, West Chester University

Many organisms have the ability to alter various aspects of their phenotype dependent on environmental conditions. Such phenotypic plasticity is considered adaptive if it increases fitness in a particular environment. One widely studied example of adaptive phenotypic plasticity is the array of predator-induced defenses expressed by freshwater organisms.

Freshwater snails have proved to be a very useful model to study the expression and evolution of such defenses; snails exhibit changes in behavior, morphology and life history in the presence of predators, many of these changes decrease predation risk and increase individual reproductive success. Pulmonate freshwater snails (Basommatophora) are all simultaneous hermaphrodites with the opportunity to produce cross-fertilized offspring (i.e., with one or more partners) as well as self-fertilized offspring. Almost exclusively, snails prefer to reproduce by one of these mechanisms (i.e., outcrossing or selfing); outcrossing snails delay reproduction in the absence of mates and only self-fertilize if no mates are available. Selfing snails exhibit no such delay.

I will report results from a series of experiments designed to evaluate the role of predation risk in mediating the delay in selfing and the consequences of selfing (e.g., inbreeding depression) in the preferential outcrossing species *Physa acuta*.

History of Malacology at the Museum of Comparative Zoology, Harvard University

Adam J. Baldinger

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In 1859, Louis Agassiz founded the Museum of Comparative Zoology (MCZ) at Harvard University. The enthusiastic oversight of past curators, namely John G. Anthony, William J. Clench, Ruth D. Turner and Kenneth J. Boss, enabled the Department of Malacology at the MCZ to develop one of the largest and most diverse collections in the world. The collection is rich in types, and currently includes over 370,000 cataloged lots and at least another 150,000 uncataloged lots.

Since its inception the collection has grown through collecting expeditions, exchanges and donations. In 2011 donations alone contributed over 15,000 lots. Overall strengths of the collections include western Atlantic species, North American Unionidae and Pleuroceridae, deep-sea mollusks, Teredinidae, Achatinellidae and other pulmonate groups. Since the late 1890s the collection has been stored in wooden drawers and cabinets. Renovations that facilitate collections storage and collections-based research have recently taken place in the Department and included the installation of new storage efficient collections cabinetry. The specimens in the collection are now arranged alphabetical by family, genus, and species. A brief history and summary of recent and current activities within the Department of Malacology will be discussed.

Beauty and the Beast – diversity, research history, and ongoing challenges in two families of marine gastropods, Architectonicidae and Vermetidae

Rüdiger Bieler

Field Museum of Natural History, Chicago, IL

The Architectonicidae (sundials) and Vermetidae (worm-snails) are two of the lesser studied families of marine snails. Some architectonicids, especially the larger-shelled species of *Architectonica* and *Heliacus*, are fairly popular with shell collectors and have found their way into most museum collections, but the vermetids, with their irregular, uncoiling shells that are attached to hard substrata, have remained broadly ignored (if not universally despised) by private collectors and publishing researchers alike.

The presentation explores the morphological diversity of these groups, their unique adaptations of feeding mechanisms and dispersal biology, as well as their relationships to other gastropod groups, and highlights ongoing morphological and molecular research that proves that these groups are worthy of much more attention. (Supported by NSF-DEB-0841760)

Exploration of a "well known" marine fauna: mollusks of the Florida Keys

Rüdiger Bieler* & Paula M. Mikkelsen

Field Museum of Natural History, Chicago, IL (RB)
Paleontological Research Institution, Ithaca, NY

The Florida Keys, a large area consisting of a hundreds of small coral, sand, and mangrove islands and surrounding marine environs at the southern tip of Florida, have been the subject of numerous individual malacological studies and a series of shell books, but few in-depth surveys of the entire fauna. Situated at the intersection of Florida Bay, the Gulf of Mexico, and the Atlantic Straits of Florida, the area hosts a unique mix of species, ranging from temperate Carolinian to the subtropical/tropical West Indian faunal elements. Its molluscan fauna is extremely rich, both in terms of number of species and diversity of families represented.

Heavily exploited by the tourism industry (e.g., fishing and recreational diving in the "Conch Republic") and under various environmental challenges, the region is home to more than a dozen local, State, and Federal protected areas, of which the Florida Keys National Marine Sanctuary, established in the mid-1990s, is the largest and most encompassing. This presentation outlines the long research history of the Keys and the approaches taken in an ongoing malacological survey of the Keys waters (a study area of about 28,000sq. km, about the size of the country of Belgium or the combined areas of Massachusetts, Delaware, and Rhode Island).

Preliminary findings, which to date have tripled the number of recorded molluscan species in the area (to approximately 1,700), and the various challenges faced by such a long-term, large-scale survey are outlined.

Freshwater molluscan biodiversity: distribution, extinction and the future

Arthur E. Bogan

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Freshwater mollusks occur on six of the seven continents, but are not evenly distributed. Representatives of 19 families of bivalves and 33families of gastropods are reported from freshwater environments. Total recognized species level taxa include about 1,026 bivalves and approximately 4,000 gastropods. Two major hotspots of aquatic mollusks are the Mobile River basin in the southeastern United States and the Mekong River basin in Southeast Asia.

Considering the 365 species of native freshwater bivalves in North America, 78 percent are listed at some level of endangerment and about 30 species have been lost to extinction. The freshwater gastropod fauna of the United States and Canada is comprised of 698 species with about 74 per cent at some level of endangerment and 67 species presumed extinct (9% of the fauna).

Due to a lack of modern survey efforts, it is difficult to estimate the diversity in some regions. Bivalves in the order Unionida typically have rather large shells and have been over-described in the 19th and early 20th century, but we continue to find and describe new taxa. Freshwater gastropods are being described today in increasing numbers, especially in the families of the Rissooidea.

Land mollusks in northern South America: biogeographic and ecological studies in megadiverse hotspots

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The terrestrial malacofauna of northern South America is very poorly known. As a team of Colombian, European, and USA scientists (6 institutions total) we are studying the land snails of Colombia to enhance knowledge of systematics, distribution, and phylogeography of terrestrial mollusks and to address broader questions regarding the origin and maintenance of Neotropical biotic diversity. We will assess relations of the northern South America fauna with those of North and Central America, the Caribbean, and the rest of South America. We focus on Colombia because (1) it is at the crossroads of multiple biogeographic provinces and of the inter-American faunal exchange that was facilitated by joining previously separated faunas at Panama, and (2) it includes two megadiverse hotspots (Biogeographic Choco and Northern Andes). Land snails are uniquely well suited for these analyses as they are ancient, diverse, abundant, and, due to their limited dispersal ability, they address our questions better than more mobile taxa.

We outline the rationale, main methodology, and preliminary results of this first modern, comprehensive survey program of any non-arthropod invertebrate animal group in Colombia and northern South America. A species accumulation curve for Colombia continues climbing steeply, indicating that many species remain to be described; a sharp climb since year 2000 (including work by us and others), shows that relatively little effort can markedly increase the known biodiversity.

Suitably collected material will allow us to (1) compare diversity and endemism in various ecosystems, (2) study influences of dispersal limitation and habitat specificity in snail distributions, (3) assess whether snails are as diverse as other invertebrates in leaf litter and canopies, (4) study how the American interchange of land snails differs from that of other groups, and (5) examine the contributions of in situ speciation and accumulation of fauna from other regions to Colombia's land snail diversity.

The tropical Indo-Pacific: the ultimate frontier, a world of small and rare species

Philippe Bouchet

Muséum National d'Histoire Naturelle, Paris, France

The work of entomologists on the diversity of beetle species living in the canopy of rainforest trees has fueled a rich debate on the magnitude of global species diversity. The mollusks of the Indo-West Pacific are the beetles of the sea: they are the most species-rich taxon in the most complex marine province of the world.

A general property of biodiversity is that most species are (naturally) rare. Many mollusk species are in fact so rare, seasonal or elusive that they are rarely or never sampled alive: after 30 years of intensive exploration in New Caledonia, as many as 73% of all 1,409 turrid species documented are represented only by empty shells, and 34% by a single empty shell. Taxonomical expertise on different molluscan families is directly proportional to the metric size and inversely proportional to the taxon size of those families.

A few families of "seashells" (miters, cowries, cones, volutes, etc.) concentrate an inordinate amount of interest, but contribute little to global numbers. By contrast, a few hyperdiverse families of micromolluscs (Triphoridae, Eulimidae, Cerithiopsidae, Pyramidellidae, Galeommatoidea) are so intimidating that few, if any, experts specialize on them: They are the largest unrecognized reservoir of unknown marine mollusks in the world. The tropical Indo-Pacific is also spatially more complex, with more subtle hydrological layering than in other oceans: the implication is that there are more numerous narrow-range "bathymetrical endemics" in the Indo-Pacific than in other provinces.

Whereas we have probably already described 60 to 90% of the molluscan diversity of most biogeographical provinces of the world, the combination of size, rarity and restricted endemism suggest that we may have documented as little as 30% of the molluscan diversity of the Indo-Pacific.

Alternatives to expensive machinery: do what you can with what you have

Paul Callomon

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Producing high-quality digital data and images is often thought to require expensive, up-to-date devices and equipment. Although outdated software can be a hindrance to such work, there are many tasks that can be performed to present-day standards using hardware that is decades – and sometimes centuries – old.

Some practical examples of high-volume data gathering and digital imaging using existing or cheaply obtainable equipment are shown.

The Academy of Natural Sciences of Philadelphia: driver of 19th century Neogene molluscan paleontology and foundation for subsequent centuries

Lyle D. Campbell* & Sarah C. Campbell

University of South Carolina Upstate

The Academy, the Charleston Museum, and the Wagner Free Institute provided the intellectual axis for nineteenth century molluscan paleontology in North America. From 1820 to 1898 some twenty American authors described or listed Atlantic Coastal Plain Neogene molluscs. Thomas Say, Samuel Morton, Timothy Conrad, John Redfield, William Gabb, and Angelo Heilprin were directly associated with the Academy. Say was the first American-born scientist to describe new species of Recent and fossil molluscs, as earlier workers were European. Morton was a major influence at the Academy. Conrad was prolific, publishing Paleozoic to Recent papers from 1830 to 1877. Redfield, a botanist, also studied Marginellidae. Gabb worked in California and the Caribbean. Heilprin succeeded Conrad, publishing in the 1880's. Of the twenty, Say, Morton, Conrad, William Wagner, Edmund Ravenel, Henry Lea, Michael Tuomey, Redfield, Gabb, Heilprin, and Lewis Wollman published in the Journal or the Proceedings of the Academy. European authors contributing to Western Atlantic nineteenth century systematics included Jean Baptiste Lamarck (1818), Francis de Castelnau (1843), Charles Lyell (1845), Alcide d'Orbigny (1850-1852), and Otto Meyer (1888), the latter publishing in Proceedings of the Academy. Lyell's and Lamarck's works are commonly cited, Meyer's Neogene work is little recognized, and de Castelnau remains obscure. D'Orbigny's Prodrome rectified international literature and contained replacement names for homonyms by Conrad and others. A comprehensive review of the Prodrome and its impact on Western Atlantic Cenozoic molluscan taxonomy has yet to be published.

These authors built the foundation for subsequent Atlantic Coastal Plain Neogene studies, but the process was often acrimonious, with turf wars, pre-emptive publishing, hasty and inadequate scholarship, hostile social settings, professional feuds, schisms, occasional invective, and the necessity of dealing with state legislatures who commissioned work, and then refused funding to publish. Change comes slowly.

Campbell, L. D., Campbell, S. C. & Campbell, M. R.

Monday, 1:40 pm
Plaza Rooms 1&2

Late Pleistocene molluscan provinciality in the Western Atlantic: a test case for genus richness

Lyle D. Campbell*, Sarah C. Campbell & Matthew R. Campbell

**University of South Carolina Upstate; Charleston Southern University*

Recent continental shelf molluscs from New England to Florida define cold-temperate (Boreal), temperate (Virginian), warm-temperate (transitional, Kitty Hawk to Cape Hatteras) and subtropical (Carolinian, south of Cape Hatteras) provinces. The Virginian fauna was further divided into three sub-assemblages at New Jersey and Maryland. Projecting these thermal regimes through time by species richness was limited by extinction typically exceeding 80% in Pliocene mollusks. With 95% of Pliocene genera extant, genus-level comparisons were more inclusive. We developed a quantified approach of genera richness for analyzing provinciality and interpreting Atlantic Coastal Plain molluscan assemblages. Testing our model using Late Pleistocene faunas enabled species-level [less than 2% extinction] and genus-level comparisons. These analyses with Pleistocene assemblages supported our genus-richness model, only differing slightly where calculated values indicated almost equal affinity for temperate or warm-temperate interpretations.

We compared Late Pleistocene molluscan species assemblages from eastern Virginia and North Carolina with Recent faunal provinces. Differences between fossil and Recent population patterns were calculated using equivalent points in nine-dimensional hyperspace. The resulting provinciality of VA Pleistocene formations, oldest to youngest is: Great Bridge, temperate to warm-temperate; Lower Norfolk, warm-temperate; Upper Norfolk, temperate to warm-temperate; Lower Kempsville, temperate to warm-temperate; Upper Kempsville, temperate; Londonbridge, temperate; Lower Sandbridge, temperate; and Upper Sandbridge, temperate to warm-temperate. None of these documented assemblages approached sub-tropical patterns. North Carolina Pleistocene Flanner Beach Formation assemblages strongly conformed to the Recent shelf warm-temperate biota. However, when the Recent reference assemblages were restricted to coastal species, the Flanner Beach fauna showed greater affinity for the subtropical biotas south of Hatteras.

Most of these Virginia strata were deposited during the Sangamon, when sea levels were as much as 10 to 15 meters higher than present. These Pleistocene faunas indicate that interglacial sea level maxima may occur without major shifts in marine provinciality.

Chang, D., Olenzek, A. M. & Duda, T. F.

Wednesday, 4:40 pm
COA Winners, Plaza Rooms 1&2

Geographic mosaics in biotic interactions drive evolution: patterns of variation of venom genes tightly associated with prey diversity

Dan Chang[1,2], Amy M. Olenzek[1] & Thomas F. Duda, Jr. [1,3]*

[1]*Department of Ecology and Evolutionary Biology and Museum of Zoology, University of Michigan*
[2]*Department of Statistics, University of Michigan*
[3]*Smithsonian Tropical Research Institute, Balboa, Republic of Panama*

Predatory snails of the gastropod genus *Conus* use venoms containing the gene products of multiple 'conotoxin' gene superfamilies to subdue prey and hence represent an ideal system to study predator-prey interactions at the molecular interface. We investigated geographic patterns of variation of five conotoxin loci and diets of the vermivorous cone *Conus ebraeus* to examine the evolutionary phenomena associated with intraspecific diversification of venoms and diets. Three of the examined genes exhibited high levels of allelic variation and a consistent pattern of structure among local populations at Guam, American Samoa and Hawaii. The other two loci showed lower levels of diversity and no differences in allelic frequencies among locations. The majority of substitutions among alleles are responsible for amino acid changes in expressed toxins that presumably result in unique functions of these peptides. Neutrality tests of four of the loci also showed that the loci are subject to different modes and intensities of selection. Investigation of dietary compositions at each location with a DNA barcoding approach revealed highly divergent prey utilization patterns among locations.

Local conotoxin gene diversity and prey diversity as well as patterns of geographical variation of conotoxin genes and dietary specialization are highly correlated. These results imply that selection pressures on venoms are imposed by predator-prey interactions. We posit that the tight association of conotoxin gene evolution and dietary differentiation is affected by heterogeneous prey distributions and/or differences in prey availability among locations. This work shows that geographic mosaics in biotic interactions drive local adaptations that may ultimately result in the adaptive divergence of populations.

Description of gonad development in a pleurocerid snail (*Leptoxis carinata)*

Serena Ciparis*, William F. Henley & J. Reese Voshell

Freshwater Mollusk Conservation Center, Department of Fish and Wildlife Conservation, Virginia Tech and the Department of Entomology, Virginia Tech

Little is known about the timing of sexual development in pleurocerid snails or the effect of environmental conditions on this process. The objectives of this study were to describe gamete development in *Leptoxis carinata* with respect to snail size and season, and to compare this process between two streams with different environmental conditions. Morphological and histological examinations of two generations of *L. carinata* were conducted for 16 months at two sites in the Shenandoah River watershed (Virginia, USA); one site represented reference conditions and the other was impacted by agricultural activities. Water temperatures were similar between sites during the sampling period. Population sex ratios were consistently female-biased at the impacted site (mean 81% females), compared to balanced sex ratios at the reference site (mean 49% females). Morphologically, sexes did not become fully distinct at the reference site until approximately 15 months after hatching, and there was an additional seven-month delay in morphological development at the impacted site.

Histological observations demonstrated that gamete production began earlier than indicated by external morphology. The majority of snails from both sites were producing gametes eight months after hatching and the timing of gametogenesis was related to snail size. Histological comparisons of mature snails showed differences in gamete production between study sites. At the impacted site, both male and female snails had significantly fewer acini and there were apparent differences in oocyte developmental stages and the condition of male acini, compared to the reference site.

The differences in sex ratios and gamete production between the two study sites suggest that environmental factors other than water temperature may affect pleurocerid snail sexual development. The applicability of reproductive and other histological endpoints to monitoring the health of freshwater mollusk populations will also be discussed.

An introduction and brief history of 20th-century molluscan conservation issues in North America

Jay Cordeiro

Biology Dept., University of Massachusetts Boston

In North America, mollusks have been utilized by humankind as a natural resource since pre-colonial times. As human populations expanded to industrialized areas, associated impacts contributed to declines across marine, terrestrial, and freshwater mollusk populations. The first indication of awareness came during the latter half of the 19th Century. Initially, threats were directly correlated with utilization and exploitation as a natural resource. Later, declining water quality and increased pollution were noted in major waterways that flowed through industrialized areas. By the early 20th century, mollusk harvest/fisheries stocks were becoming impaired. Regulations were few and far between and compliance was lacking for what was deemed an inexhaustible resource.

Early "conservation" efforts were driven by fishing and harvesting mollusks as a natural resource and regulations directed at maintaining stocks and eliminating wasteful practices. Additional indirect threats such as non-point source pollution, habitat degradation, ecosystem modification, invasive species and climate change, further contributed to mollusk imperilment. Today, mollusk conservation issues, long-neglected in endangered species management, have been awakened by unprecedented declines in diversity, range, density, and occupied habitat. Freshwater mussels (esp. in the American southeast) are considered the most imperiled group of organisms in North America, and freshwater snails appear to be approaching similar levels. The tremendous diversity of endemic Hawaiian archipelago tree snails is suffering largely due to interaction with introduced predators and competitors. Declines in terrestrial snails (esp. in the southwestern U.S) have become evident in recent years. Crashes in marine (and freshwater) fisheries stocks are catching up with poor and belated fisheries management practices.

Mollusk conservation, long neglected in endangered species management, began with casual observations by both amateur and "professional" conchologists as well as fisheries biologists with little regard to future conservation practices, but continues with a series of rules and regulations enacted from a conservation standpoint to reverse or at least delay these declines.

The age of the molluscan monograph series in America - legacies of R. Tucker Abbott.

Leslie A. Crnkovic

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Until the 20th Century, monographs on Mollusca were a rarity; Molluscan publications, primarily from Europe (1500-1900), had been grand master-works, or the serial publications of Museums and Societies, which were non-Mollusca-specific and seldom monographic.

Beginning with *Johnsonia*, Dr. R. Tucker Abbott was the driving force for the age of the "American Molluscan Monograph" (from 1941-1991). A broadened list of those Monographs is: *Johnsonia, Indo-Pacific Mollusca, Monographs of Marine Mollusca, Standard Catalog of Shells,* and *Hawaiian Marine Mollusks.*

Why are these publications so important? It is because they are a wholesale departure from the classic old works, moving from works focused primarily on new species, collections or surveys, to Family-or-Genus specific monographs; moving from primarily shell morphology to include anatomy and radula; and from engravings and watercolors to photographs and inclusion of maps. It also marks a distinct 50-year era in the publishing history of American Malacology, which was dominated by the fondly renowned Dr. R. Tucker Abbott. As a part of this unique era, Abbott evolved his own publishing style and techniques, using binder systems, and devising a systematic numbering schema.

Today, a composite of the contents (Family/Genus/Species) of these publications has yet to be published. Privately published is an 8-page paper covering the somewhat complicated issues of *Indo-Pacific Mollusca* and *Monographs of Marine Mollusca*, but not of the contents.

A publication is in the works by this author, to document the history and create a master index. To date, the paper is 28 pages of historical and investigative narrative. This presentation is a call for assistance from those who are "in-the-know" about the history of these publications, to submit comments and peer review, and to those who are willing to help create a master index of the Family/Genus/Species content for these publications.

Changes in the freshwater mussel (Unionoidea) fauna of Illinois over the past 100 years as an exemplar for North America.

Kevin S. Cummings, Sarah A. Bales, Alison L. Price & Diane K. Shasteen

Illinois Natural History Survey, Prairie Research Institute, University of Illinois 607 E. Peabody Dr., Champaign, Illinois 61820

Eighty species of freshwater mussels once occurred in Illinois and boundary waters. Of those species, 16 are now state endangered (five of which are also federally listed and four are in review), eight are state threatened, 13 are considered extirpated, and five are globally extinct. That leaves only 42 species, or slightly more than half of the historical fauna present in the state, that are not in immediate peril.

Which species are able to persist through habitat loss? Which species or groups of species are disappearing? The Illinois Natural History Survey maintains a substantial freshwater mollusk dataset that may help elucidate the timeline of species' loss (or gain) and explain species' persistence. In this presentation, we will showcase data from extensive surveys of mussels across six decades. We will highlight a few Illinois watersheds that provide interesting perspectives regarding distribution patterns and prevalence of at-risk species and compare that to what is happening to the fauna across North America.

University of Kansas Fitch Natural History Reservation mollusks: then and now.

Elizabeth C. Davis-Berg

Columbia College, Chicago

The University of Kansas Fitch Natural History Reservation was founded in 1947 and is located in Douglas County, Kansas northeast of Lawrence. Prior to becoming a Natural History Reservation, much of the non-forested land had been cultivated or grazed. Since 1948, the land has been allowed to undergo natural succession. The reservation today is mostly wooded in comparison to the many fields and grasslands when the reservation was established. In the late 1940s and 1950s there were extensive surveys of the molluscan fauna by A. Byron Leonard, C. Raymond Goble, Henry S. Fitch, Donald H. Lokke and others. These surveys have provided a species list by location along with information on the local ecology at the time.

To see how succession and time have changed the fauna at the university of Kansas Fitch Natural History Reservation, I conducted a series of samplings from 2004 to 2007. Three sites (two terrestrial and one aquatic) were sampled. All sites were identified with GPS coordinates and were of different habitats to better sample the diversity of mollusks found in the areas. These results allow us to see how the molluscan fauna has changed and stayed the same on this reservation over the last 50 - 60 years. In addition we will be able to determine if any common species have not been found in this survey and if further surveys should include more of the areas in the original surveys by Leonard and Goble.

Dillon, R. T. Jr., Jacquemin, S. &
Pyron, M.

Monday, 11:40 am
Plaza Rooms 1&2

Pleurocera acuta (Raf. 1824) and *P. pyrenellum* (Conrad 1834) are small-stream ecophenotypic morphs of *P. canaliculata* (Say 1821)

Robert T. Dillon, Jr[1]*, Stephen Jacquemin[2] & Mark Pyron[2]

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The taxonomy of the freshwater gastropod family Pleuroceridae has historically been based entirely upon qualitative aspects of the shell. Yet evidence has mounted for years that certain key aspects of shell morphology, sometimes called "robustness," may be correlated with stream size independently of the evolutionary relationships of the populations bearing them. Here we use allozyme electrophoresis to estimate gene frequencies at 9 polymorphic loci, calculating overall genetic similarities among four populations of *Pleurocera canaliculata*, four populations of nominal *P. acuta* and one population of nominal *P. pyrenellum* sampled from upstate New York to northern Alabama. These nine populations all clustered together (relative to a *P. semicarinata* standard), with populations of (elongated, fusiform) *acuta* or *pyrenellum* from the smaller tributaries each more genetically similar to (broader, more robust) *P. canaliculata* populations from large rivers immediately downstream than to any nominal conspecific. Thus the pleurocerid nomina *acuta* (Rafinesque 1824) and *pyrenellum* (Conrad 1834) would appear to be junior synonyms of *canaliculata* (Say 1821).

We used geometric morphometrics to explore the gradient in shell morphology from the *acuta* form to the typical *canaliculata* form in 18 historic samples taken down the length of Indiana's Wabash River. The shell forms appeared generally distinctive on the two relative warp axes extracted (decreasing robustness and increasing spire elongation), although some overlap was apparent. Significant negative correlations were discovered between variance on both these axes and stream size. We suggest that the fundamentally binary nature of river drainage systems, which overlies their tendency to gradual augmentation, may profoundly affect the shell morphology of the freshwater gastropod populations inhabiting them, thus indirectly confusing pleurocerid taxonomy for 200 years.

Symbiosis in *Kuphus polythalamia* (Bivalvia: Teredinidae).

Daniel L. Distel[1*], Julie Albano[4], Marvin Altamia[3], Rowena Antemano[3], Gisela Concepcion[3], Rande Dechavez[4], Imelda Forteza[3], Andrew Han[2], Margo Haygood[2], Gwen Limbaco[3] & Roberta O'Connor[1]

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[4]*Sultan Kudarat State University, Tacurong City, Sultan Kudarat, Philippines*

Among species that comprise the bivalve family Teredinidae (shipworms), *Kuphus polythalamia* is the one most poorly understood. It is the only named teredinid species that burrows in marine sediments rather than in wood or other terrestrial plant materials. It is also the largest teredinid species, growing to nearly 2m in length and 5cm in diameter.

Here we show that *K. polythalamia*, like other shipworm species, harbors bacterial endosymbionts within specialized cells in its gills. However, the detected symbionts of *K. polythalamia* are more closely related to sulfur-oxidizing chemoautotrophic symbionts of annelids and ciliates than to known symbionts of Teredinidae. Furthermore, we detected bacterial genes associated with carbon fixation (RuBisCO) and sulfur oxidation (APS reductase) in whole gill lysates and in cultured symbionts of *K. polythalamia.*

These results suggest that this species, unlike previously described teredinid species, may obtain nutrition by utilizing a sulfur-based chemoautotrophic endosymbiosis.

Insights on the ecology and management of slugs in Pennsylvania no-till crop fields

Margaret R. Douglas* & John F. Tooker

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No-till farmers in Pennsylvania have identified slugs as one of their most challenging pest problems. However, basic ecological information that could guide integrated management of slugs remains limited. We conducted laboratory and field experiments over two years to better understand slug natural history in Pennsylvania and the influence of crop management strategies on slugs and their predators. Our field site had a slug fauna comprising three species, dominated by the exotic gray garden slug *Deroceras reticulatum*, which was abundant during vulnerable crop stages in spring and fall. Of potential natural enemies, the introduced ground beetle *Pterostichus melanarius* dominated at this location.

Weed and nutrient management practices influenced slugs and their predators in complex ways. In laboratory bioassays, common insecticidal seed treatments were passed from seedlings to slugs to ground beetle predators, with potentially important consequences for biological control. We synthesize these results into a tritrophic model of slug interactions to help guide future research and management efforts for slugs in the Northeastern U.S.

Our sea of "*sp.*"s—the non-professional to the rescue

Philip J. Fallon, Jr.

There is a real need to update existing descriptions and to describe the many undescribed western Atlantic species. The tools, methods and personal experience of a non-professional will be discussed, with examples drawn from current research on the western Atlantic Drilliidae.

Demand for taxonomic work has grown because of the accumulating body of unknowns brought on by greater access to previously unexplored areas, and because of the shortage of formal training by universities in classic descriptive biology. The number of misidentifications has grown with the proliferation of guide books.

Tools that are a must for taxonomic research have become readily available to the non-professional in the last decade—much of the large body of classic literature is on the internet, and digital cameras have appeared with macro lenses that can take high-quality photos for publication that are also useful for the rapid accumulation of large personal reference catalogs of individual specimens. Museum collections are open to the serious amateur. E-mail has become an invaluable way to rapidly exchange ideas, photos, and to transfer material. Since lots of time and effort may be necessary to track the taxonomic history and synonymy of a species, the hobbyist or non-professional usually has the advantage.

Undescribed and misidentified species can be found just about everywhere. Examples of misidentifications are given from identification guides, museum collections, and dealers' shell lists. Examples of how under-described species lead to misidentifications are given. These are presented in the context of preparing a work for publication

Phylogeny incongruent with morphology in *Stagnicola* (Gastropoda: Lymnaeidae): historical factors driving present diversification?

Samantha Flowers

University of Michigan

Pleistocene glaciations greatly impacted the freshwater biota of the Nearctic due to their extensive and frequent restructuring of aquatic ecosystems. Cyclic patterns of glacial expansion and contraction facilitated formation of barriers to gene flow as well as routes for dispersal and range expansion, thereby promoting both diversification of lineages in refugia and genetic exchange during secondary contact once geographic isolating barriers are removed. The diffuse Neartic distribution of a morphologically diverse molluscan subgenus, *Stagnicola* (Gastropoda: Lymnaeidae), provides an excellent system to examine the impacts of these phenomena on the diversification of North American freshwater species with phylogeographic methods.

While nuclear gene sequences (ITS-1) were largely homogeneous and showed no differentiation among nominal species, molecular phylogenetic analyses of mitochondrial gene sequences (COI) of ~100 individuals representing seven North American *Stagnicola* species reveal that although several genetically distinct clades occur within *Stagnicola*, clade members often exhibit a variety of shell morphologies that define multiple species. These results imply that (i) shell morphology of *Stagnicola* species is largely ecophenotypic, and as such shell-based characters are unreliable in distinguishing members of this subgenus, (ii) recurrent hybridization has occurred between recently diverged lineages, and/or (iii) there has been an incomplete sorting of haplotypes that were shared in glacial refugia, all of which hinder the ability to distinguish and reconcile relationships among *Stagnicola* species using single-gene approaches.

Other molecular studies of heterobranch gastropods reveal similar trends, suggesting that universal underlying mechanisms are responsible for morphological and geographical molecular incongruencies as those observed here. These patterns imply that historical ecological factors have driven the current genetic population structure and diversification patterns observed in such groups, however further work is required to resolve these hypotheses.

Frey, M. A., Vermeij, G. J. & Eichorst, T.

Wednesday, 2:00 pm
COA Winners, Plaza Rooms 1&2

Diversity and diversification in a group of tropical gastropods (genus *Nerita*)

Melissa A. Frey*, Geerat J. Vermeij & Thomas Eichorst

Royal British Columbia Museum
University of California Davis
Conchologists of America

To determine how historical processes, namely speciation, extinction, and dispersal, have contributed to regional species diversity patterns across the marine tropics, we examined the biogeographical history of a circumtropical genus of intertidal gastropods.

A species-level phylogeny of *Nerita*, representing approximately 87% of extant species, was developed using mitochondrial and nuclear markers. Phylogenetic relationships generally corresponded to prior classifications; however, comprehensive sampling revealed a number of previously undetected ESUs. Using the resulting tree as a framework, we combined geographical distributions and fossil evidence to reconstruct ancestral ranges, produce a time-calibrated chronogram, and estimate diversification rates. Analyses revealed two monophyletic eastern Pacific + Atlantic (EPA) clades, each of which likely split from an Indo-West Pacific (IWP) sister clade prior to an early Miocene Tethys Seaway closure.

More recent diversification throughout the IWP appears to have been driven by both vicariance and dispersal events; EPA diversity has been further shaped by speciation across the Central American Seaway prior to its closure and dispersal across the Atlantic. Despite the latter, inter-regional dispersal has been rare, and likely contributes little to regional diversity patterns. Similarly, infrequent transitions into temperate regions combined with reduced diversification rates may explain low diversity in West and South Pacific clades.

Since origination, *Nerita* diversification appears remarkably constant, with the exception of a lag in the late Eocene-early Oligocene and elevated rates in the late Oligocene-early Miocene. However, a comparison among regions suggested that IWP clades have experienced, on average, higher rates of speciation. Fossil evidence indicates that the EPA likely witnessed greater extinction relative to the IWP. We propose that regional differences in species diversity in *Nerita* have been largely shaped by differential rates of speciation and extinction.

Morphological and molecular analysis of the Andean land slugs *Colosius n. sp.*, a newly recognized pest of cultivated flowers and coffee from Colombia and Ecuador, and *Colosius pulcher* (Colosi, 1921) (Gastropoda: Veronicellidae).

Suzete R. Gomes[1*], David G. Robinson[1], Frederick J. Zimmerman[2], Oscar Obregon[3] & Norman B. Barr[3]

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In this study we identify a new species of *Colosius*, recognizing it as pest of coffee and cultivated flowers from Colombia and Ecuador. We compare it with *C. pulcher*, a species with which it has been confused. In order to analyze the genetic relationship of *Colosius n. sp.*, *C. pulcher*, *C. propinquus* (currently synonymized with *C. pulcher*) and *C. lugubris* (type species), fragments of COI, 16S rRNA, and 28S rRNA genes are analyzed.

Genetic variability within *Colosius n. sp*. and *C. pulcher* is also analyzed based on COI and 16S rRNA. In *Colosius n. sp.* the phallus has a deep longitudinal groove from the base, near the retractor muscle, to its distal region, close to the papilla. In C. pulcher there is an oval to rectangular swelling on the basal region of the phallus. Some important differences between both species are also found in the digitiform gland and bursa copulatrix.

Colosius n. sp. is a distinct lineage within the genus *Colosius*. It is not a sister species of *C. pulcher*, which has *C. propinquus* as a sister species, here confirmed as valid. *Colosius n. sp.* is closer to the clade that includes *C. pulcher* and *C. propinquus* than it is to *C. lugubris*. Based on the phylogenetic reconstruction, *C. lugubris* is sister to all the other *Colosius*. Genetic diversity within *Colosius n. sp*. and *C. pulcher* is low.

We describe, illustrate and discuss the color variation, morphological similarities, diagnostic characters and variability, habitat and distribution for *Colosius n. sp*. and *C. pulcher*. Associated imports and number of interceptions per year of *Colosius n. sp*. by federal agricultural inspectors are also presented.

The nudibranch revolution: are they evolving faster than we can find them?

Terrence Gosliner

California Academy of Sciences

In a rapidly changing world, there is great urgency for exploration and discovery of novel biodiversity. The last several decades of marine research have provided an exponential rate of discovery of opisthobranch mollusks from all parts of the world. Several fundamental causes have contributed to this rapid discovery. New technologies, including advances in areas of molecular systematics, scuba diving, digital photography and informatics, have provided essential tools for facilitating species discovery. Expanding ecotourism opportunities, mobilization of citizen scientists and more opportunities for training systematic biologists have also contributed to this rapid rate of discovery and the expansion of our geographical coverage of the world's oceans.

Comparative data from distinct regions of the world demonstrate the extent of the nudibranch revolution that is still underway. Our current state of knowledge is highly variable geographically. Discovery rates are highest in some of the richest areas that are under the greatest threat. These biodiversity hot spots represent areas of great opportunity for scientific exploration. In areas that are well known, species distribution patterns are changing as a result of climate change and other impacts of human activity.

It is impossible for the small cadre of trained scientists to mobilize sufficient personnel or resources to monitor these changes in a cost effective or geographically expansive manner. Mobilizing citizen scientists and professional scientists represents a possible solution to this problem. Examples of how this has led to success in documenting climate change are presented. Engaging advances in research and informatic tools and mobilization of new kinds of data collector are critical in both biodiversity discovery and conservation.

Slugs and other grower concerns in no-till production systems in the Midwest

Ronald B. Hammond

Department of Entomology, OARDC, The Ohio State University
Wooster, OH 44691

Although slug problems in field crops continue to cause grower concerns in Ohio and surrounding states, there has been a shift in how the problem is viewed, with the thought that they can be managed in the majority of cases. Growers have become more educated through a series of articles, presentations, and meetings, and also through a three year EQIP program conducted during the early 2000s. This program provided funds to growers to help scout and manage the slugs when necessary, and to cover potential losses if bait treatments were not applied. As part of that program, numerous growers and crop consultants were trained on slug biology, life cycles, damage potential, and management, and efficient record keeping.

Having gotten a handle on the slug issue, numerous other issues are now consuming much of their thought and meeting time, including the increasing use of cover crops and issues with phosphorus fertilization in no-till production systems.

Diversity, phylogeography and relationships of the *Cerion* (Gastropoda: Cerionidae) of the Dutch Leeward Islands

M. G. Harasewych

Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution

Long known for its exceptionally high diversity, the family Cerionidae ranges from the barrier islands of southern Florida to the Dutch Leeward Islands, usually inhabiting terrestrial vegetation with a few hundred meters of the shore. The nominotypical subgenus *Cerion* is restricted to the Dutch Leeward Islands, and separated from all living congeners by the Caribbean tectonic plate.

Nine taxa have been proposed for this fauna based exclusively on shell morphology. Several have been supported by subsequent, detailed morphometric analyses. Phylogenetic relationships of the subgenus and its constituent taxa are reviewed based on the first molecular studies of this fauna [partial 16S and CO I sequences]. Samples from the type localities of all named taxa are included in the analyses to infer patterns of interrelatedness among populations on Aruba, Curaçao and Bonaire, and to evaluate biogeographic hypotheses.

Biological determinants of extinction risk in the marine bivalve fossil record

Paul Harnik

National Evolutionary Synthesis Center

Rarity is a primary determinant of extinction risk in extant and extinct clades. There are many different ways to be rare, however, and few studies have assessed their relative influence. Paleontological data can be used to explicitly test many of these hypothesized relationships, and general patterns revealed through analysis of the fossil record can help refine predictive models of extinction risk developed for extant species.

Using the marine mollusk fossil record I introduce a method for unveiling rare diversity that minimizes sampling biases by combining museum, literature, and field data. I then present a series of multivariate analyses of the direct and indirect effects of different aspects of rarity on extinction risk, focusing on marine bivalve species from the early Cenozoic (65 - 28 Ma) of eastern North America.

I find that geographic range size has a strong direct effect on extinction risk, and that an apparent direct effect of abundance can be explained entirely by its covariation with geographic range. The influence of geographic range on extinction risk is manifest across three ecologically disparate clades (the Carditoidea, Pectinoidea, and Veneroidea). Body size also has strong direct effects on extinction risk, but operates in opposing directions in different clades, and thus seems to be decoupled from extinction risk in bivalves as a whole.

Although abundance does not directly predict extinction risk, I reveal weak indirect effects of both abundance and body size through their positive influence on geographic range size. Multivariate models that account for the pervasive covariation between biological factors and extinction are necessary for assessing causality in evolutionary processes and making informed predictions in applied conservation efforts.

Slugs in North America: options for biological control

James D. Harwood

Department of Entomology, University of Kentucky

Slugs have significant ecological and economic impacts worldwide, and in agricultural systems can reduce crop yield. Slugs also decrease the quality of produce by soiling with mucus and fecal matter. Furthermore, damage to plants tends to promote bacterial and fungal growth, which can result in further damage to fruit, vegetables and ornamentals.

This paper will discuss the status of slugs in North America and identify options for biological control in agricultural production systems.

Conchologists of America: fostering the future of Malacology and supporting student research through grants to Malacology

Kenneth A. Hayes

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With few exceptions, funding from major agencies like the National Science Foundation is restricted to researchers with terminal degrees. Few extramural funding opportunities exist for students pursuing advanced degrees, and even fewer sources are available for those studying basic biological questions in invertebrate groups such as mollusks. Awards from the Conchologists of America during my MS thesis (2001) and my PhD dissertation (2004, 2005) research provided me with supplemental funding needed to pursue my research interests, and more significantly, the sort of confidence-boosting affirmation that is needed to encourage a young scientist in the competitive field of academic research.

The data from these projects and the research experience gained completing them were critical to establishing the foundation of my early research and for building a solid research program in Malacology aimed at understanding the determinants of biodiversity. The results from my MS research indicated that all populations of the Florida Crown Conch were derived from a single phylogenetic lineage of one species, *Melongena corona*. This finding was in stark contrast to the taxonomy for the genus *Melongena* at the time. Additional population level analyses using microsatellites revealed substantial population structure dynamics that are influenced by frequent, short distance dispersals of eggs and juveniles among connected habitats. Building on my experience during my thesis research, I began a dissertation focusing on resolving the identity, evolutionary history and phylogenetic relationships of another group of snails, Ampullariidae. This work clarified the identity of several species of apple snails that have become major invasive pests throughout the world, and provided the most comprehensive phylogeny of the family. Using this phylogeny and the experiences of writing grant proposals, like those for the COA, gave me the necessary data and skills to help co-author an NSF grant in ampullariid revisionary systematics.

Western American perspectives on molluscan conservation

Robert Hershler

National Museum of Natural History, Smithsonian Institution

This paper reviews the history of molluscan conservation in the American West over the past 50 years. Several key developments are discussed, including the early stirrings of a conservation agenda that came about as a result of field surveys suggesting that the regional fauna is much larger than previously thought, the first additions of western mollusks to the Federal List of Threatened and Endangered Species, and the inclusion of a large number of mollusks in conservation initiatives mandated by the Northwest Forest Plan. The important contributions that various malacologists (e. g. Terry Frest, Jerry Landye, Dwight Taylor), other biologists (e. g. Peter Bowler, Wendell Minckley, Don Sada), governmental agencies and NGOs have made to molluscan conservation in the West are also briefly discussed.

Grades are as important as clades for understanding hyperdiversity of skeneiform microgastropods

Carole S. Hickman

Department of Integrative Biology, University of California, Berkeley, CA 94720

There are more than 100 available genus-level names that have been classified under Skeneidae. Although many phylogeneticists refer disparagingly to Skeneidae as a "mess," a "lumping pot" or a "dumping ground" for minute globular shells, there is increasing evidence of distinctive hidden clades. In spite of growing reliance on sequence data, shell morphology and anatomy have been more decisive in removing taxa from the lumping pot and reclassifying them. Some genera have been removed from Trochoidea to other vetigastropod groups, while others have been reallocated more distantly to families within Heterobranchia and Caenogastropoda.

Four major problems plague anatomical and molecular assessment: (1) type species of most skeneiform genera have never been collected alive, (2) type species of many genera were never illustrated or were illustrated by inadequate line drawings or poorly-focused photographs, (3) monophyly of many genera is suspect, so that sequencing or anatomical reconstruction of non-type species is not helpful, and (4) many skeneiform genera are represented primarily by fossil species. Scanning Electron microscopy is increasingly helpful in defining novel protoconch and teleoconch characters. Many shells once thought to be "featureless" are rich in detail. In some genera, fossil shells are in more pristine condition than shells of living congeners. This is especially true for extant species known only from shell grit pickings.

As an evolutionary grade, the small size of microgastropods is linked with ecological specializations including adaptations for life in interstitial habitats, life on biogenic substrates in the deep sea, and life on the discontinuous surfaces of marine plants. Small size is also correlated with recurring life history features, including simultaneous hermaphroditism and bizarre reproductive behaviors and features. The hyperdiversity of micromollusks remains poorly documented. The problem of why most of molluscan diversity is small is clearly a question about grade, not clade.

Malacological contributions of Howard A. Bern (1920–2012)

Carole S. Hickman

Department of Integrative Biology, University of California, Berkeley, CA 94720

World renowned as a comparative endocrinologist, Howard A. Bern was a scholar who championed the comparative method and research that crossed discipline boundaries. During 40 years on the faculty at the University of California, Berkeley, he supervised and mentored 46 PhD students, 36 Master's degree students, and more than 90 postdoctoral fellows and visiting professors. Although he did not identify himself as a malacologist, his interest in chemical mediation and neuroendocrine mechanisms led to classical comparative studies of neurosecretory structures in gastropod mollusks, including prosobranchs (*Haliotis*), opisthobranchs (*Aplysia*) and pulmonates (*Helisoma*). His interest in neurosecretion extended to cephalopods. He and his students and associates provided elegant documentation of innervation of the cephalopod optic gland and fine structure of the epistellar body. Comparative study of six cephalopod species included microanatomy, histology, ultrastructure, biochemistry, and neurological observations leading to the conclusion that structures previously interpreted as neurosecretory were more likely involved in light reception. He was prescient in suggesting that small photoreceptive structures in the nervous system could be viewed as "light recorders" rather than true organs of "image formation."

Eloquent communication was a hallmark of Bern’s scholarship. His 11 mollusk papers are illustrated by more than 100 electron micrographs, drawings, and diagrams. The topic of his Presidential Address to the American Society of Zoologists in 1967 was not chemical mediation or cancer research, but the broader implications of his molluscan studies. His fascination with the topic is encapsulated in his title: “On Eyes That May Not See and Glands That May Not Secrete.” He used the comparative molluscan research to warn that academic scholarship can be too narrow and that communication of knowledge gained experimentally in the laboratory is most expertly delivered by biologists who also “know the forms under consideration and have seen them in their natural environments.”

Sunday, 1:40 pm
Terrace Room

"Keep your friends close and your enemies closer": behavioral ecology of invasive predators in Hawaii

Brenden S. Holland

Associate Researcher, Center for Conservation Research and Training
Pacific Biosciences Research Center, 408 Gilmore, Honolulu, HI 96822

Many biologists are drawn to live and work in the Hawaiian Islands thanks to spectacular levels of endemism and biodiversity, driven by extreme isolation and diversity of microhabitats. But due to the devastation of native species by habitat loss and release of invasive predators, evolutionary biologists are often compelled by necessity to transition into the field of conservation biology.

With about the same number of species of land snails as all of North America, the Hawaiian Islands harbor a disproportionate level of snail biodiversity, which is currently under assault by direct predation. During this talk I will focus on my lab's recent efforts to improve our understanding of the tracking and foraging behavior of two different invasive predators on native invertebrates, the wolf snail *Euglandina rosea* and Jackson's chameleon *Chamaeleo jacksonii xantholopus*. We are seeking data that will ultimately help us devise control and eradication strategies for these invasive pests.

Impact and pest status of *Parmarion cf. martensi* and *Veronicella cubensis* in the Pacific region, and tools to prevent damage and spread

Robert Hollingsworth[1]* & David Robinson[2]

[1]*USDA-ARS-PBARC, 64 Nowelo Street, Hilo, HI 96720, U.S.A.*

[2]*David Robinson - USDA APHIS National Malacology Laboratory, Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, Philadelphia, PA 19103*

The Asian semi-slug, *Parmarion cf. martensi* Simroth, 1893, and the Cuban slug, *Veronicella cubensis* (Pfeiffer, 1840) are two very important pest gastropods in the Pacific region.

The Asian semi-slug was first discovered on the Big Island of Hawaii (Hawaii Island) in 2004 and is now abundant in certain lowland areas along the wetter eastern side. This species is probably native to Southeast Asia and could have been introduced into Hawaii on potted plants. It is an important carrier of the nematode *Angiostrongylus cantonensis*, the causative agent of human angiostrongyliasis (rat lungworm). Human cases of this disease have spiked in eastern Hawaii Island following the introduction and spread of this species. The behavior of this species in combination with high rates of nematode infection and high worm burdens make it a serious disease risk and therefore an important agricultural pest.

The Cuban slug was first introduced to the Hawaiian islands in the mid-1980s. It was found in the Mariana islands prior to 1995 and its presence in American Samoa was confirmed in 2004. For reasons not understood, on certain islands it becomes extremely abundant in the landscape, causing serious damage to established crops and making crop establishment difficult. Like the Asian semi-slug, the Cuban slug is an important carrier of rat lungworm. Both of these species can be controlled by the judicious use of metaldehyde baits. To a lesser degree, both species are also susceptible to baits containing iron as the active ingredient. However, preliminary data suggest the semi-slug has an unusual resistance to iron-containing baits, which can delay death by 1-2 weeks.

Systematics, phylogeny and ecology of the Octopoteuthidae Berry, 1912 (Cephalopoda: Oegopsida)

Jesse T. Kelly

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Octopoteuthid ('eight-armed') squids have been known to science for nearly 250 years, and have been collected from every ocean except the Arctic. They are an ecologically important group, having been recorded in the diets of pinnipeds, sea birds, predatory fishes and cetaceans, most notably sperm whales. Octopoteuthid squids are also active predators themselves, and link lower trophic levels to apex predators in oceanic food webs. Despite this, the family has been poorly studied due to the difficulty in identifying its species, arising from the taxonomic disarray of the family.

Ten formal species descriptions have been published, of which six to eight are generally recognised, though of these only two are readily identifiable. Previous studies have identified lost holotypes, dubious taxa, junior synonyms and undescribed species, but no study has sought to place these findings within, and resolve the systematics of, the entire family. The primary goal of this research programme is to critically review the systematics of the family Octopoteuthidae and redescribe all nominal taxa. Genetic data will be used to support species identification based on morphology. Once species designations are clarified, the intra- and inter-familial relatedness will be examined and studies initiated on the growth, reproductive life history and predator-prey relationships of octopoteuthids.

Preliminary observations of New Zealand specimens suggest the existence of two previously undescribed species. Current lower beak length-to-mantle length regressions underestimate size for some species by 22.9 - 28.5%, which significantly impacts the accuracy of prey biomass reconstructions of octopoteuthid predators. When completed, this programme will provide an identification guide to all octopoteuthid taxa, further develop our understanding of the biology and ecology of this unique family, and clarify its significance and placement in open ocean food webs.

The glass half empty: frontiers in the exploration of Australia's non-marine molluscs

Frank Köhler

Australian Museum. 6 College Street, Sydney NSW 2010, Australia

Australia is known for its diverse and endemic biota – mollusks not being an exemption. It is estimated to harbor about 19,000 species of mollusks, including perhaps 2,000 species of non-marine gastropods. Endemism, particularly in non-marine molluscs, is extremely high (98.6%), more so than in most other Australian groups. Despite a strong tradition in malacological research in Australia, much fewer species are formally known. The non-marine fauna is comparatively small, with about 600 species listed in 1998. Two groups, the Charopidae and Camaenidae, account for the majority of known species amongst terrestrial gastropods.

Large numbers of species were newly described in recent years, mainly from the mesic eastern fringes of the continent. This has more than doubled the number of known species (>1,200). The last decade has also seen major progress in documenting and analysing general patterns of Molluscan diversity. A substantial amount of geo-referenced collection data are available in on-line databases, such as the Online Zoological Collections of Australian Museums (www.OZCAM.org) and Australian Natural Heritage Assessment Tool (ANHAT). However, continued efforts are needed to database the remaining 60-70% of museum collections.

While currently available information permits the identification of geographical and taxonomic knowledge gaps, molecular works – still in their infancies – have helped to identify drivers of radiations, such as past climate change and narrow-range endemism. Continuously high numbers of new descriptions show that the exploration is far from over. However, the vastness of the continent sets the limits to the pace of discovery. Large efforts are made to close spatial survey gaps (i.e., helicopter-based surveys in remote regions) but a comparatively small workforce of specialists is unable to survey all major groups in an equal fashion. It remains to be seen how potential shifts in research priorities, away from 'traditional taxonomy', will influence future discovery rates.

Conus of the southeastern United States and Caribbean region

Alan J. Kohn

Dept. of Biology, University of Washington

This is a progress report on a project to develop a species-level systematic revision and to facilitate identification of the extant species of *Conus* in the western Atlantic region north of Brazil. To accomplish this goal, each of the 263 nominal species described by 71 authors and co-authors between1758 and 2011 was analyzed objectively and consistently. For those for which the results support the hypothesis of validity, within-species variation is estimated and each is differentiated as clearly as possible from its most similar congeners. Shell characters are emphasized primarily, because they are the most durable and because they are likely to be the only characters accessible to most users. In some cases, non-traditional characters such as shell and radular tooth morphometry are also described quantitatively, and similarities and differences in key mitochondrial genes are analyzed both as taxonomic characters and to evaluate phylogenetic relatedness among species.

The recent rapid advance of molecular genetics belies the author's (1995) statement that "the application of...character sets...from molecular biological study awaits the next generation of researchers." Other traits of western Atlantic *Conus,* e.g. specific habitats, feeding biology, reproduction, and geographic distribution, remain more poorly known than for their Indo-Pacific relatives, but available information on these biological attributes has been collated. At present, 53 species meet the criteria of at least one objectively defined character distinct from closest relatives. Graphs show the trajectories over time of the numbers of described and valid species, and the numbers of species with name-bearing type specimens. Finally, the current status of species-level phylogeny of western Atlantic *Conus* is summarized.

Presently molecular genetic information is limited to small sample sizes and only about one-third of the species. Such data can reveal the existence of cryptic species with indistinguishable morphological features, so future work will undoubtedly increase the number of known valid species.

H. J. Krebs and the earliest survey of West Indian mollusks

Alan J. Kohn

Dept. of Biology, University of Washington

Educated as a botanist and pharmacist in his native Denmark, Henrik Johannes Krebs (1821-1907) moved to St. Thomas, Danish West Indies in 1843 and lived there until he retired to Denmark in 1870. Initially he pursued both interests but became increasingly successful as a general merchant.

With knowledge of malacology presumably from his natural history studies in Denmark, Krebs was soon influenced by the interest in shells of his first employer, St. Thomas's only apothecary. Impeded but not undaunted by a shortage of reference books, he attempted to catalogue the marine shells of the Virgin Islands and other Caribbean areas where traveled for business and botany, including Puerto Rico, the Bahamas, and Trinidad, and Central and South America. His small book, "The West-Indian Marine Shells," published anonymously in a very limited edition in Denmark in 1864, is mainly an annotated catalogue of 1,170 species in 151 genera (103 of gastropods, 46 of bivalves, and 1 each of chitons and scaphopods). The annotations include notes on locality, habitat, and collectors. Because of the book's scarcity, Clench, Aguayo and Turner republished it in 1948, and re-evaluated some of the species names used.

Krebs later published three short papers with additions and corrections based on further collections and visits to U.S. museums, and he may have planned a revision, but that did not materialize. *Pleurotoma* lists the most species (66). *Strombus* begins the account (10 species), followed by *Conus* with 35. Fourteen of these can be associated with currently recognized valid species; ten of them bear their currently accepted names. Most of the others were given the names of Indo-West Pacific species with which Krebs was evidently familiar, but they cannot be assigned confidently to any known Caribbean species. Attempts to locate Krebs's specimens to assess his identifications have not succeeded to date.

Do scallops see in color? Understanding the visual capabilities of scallops

Anita J. Krause* & Jeanne M. Serb

Iowa State University, Department of Ecology, Evolution, and Organismal Biology

Animals live in diverse photic environments and adjusting visual ability to these specific environments can increase the probability of survival. Visual adaptations can evolve by increasing the number of visual pigments, changing or increasing photoreceptor cells, or altering the gene sequence of the visual protein, opsin. Opsin is a seven-transmembrane protein housed in photoreceptor cells of the eye, and is required for vision in all animals.

Scallops are an excellent system to explore visual adaptation, as they are cosmopolitan, exhibit visually-mediated behaviors, and contain up to 200 unique mirror-type eyes. Scallops are unlike most other organisms because within each eye, scallops contain not one but two opsin types, the Go-opsin and the Gq-opsin. While conducting a molecular survey of Gq-opsin diversity across 30 scallop species, we made three discoveries: 1) a gene duplication event of Gq-opsin has occurred at least once in Pectinidae, which produced two putatively functional copies; 2) there is an association between the presence of one or both Gq-opsin copies and the scallop's behavior; and 3) certain behaviors are associated with a convergent Gq-opsin sequence.

As a model, scallop eyes may not only help identify key amino acid sites that may be critical for visual adaptation in molluscs, but they may further resolve questions of visual evolution across animals.

Rare freshwater mussels (Unionidae) in the urban corridor of the Delaware estuary

Danielle Kreeger[1,2], Roger Thomas*[2], Sylvan Klein[2], Angela Padeletti[1], Melanie Mills[2], William Lellis[3] & William Whalon[2]

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[2]The Academy of Natural Sciences of Drexel University, Patrick Center for Environmental Research, 19th and Parkway, Philadelphia, PA 19103
[3]USGS - Leetown Science Center, 176 Straight Run Road, Wellsboro, PA 16901

Freshwater mussels are the most imperiled of all fauna and flora in the Delaware River watershed and across North America. These filter feeders normally form dense beds in streams and rivers, and their decline contributes to degraded water quality and aquatic ecosystem resilience, and decreased habitat complexity.

The Freshwater Mussel Recovery Program (FMRP) was launched in 2007 in an effort to restore mussel populations as a means to advance ecosystem-based restoration (along with marine species such as oysters.) The FMRP depends on finding genetic broodstock from the same basin for hatchery propagation and/or relocation to historically populated stream reaches. To date, the FMRP has been constrained to one species (*Elliptio complanata*) because other native species are rarely found in southeastern Pennsylvania streams.

Between 2009 and 2011, live specimens and relic shells of several species of native freshwater mussels were discovered by snorkeling and dredging in the tidal freshwater portion of the Delaware Estuary between Trenton, NJ, and Chester, PA including the Pond Mussel, *Ligumia nasuta*; Tidewater Mucket, *Leptodea ochracea*; Alewife Floater, *Anodonta implicata*; Creeper, *Strophitus undulatus*; Eastern Floater, *Pyganodon cataracta*; Yellow Lampmussel, *Lampsilis cariosa*, and the Elliptio, *E. complanata*. At least four of these species are critically imperiled in NJ and PA and two were believed extirpated from this section of the Delaware River drainage.

The mussels formed robust, mixed-species beds in shallow subtidal areas mainly having fine-grained bottom sediments with cobble. Their presence in the tidal freshwater portion of the watershed, but not in smaller tributaries, may result from dams in those streams, which interfere with passage of fish hosts essential for mussel reproduction.

Since the remaining broodstock of these rare and ecologically important unionids exists in the urban corridor, their protection is paramount for future mussel restoration efforts, in support of broader water quality, habitat and living resource goals.

Status of cataloguing the megadiverse marine gastropod family Pyramidellidae

Patrick I. LaFollette

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The family Pyramidellidae is distinguished by heterostrophic larval shell, lack of radula, and specialized feeding apparatus for its ectoparasitic mode of life. Host specificity has been proposed to account for numerous phenotypically similar species, but supporting data are sparse. Many species are now known to exploit multiple hosts. Shell sizes are mostly minute to microscopic, ~1-10 mm, though a few exceed 3 cm. Species occur at all latitudes and depths, but most are shallow water, temperate to tropical, with greatest diversity in the Indo-Pacific region. The fossil record extends at least to the Maastrichtian stage of the Cretaceous.

There have been several efforts to compile worldwide species lists from the literature. Helmer Odé published catalogs of Turbonillinae (1996-1998) totaling 2,130 species, compiled from a bibliography of 600 references. James Corgan has located 1,956 citations, from which he prepared a table of 6,808 species level names; he has turned his unfinished work over to me. Working independently and until recently unknown to one another, Marc S. S. Lavaleye of the Royal Netherlands Institute for Sea Research and I have compiled bibliographies of 5,362 and 5,173 titles respectively. A preliminary comparison finds an overlap of only 32%, suggesting that the combined total will be about 8,100 titles. The small overlap indicates than many titles remain to be discovered. I expect we will find about 10,000 published names, including many synonyms and unavailable names.

Museum collections contain hundreds of unidentified and undescribed species, particularly from ongoing faunal surveys of the MNHN in the Indo-Pacific. Bouchet (2009) reports a sample of 8903 specimens of Pyramidellidae from Panglao, Philippines that yielded 715 morpho-species. The pool of as yet undiscovered species must be large. The absence of complete information on available genera and a catalog of the species has been a major obstacle to work on the family.

The Bailey-Matthews Shell Museum: a museum for Malacology

José H. Leal

The Bailey-Matthews Shell Museum

The Bailey-Matthews Shell Museum was incorporated as a non-profit museum in 1986. A gift of land from the Bailey family in 1990, and the hiring of noted malacologist R. Tucker Abbott, Ph.D., as a consultant and eventually founding director, set the wheels in motion.

In 1993, the Museum acquired a bank loan to complement a construction grant from the State of Florida Cultural Facilities Program. It opened to the public on November 18, 1995. In February 1996, malacologist José H. Leal was hired as director. In 1997, the Museum became the publisher of *The Nautilus*, the second-oldest English-language shell science journal in the world. In 2003, the Museum underwent the American Association of Museums' (AAM) Museum Assessment Program and, in 2004, the Heritage Preservations' Conservation Assessment Program, both sponsored by IMLS. Full accreditation with AAM was granted in March 2010.

The BMSM collection includes an estimated 116,100 lots, of which 24.9% have been catalogued and posted online. In addition to its 35 exhibits, public programs, fully catalogued library, and other in-house resources, the Museum offers facilities in its collection and research area for visiting researchers, interns, and students; museum resources are used by national and international professionals in the fields of environmental and marine sciences, biology and ecology.

Although worldwide in its initial scope, there has been an increasing effort on expanding the focus of the collection on Florida, Gulf of Mexico, and Caribbean mollusks. The anticipated hiring of a Collection Manager in late 2012 will enable the Museum to complete the first part of a broader two-part processing and cataloguing initiative.

Audubon's shells

Harry G. Lee

Jacksonville Shell Club

I have tried to identify and analyze the shells depicted in John James Audubon's folio editions of *Birds of America* and *Quadrupeds of North America*, as well as his manuscript descriptions of a species of aquatic mollusk later made available by a collaborator.

The historical, ecological and social context of his malacological contributions as well as the rôle of his collaborators will be explored.

How can extant species of molluscs help us understand the evolution of life on Earth?

Manuel António E. Malaquias

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Over geological time (deep time), climate change and plate tectonics played chief roles reshaping the geography, landscape, ocean circulation patterns, and ecosystems of the planet. These events led to massive extinctions but simultaneously generated opportunities for the origination of new species and biota.

The rich molluscan fossil record is a notable illustration of these organismic turnovers, providing many examples of dramatic latitudinal changes in faunal composition over time. Less common is to regard extant species as a "window" to look into deep time. However, the advent of molecular phylogenetics and dating methodologies changed this paradigm.

During this talk I will show examples from shallow and deep-sea marine gastropods ("bubble-shells"; *Bulla, Haminoea, Scaphander*) to illustrate how sound knowledge of species morphology and geographic distribution, coupled with the use of molecular phylogenetic tools, provide a unique opportunity to understand the impact of major tectonic and climatic events on the evolution of marine molluscs.

Marko, P., Cox, L. N. &
Zaslavskaya, N. I.

Sunday, 10:20 am
Terrace Room

East meets west: trans-Pacific phylogeography of the rocky shore gastropods *Littorina sitkana* and *Nucella lima*

Peter B. Marko[1], L. Nicole Cox[1] & Nadezhda I. Zaslavskaya[2]

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Fluctuating climate during the last 2 million years repeatedly caused latitudinal shifts and fragmentation of species distributions. In the north Pacific, regional extinction of northern populations during cooler Pleistocene glacial periods may have fragmented species ranges, and for those with trans-Pacific distributions, climate-driven vicariance may have provided opportunities for geographic isolation and speciation.

In this context, we have investigated the phylogeographic structure of two intertidal gastropods, *Nucella lima* and *Littorina sitkana*. We have gathered mitochondrial and nuclear sequence markers from both species and have analyzed those data with a variety of phylogeographic and population genetic methods. The results show that although both nominal species are currently distributed across the entire Pacific, strong patterns of genetic differentiation exist on a variety of spatial scales, consistent with east-west differentation followed by large range expansions and secondary contact.

Both species show a clear pattern of low genetic diversity and population substructuring in the east (Alaska and British Columbia) combined with greater diversity and substructuring in the west (Kamchatka, Sakhalin Island, and Hokkaido). Low genetic diversity in “eastern” populations of *L. sitkana* extend from Alaska to eastern Sakhalin Island, indicating a massive post-glacial range expansion.

Prehistoric coastal shell midden research in Maine

Scott Martin

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Over 2000 prehistoric coastal shell middens are present along the 220-mile serpentine coastline and adjacent islands of Maine. The most famous are the vast heaps of *Crassostrea virginica* shells along the banks of Maine's tidal Damariscotta River. Although their existence had been known to Europeans since the early 17th century, Charles Thomas Jackson (1805-1880) in 1839 was the first to study these man-made mounds scientifically.

The dominant species in most of Maine's prehistoric middens is *Mya arenaria*. In 1859, a youthful Edward Sylvester Morse (1838-1925) conducted the first paleoecological investigation of a Maine shell midden, noting how vegetation, climate, and species had changed over time. In the 1860s, Jeffries Wyman (1814-1874) directed a concerted shell midden research program in Maine and Massachusetts in order to understand the prehistoric inhabitants of New England. Another serious effort was mounted by Warren King Moorehead (1866-1939) in the early 1920s. Although shell midden research has continued to the present, most of the known mounds in Maine have never been excavated, and some have been, or are being, lost to erosion.

At least 20 marine gastropod and bivalve species have been found in Maine's shell middens, along with 17 different land snails. The bones of at least 31 mammal, 32 bird, 5 herptile and 25 fish species have also been found, including remains of the extinct sea mink, great auk, and passenger pigeon. Bone and stone tools of prehistoric man are commonly present in the mounds. The shell mounds bear cultural strata from the Middle Archaic through the Ceramic Periods. Meticulous study of the shells, bones, and human artifacts in these refuse heaps sheds light on the paleoenvironment, seasonal activities, subsistence patterns, and sophistication of prehistoric societies.

Wednesday, 2:40 pm
History of Malacology, Ballroom C

Edward Sylvester Morse: quintessential malacologist – and more

Scott Martin

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Maine's inimitable Edward Sylvester Morse (1838-1925) commenced his scientific career as a youthful malacologist whose discovery of the polygyrid *Planogyra astericus* at Bethel, ME was read before the Boston Society of Natural History when he was only eighteen. Four other land snails with type localities in Maine were described by Morse. His self-illustrated 1864 monograph *Observations on the Terrestrial Pulmonifera of Maine* remains a classic.

Morse's taxonomic research on mollusks would generate one variety, 11 species, one subgenus, eight genera and one subfamily. His boyhood shell collection earned him employ with Louis Agassiz at Harvard, where he attended his master's lectures. He then commenced a curatorial career in natural history at museums in Maine and Massachusetts. He made illustrations for Temple Prime and Augustus Gould, for *The American Naturalist* (a journal he co-founded), and for his own zoology textbook. He also taught college biology courses and delivered public natural history lectures country-wide that he illustrated ambidexterously.

Morse's pioneer paleoecological research on a Maine prehistoric shell midden used land snails to demonstrate changes in vegetation, climate, and species over time. When Morse visited Japan to study brachiopods, he was hired to establish Tokyo University's zoology department, natural history museum, and marine biological laboratory. His meticulous midden research there led to *Shell Mounds of Omori*. Morse became an expert on Japanese pottery, and his vast collection now resides at Boston's Museum of Fine Arts. Morse encouraged the Japanese to preserve their antiquities, and he wrote several books on Oriental civilizations. Japanese scientists trained in Morse's scientific methods discovered that freshwater snails carry the deadly blood and liver flukes of Asia.

Olof Olsson Nylander: malacologist of Maine's north woods

Scott Martin

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Olof Olsson Nylander (1864-1943) was a Swedish immigrant who settled in Maine's northernmost county, Aroostook. For several decades, this self-taught amateur naturalist tramped the North Country of Maine and New Brunswick by railway, canoe, and on foot in search of mollusks, geological specimens (including fossils), and plants (especially orchids and ferns). Nearly all of Aroostook County's 21 species of fingernail clams, 34 species of freshwater snails, and 58 species of terrestrial gastropods were first collected by Nylander, who sent thousands of specimens to specialists for identification. Victor Sterki named a number of new species using Nylander's material, but most have since been synonymized with other forms

The type localities for *Vertigo nylanderi* and *Vertigo paradoxa* are Woodland, ME, where Nylander collected them not far from his home. Nylander donated molluscan specimens to the nation's most prestigious museums. He drafted about 60 scholarly works in the natural sciences. Some appeared in *The Nautilus*, while others were self-published mimeographs preserved at the still-extant Nylander Museum in Caribou, ME and in sundry libraries. An important publication was *The Lymnaeidae of Northern Maine and Adjacent Canadian Provinces*, published posthumously in 1943.

Nylander was a field geologist of such renown that professional geologists journeyed to Aroostook County just to be guided by him. He sent numerous fossil specimens to paleontologists who wrote monographs that incorporated his material. They named a trilobite, a starfish, a brachiopod, and three graptolite fossils after him. In 2011, a qualitative inventory of Aroostook County's Fish River Lakes suggested that the freshwater snail fauna collected there by Nylander nearly a century ago remains mostly intact today.

McCullagh, G. B., Bishop, C. & Wyeth, R. C.

Wednesday, 11:20 am
COA Winners, Plaza Rooms 1&2

The rhinophores are sufficient and necessary during odor-gated rheotaxis in the nudibranch *Tritonia diomedea*

Gregory B. McCullagh*, Cory Bishop & Russell C. Wyeth

St. Francis Xavier University, Department of Biology

Animals navigating in odor plumes must detect and often integrate multiple sensory cues to find food or avoid harmful encounters. The nudibranch *Tritonia diomedea* is known to combine detection of odor and flow cues to orient and crawl upstream towards prey and will turn downstream away from upstream predators.

The mechanism by which *T. diomedea* integrates odor and flow cues to create these behaviors is likely odor-gated rheotaxis, whereby animals use flow direction to locate or avoid the source of an odor. Alternatively, a bilateral comparison of odors alone has not been ruled out. The rhinophores detect odors and are necessary during navigation in odor plumes, and the oral veil was shown to detect flow during slug locomotion in flow alone. However, within odor plumes, the rhinophores or the oral veil may detect flow stimuli.

The goals of this study were to determine 1) whether *T. diomedea* navigates using a bilateral odor comparison between rhinophores and, 2) whether flow, in odor plumes, is detected by the rhinophores or the oral veil. Prey and predator odor plumes were generated in a non-recirculating flow tank and we tested the navigational performance in experimental slugs that had one rhinophore removed, a lesioned oral veil, or one rhinophore removed and a lesioned oral veil. Our results show that all slugs with manipulated sensory organs oriented similarly to control slugs. These results strongly suggest that within odor plumes, *T. diomedea* does not sample odor cues using bilateral comparisons, and that the rhinophores are sufficient for navigation. As a corollary, the rhinophores are implicated to be capable of detecting flow, and odor-gated rheotaxis is the most likely behavioral strategy for navigation in odor plumes.

Future studies will evaluate the cellular components of the peripheral nervous system within the rhinophores in *T. diomedea* and further explore the functional relevance of the oral veil during navigation.

McDonnell, R., Hollingsworth, R. & Paine, T.

Poster

Essential oils as novel tools in the management of snails and slugs in potted plants

Rory Mc Donnell[1], Robert Hollingsworth[2] & Tim Paine[1]

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Export ornamental plants are high risk for pest gastropod species because their eggs and juveniles can hide within the planting medium of potted plants. While pre-harvest control practices (e.g. molluscicide baits) for slug and snail control in potted plants are helpful, they are frequently not sufficient to achieve quarantine security.

In this investigation, eleven essential oils and one terpene were used in experiments to assess their efficacy as potential drench treatments. In laboratory Petri dish bioassays, pine, lemongrass, clove, spearmint, garlic, peppermint and cinnamon oils were most effective (100% mortality) against eggs and juveniles of *Cantareus aspersus* and eggs of *Succinea spp*. when tested at a 1% concentration. For eggs of *Veronicella cubensis* and *Lissachatina fulica*, hatch was completely inhibited by a 24-hour exposure to 1% concentrations of cinnamon oil, lemongrass oil, peppermint oil and pine oil. We also quantified the toxicity of these oils using probit analysis and results showed that clove oil proved to be the most toxic to *C. aspersus* juveniles (LC50 = 0.027%).

To test our results, we artificially infested pots containing Sunshine #4 potting media with eggs and juveniles of *C. aspersus*. Two treatment concentrations [0.058% (= LC99 for juveniles) and 0.116% (twice this LC99 value)] were used. The results showed that 100% mortality of eggs and juveniles was achieved at 0.116% after exposure periods of 1 and 3 days. In a similar manner, drenches of clove oil at 0.116% and 0.50% completely controlled juveniles and eggs, respectively, of *Parmarion martensi*.

Finally, to test for potential phytotoxicity we drenched the leaves and the soil of *Gardenia jasminoides* with 0.116% clove oil solution. No symptoms of phytotoxicity were observed on the leaves or roots of the test plants over the course of 1 week.

Elucidation of an invasive slug species complex in California with comments on the source location of introductions

Rory Mc Donnell[1]*, Paul Rugman-Jones[1], Thierry Backeljau[2], Karin Breugelmans[2], Kurt Jordaens[3], Richard Stouthamer[1], Tim Paine[1] & Mike Gormally[4]

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Arion subfuscus sensu lato (*s. l.*) refers to a cryptic slug species complex that is native to Europe and which, from there, has been introduced into the northeastern U.S. The species complex was detected in California for the first time in 2005, and during 2007 twelve specimens were collected during statewide surveys.

The genital morphology of these specimens suggested that only *A. subfuscus sensu stricto* (*s. s.*) was present, and partial sequences of mitochondrial 16S rDNA (443 bp) showed that they all belonged to a single haplotype of the mitochondrial lineage, S1 sensu Pinceel et al. (*Genetica* 125: 155–171, 2005). This result was corroborated by a parallel analysis of a 655 bp COI DNA barcode. The 16S rDNA S1 haplotype (S1-03) of the Californian specimens is hitherto known only from the northeastern U.S. Hence, it is likely that populations may have been introduced to California from the northeastern states, rather than directly from the native area of the S1 haplogroup in Europe.

Revision of living and fossil Liotiidae and Areneidae of the world: the beaded operculum synapomorphy

James H. McLean

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Two long-neglected trochiform families, the Liotiidae Gray, 1850 and the Areneidae (which will be formally proposed in the monograph) are plesiomorphic for their nacreous interiors and generalized, rhipidoglossate radular plan, shared by some skeneids and colloniids. Synapomorphic characters that unite them in a new superfamily include lamellar micro-sculpture throughout the teleoconch, a thickened final lip, and an unenveloped, conchiolinous, multispiral operculum with an embedded, bead-bearing calcareous ring. In not being enveloped, the operculum is more like that of trochids than colloniids and turbinids, in which the entire operculum is enveloped by the foot. The newly revised classification is based on shell morphology, recognizing regionally and bathymetrically characterized subfamilies and tribes, arranged according to earliest fossil appearance.

Shells of the more speciose, chiefly Indo-Pacific Liotiidae lack color patterns, have the thickest final lips, and range in diameter from 2 to 25 mm. Six living subfamilies and three extinct (Permian to Eocene) subfamilies are to be recognized. Two subfamilies have representation in temperate regions of Australia and the Americas. Numerous new genera and species been collected at bathyal depths in the Indo-Pacific, a result of the Tropical Deep-Sea Benthos expeditions of the MNHN. Additional new species have been found elsewhere by intertidal collectors and divers who have collected shell grit for small specimens. Results for Liotiidae: 383 species, including 297 new species; 125 genera, including 114 new genera.

Shells of the less speciose Areneidae have variegated color patterns, less thick lips and a minor opercular distinction; they range from 2 to 10 mm in diameter. Known from the Cretaceous, six living subfamilies are to be recognized; one of these is broadly distributed on both sides of the Atlantic, three occur in the Americas, one in southern Africa, and another in west Africa. Most genera occur in relatively shallow water. Results for Areneidae: 128 species, including 63 new species; 55 genera, including 51 new genera.

Only a few species have broad distributions, due to constraints on larval dispersal of vetigastropods. For the Liotiidae, 67 new species are known from single specimens, which is an indication that sampling throughout the Indo-Pacific is far from complete; I expect that many more species remain to be discovered.

Habitat preferences and intertidal zonation of *Cittarium pica*: what rocks their world

Erin L. Meyer

University of California, Berkeley

The rocky intertidal is characterized by unique biological diversity and geomorphological complexity. Although extensive research has addressed community structuring in the rocky intertidal, visualization of distribution patterns on geomorphological structures is largely ignored or oversimplified.

This study re-emphasizes the importance of observational data and proposes a new illustrative method for visualizing rocky intertidal shores. The Tropical Northwestern Atlantic is a unique geographic region with abundant rocky intertidal habitat, occupied by *Cittarium pica*, which is an important gastropod fishery. This location and species are an ideal case study for investigating fine-scale distribution within rocky intertidal systems, and the results provide important information to resource managers throughout the region. To document habitat preferences of *C. pica*, detailed field observations and quantitative assessments were completed. These data were used to delineate rocky intertidal habitat categories and to create cross-sections of the rock features that characterize each category. To evaluate intertidal zonation patterns, size and location of individual snails were mapped onto habitat cross-sections. Unlike previous studies, the data reported here suggest that size-specific zonation of *C. pica* does not follow a simple linear relationship with vertical position. Regardless of the habitat category or snail size, *C. pica* is most common at or near mean low water (MLW). Individuals <10 mm are most common below mean high water (MHW) for all habitats. The largest snails are rarely found above MHW; they are most common at MLW.

Because range boundaries of rocky intertidal species at high latitudes have reacted quickly to environmental conditions, species in the rocky intertidal may be useful as indicators of climate change and its impacts. Thus, documenting and interpreting the current distribution of rocky intertidal organisms is increasingly important. The method developed herein provides the foundation for illustrating and understanding species distributions at multiple spatial and temporal scales.

Land snail compositional changes and the functioning of ecosystems

Wallace M Meyer III[1]* & Robert H Cowie[2]

[1]*University of Arizona*
[2]*University of Hawaii*

Diverse and geographically structured land snail faunas worldwide are disappearing and are being replaced by a small number of widespread non-native species. Understanding the consequences of these changes is difficult because the roles of terrestrial mollusks in many important ecosystem processes are largely unknown. It has been suggested that snails/slugs contribute directly (by their own metabolism) and/or indirectly (by habitat modification enhancing micro-arthropod or microbial activity) to litter decomposition and nutrient release.

To address the roles of snails and slugs in a Hawaiian rainforest, forty-two mesocosms were established at seven Hawaiian rainforest sites to examine the role of the five most abundant snail/slug species: the only abundant native species, *Succinea cepulla*, and the non-native species *Arion intermedius, Deroceras laeve, Oxychilus alliarius* and *Limax maximus*. Controls had no snails/slugs. Presence of mollusks increased litter decomposition rates, which were strongly correlated with mollusk biomass. Rates of release of specific nutrients (C, N, Ca, Mg, Mn, P and K) differed among treatments. For example, K concentrations in the *O. alliarius* treatment and C concentrations in the *L. maximus* treatment were higher than in controls; and the *S. cepulla* treatment had higher concentrations of Mn than the *L. maximus* and *D. laeve* treatments. No increases in smaller invertebrate abundances were observed in treatments containing mollusks, indicating that mollusks do not facilitate their recruitment and probably influence these ecosystem processes primarily by microbe facilitation. If a major functional role of terrestrial mollusks is to facilitate microbial growth, then maintaining adequate mollusk biomass may be essential for maintaining healthy functioning ecosystems. However, addition of invasive mollusk species may not maintain the rates of nutrient release once provided by native species, because different mollusk species influence nutrient dynamics differently.

AMS-WSM-COA: a brief history of shell societies in the U.S.

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Three interconnected societies dominate the study of mollusks in the U.S. today. The American Malacological Society (originally Union) was founded in 1931, led by Norman Lermond, an idealistic writer, naturalist, and collector from Maine. In 1931, Lermond invited every conchologist whom he knew to form a new organization; 169 persons responded and the first meeting was held at the Academy of Natural Sciences in Philadelphia. Much of what AMS is today was set at that first assembly: an annual meeting with presentations, field trips, networking, assisting students, and promoting conservation. The society grew steadily, reaching peak membership in the 1960s-1970s. Difficulties in postwar travel led to discussion about a west coast branch, and the AMU Pacific Division was born in 1948.

AMUPD thrived until the 1960s when logistical conflicts arose with AMU. The Division transformed almost imperceptibly in 1968 into the independent Western Society of Malacologists, which thrives to this day. AMS and WSM have held 12 joint meetings. Traditional “amateur activities” such as collecting, exchanging, and travelogue-type presentations were originally at the forefront of AMS, but an increasing focus on academicization over the decades generated dissatisfaction in many members.

In 1972, eight enthusiastic collectors founded Conchologists of America, which was an instant success, emphasizing all of the things that AMS seemed to have abandoned, and included a constitutionally mandated “emphasis … on CONCHOLOGY rather than Malacology." By the 1990s, membership peaked at 1,350, making COA the largest such organization in the world. Today’s COA is a vibrant organization dedicated to shell collecting, molluscan knowledge and research, and conservation. In total, these three organizations now boast over 1,600 members, a testament to interest in mollusks in the U.S. Other specialist organizations (e.g., Freshwater Mollusk Conservation Society, Cephalopod International Advisory Council, Paleontological Society) add additional interest at the specialist level.

Cowries: how well inventoried is the best-known seashell family?

Fabio Moretzsohn

Harte Research Institute, Texas A&M University-Corpus Christi, Texas

True cowries (family Cypraeidae) are arguably among the best-known seashell families. Cowries rank among the most popular shells with shell collectors, partially because their colorful and shiny shells are beautiful and diverse. Many species are common; the rare ones attract the interest of advanced collectors. Additionally, there is a vast literature, ranging from popular to scientific, dating back to Linnaeus, who named 39 species.

In the past 250 years, over a thousand taxa, at the species-, subspecies- and form-level, have been described; most represent either synonyms or invalid descriptions. A figure of at least 220 species and some 80 subspecies, or about 300 OTUs, is a conservative estimate of known cowrie diversity (including some not yet named). As would be expected for a popular family with large and conspicuous shells, found mostly in shallow tropical waters, perhaps as much as 70–80% of species may have already been discovered. Like in butterflies, amateurs play a major role in cowrie discovery and inventorying, which can be both a blessing and a curse. Traditionally, descriptions were based almost solely on shell characters, which may be quite variable. Some recent taxa have been discovered based on molecular data, although still described using shell characters.

Thanks to the breakthrough molecular work of Chris Meyer, phylogenetic relationships of most cowries are well-mapped, with a high congruence with taxa recognized by shell characters. What is left to be discovered may live in deeper water or isolated places, have restricted distribution, or represent hidden diversity as cryptic species. The latter may be discovered with the aid of molecular tools and/or anatomical studies.

The BioGoMx Database as a tool for conservation

Fabio Moretzsohn & J. Wes Tunnell, Jr.

Harte Research Institute, Texas A&M University-Corpus Christi, Texas

The Harte Research Institute sponsored a comprehensive biotic inventory of the Gulf of Mexico that was published as a book (Felder and Camp, 2009). The inventory was the fruit of the collaboration of 140 taxonomists from 15 countries, who compiled a list of 15,419 species, including 2,455 mollusks. The book was then converted into an online database, the Biodiversity of the Gulf of Mexico (BioGoMx) database, which was released in early 2011 on GulfBase.org. Besides mapping the species richness based on a query, the results can be downloaded for further analysis. Each species has its own page, where there is a map of its distribution in the GoMx, in addition to information about its habitat, ecology, bathymetry, complete taxonomy, key references, and links directly to the species pages in external resources such as the Ocean Biogeographic Information System (OBIS), World Registry of Marine Species (WoRMS) and Encyclopedia of Life (EOL).

Both the book and database serve as a benchmark of the biodiversity that was recorded in the Gulf of Mexico (GoMx) prior to the Deepwater Horizon (DWH) oil spill in 2010. Unlike the book, the database can easily perform queries across taxa and map biodiversity patterns in the GoMx. It is expected that the ongoing research effort on the impacts of the DWH oil spill will generate large amounts of biodiversity data, including new species discoveries, new records, range extensions and conservation status. The new data will be incorporated into BioGoMx as they become available.

Although spatial resolution in BioGoMx is coarse, it may still be a useful tool for conservation, identifying gaps and areas that deserve further research efforts or protection.

Overview of North American land snail biodiversity

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The most recent enumeration of the North American land snail fauna is the simple checklist of Turgeon *et al*. (1996), which encoded no ecological traits except native/introduced status. This checklist was updated to include not only all new species names since 1995, but also to include all subspecies which are likely to represent species-level entities; and to also document the median height, width, and bio-volume for each taxon via the published literature. This updated list includes 1204 taxa from 171 genera and 52 families (of Bouchet & Rocroi 2005). Seventy-six taxa (~6% total) represent species not native to the North American fauna. The most speciose families are the Polygyridae (271 taxa), Helminthoglyptidae (178), Vertiginidae (105), Oxychilidae (95), and Oreohelicidae (84). The most speciose genera are *Oreohelix* (79 taxa), *Sonorella* (71), *Helminthoglypta* (70), *Vertigo* (69), and *Ashmunella* (53). The most rapid period of species naming was from ~1890 to ~1950, during which roughly one half of the fauna was formally described (~10 spp/year). Since 1990 the rate of new species descriptions has decreased considerably (~1.7 spp/year), suggesting that complete description of the continental fauna is being approached.

Shell biovolumes range over almost 5 orders of magnitude, from the 0.183 mm^3 *Carychium nannodes* to the 33,000 mm^3 *Orthalicus floridensis*. Unlike most taxa-groups, which demonstrate a strong unimodal right-skew body size distribution along a log-transformed axis, North American land snail shell biovolumes are bimodal, with one mode occurring at ~2 mm^3 and the other at ~1500 mm^3. The right mode is approximately three times the height of the left mode. Range size appears to be negatively correlated with shell biovolume, with the smallest snails often possessing continental ranges and the largest being local endemics restricted to single mountain ranges.

Conservation considerations for North American land snails

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The North American land snail fauna encompasses approximately 1200 species. Approximately 2/3 of these are considered globally critically imperiled (356 taxa), imperiled (215), or vulnerable (215) by the TNC NatureServe database as of May, 2012. This list may overstate the peril faced by the fauna, however, because (1) oversplitting of large-shelled taxa and (2) underreporting of species with shells <5 mm in maximum diameter have both led to higher rates of listing than may be biologically justified.

Body size plays an important role in conservation through its negative correlation with range size. As a result, large-shelled species are more likely to be local endemics and to be under the greatest conservation threat. Additionally, a number of broad-ranged large-shelled eastern species have apparently undergone a recent catastrophic loss of population sizes, and should be carefully considered for conservation prioritization. The major issues that negatively impact the long-term survival of land snail species include: (1) habitat conversion, especially from forestry activities and deforestation; (2) air pollution; (3) habitat degradation through recreational activities; and (4) indiscriminate use of fire management by conservation organizations.

Biodiversity of continental molluscs in the western Palaearctic

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The malacodiversity of the biogeographical unit Western Palaearctic is reviewed. The core of data originates from the recently finished IUCN-project "European Red List of Non-marine molluscs", which delivers an up-to-date insight to the taxonomic structure and magnitude of the European continental malacocoenosis (Cuttelod *et al*. 2011). Some major problems of this type of check-list are discussed.

Next to the European data, information on the continental molluscs of Turkey, the Caucasus, Northern Africa, and the countries of the Middle East is supplied. A first estimate on the numbers of species level taxa living in the whole area is presented. The possible perspective for the future is discussed in order to estimate the magnitude of the "unknown".

Reference

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Jörger K. M. & Schrödl, M.

Small mollusks - big insights: the mesopsammic contribution to Malacology

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Many molluscan taxa occur in the interstices of marine sands during early ontogeny, but only some remain meiofaunal as adults. Hidden, small sized and usually worm-like reduced members occur in Solenogastres and Caudofoveata, but most mesopsammic molluscs refer to Gastropoda: species-rich prosobranch Caecidae, a few lower heterobranchs such as *Omalogyra*, and members of opisthobranch Cephalaspidea (Philinidae; Philinoglossidae), Sacoglossa (*Platyhedyle*), Nudibranchia (*Embletonia* and *Pseudovermis*), Rhodopemorpha (*Rhodope* and *Helminthope*) and Acochlidia.

Inclusion of neglected dwarfs has revolutionized heterobranch phylogeny and traditional textbook concepts on euthyneuran evolution. Until recently, acochlidians were thought to combine extremely high morphological and biological diversity with modest species diversity. In a case study on meiofaunal Acochlidia, we show that diversity estimations from traditional taxonomy are dramatic underestimations when compared with results from modern 3D microanatomical methodology and molecular systematics.

Combined evidence more closely reflects actual species diversity, disentangling cryptic species from the same sandy beaches *vs* conspecific populations on far distant islands. Such integrative approaches may be efficient for research on any micromollusks. Surprisingly enough, several acochlidian lineages emerged from tiny marine mesopsammic ancestors and radiated in brackish or freshwater habitats as secondary “giants”. The most exotic habitat switch occurred in the recently discovered “bug-eating” Aitengidae, which show a semi-terrestrial life style. Global sampling and in-depth analyses in other interstitial groups such as Rhodopemorpha and Solenogastres uncover similar trends, i.e. boosting species richness, revealing new morphological and ecological adaptations, but also narrower than expected distributional ranges and more specialized niches. Meiofaunal molluscs thus may be highly sensitive to habitat destruction and global changes.

Developing a model system for investigating how circadian clocks produce circadian behavior

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Circadian (~24 hr) rhythms of activity are controlled by neural networks that function as endogenous biological clocks. Much is known about the molecular mechanisms of cellular clocks, as well as circadian behavior itself. However, it is still unclear how these clocks ultimately produce circadian behavior. To address this gap, we are studying the circadian system in the nudibranch *Melibe leonina*. This animal offers a number of advantages for this research: 1) it exhibits nocturnal patterns of crawling and swimming; 2) neurons are large and individually identifiable within and between animals; 3) the neural circuitry underlying swimming consists of only a few identifiable neurons; and 4) the eyes are located directly on the brain, enabling isolated brain experiments with different light regimes. Therefore, we have focused on confirming that *Melibe* exhibits circadian patterns of locomotion and locating the circadian clock in the central nervous system.

Long-term monitoring of locomotion indicates that *Melibe* does exhibit a circadian pattern of both crawling and swimming. This pattern persists in constant darkness, with periodogram analysis indicating a significant endogenous periodicity of 23 hours. To locate the clock, we have used commercially available antibodies to label standard clock proteins, such as Clock, Period, Timeless, Cryptochrome, and Pigment Dispersing Hormone. These studies suggest that elements of the clock may be located in the cerebropleural ganglia. To confirm the location of the clock, we are sequencing the genome of *Melibe* and identifying species-specific circadian proteins for the development of custom antibodies. We are also using RNA transcriptome analysis to examine circadian expression patterns in clock genes.

Identification of the clock in *Melibe* will enable investigation of how the clock produces circadian rhythms of locomotion, a connection that has not yet been described at the neural level in any other organism.

Populations of abnormally-shelled giant African snails *Lissachatina fulica* (Bowdich) in Barbados

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The giant African snail, *Lissachatina fulica* (Bowdich 1822), first reported from the parish of St. Michael, Barbados in 2000, is now well established in all parishes on the island.

In 2006, specimens of giant African snails possessing abnormally shaped shells were observed. A survey of the island was initiated in 2007 to document the distribution of populations of abnormally shelled (AS) snails. Collection of snails were made at 16 sites to determine the prevalence of AS-snails, the shell lengths of snails displaying shell abnormalities and the whorl at which abnormalities could first be seen. To catalogue the types of abnormality observed, 746 shells were inspected and differences from Bequaert's description of the shell of *Lissachatina fulica* were noted.

Of the 78 locations surveyed, 32% were found to have populations containing abnormally shelled snails. The prevalence of AS-snails in these populations ranged from 1% to 70%. The first appearance of an abnormality could be as early as in the third whorl of a neonate shell (shell length, 9 mm) or as late as in the eighth whorl of an adult shell (shell length, 103 mm). Abnormalities found included a reflexed apex, uneven whorls, a disjunct body whorl, an umbilicus, two outer lips and a non-truncated columella.

An ereynetid mite has been found at all sites where AS-snails are present. An investigation as to whether this mite is implicated in the shell abnormalities seen in *Lissachatina fulica* is under way.

Conservation status of North American freshwater limpets (Ancylinae) clarified by molecular systematics

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Any assessment of conservation status is premised on the ability to accurately identify the species of interest in nature, determine its range and establish its population trends. This requires not just the availability of diagnostic characters, but also a well-corroborated taxonomic framework. Until recently, this was not possible for North American ancylinid freshwater limpets. Taxonomic uncertainty pervaded much of the literature, primarily due to pronounced ecophenotypic plasticity in shell morphology.

Molecular phylogenetic approaches can be especially useful in such cases and, in collaboration with a number of colleagues, we have used these tools to revise the taxonomy of three genera: *Laevapex*, *Ferrissia* and *Rhodacmea*. The broad outcome for the first two genera was taxonomic consolidation: merging a number of nominal species, including some with restricted ranges that were potentially of conservation concern. The outcome for *Rhodacmea* was the reverse: detection of cryptic species. *Rhodacmea* may be the most endangered endemic North American genus.

Ojeda, M., Torroglosa, M. E. &
Giménez, J.

Poster

Spawn and larval development in *Siphonaria lessoni* (Siphonariidae: Gastropoda) from Buenos Aires, Argentina

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During recent decades, sandy beaches at Buenos Aires Province in Argentina have become a new habitat for species that were previously only found on rocky shores. *Siphonaria lessoni* (Blainville, 1824) and *Brachidontes rodriguezii* (d'Orbigny, 1846) dominate hard substrates that have been introduced as docks.

Siphonaria lessoni individuals were collected monthly from May, 2011 to April, 2012 at Villa Gesell (37°16'S 56°58'O) in Buenos Aires Province. Small pieces of the hermaphrodite gonadal portion were fixed and histological characterization was carried out.

The gelatinous eggs masses were found in August and December. The egg masses were found in the mantle cavity, and there was only one egg mass per individual. The egg masses were gelatinous and transparent and development was synchronous within each egg mass. In August the egg mass contained approximately 4500 eggs. The eggs were found at an early development stage of two and four cells. In December the egg mass contained approximately 4700 eggs and they showed an advanced development stage. Juveniles were found some months later on the hard substrate. This work shows preliminary results about the histological characterization of the hermaphrodite gland and egg masses of *Siphonaria lessoni*.

Ideas on biological evolution in the writings of early American malacologists

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Opinions for and against biological evolution appeared in the 19th century writings of the North American malacologists Thomas Say, Constantine Rafinesque, Samuel Haldeman, Amos Binney, Augustus Gould and Henry Pilsbry. Some of these opinions were expressed in only a few sentences, but one was detailed in a long manuscript and another one was buried in a 207-page poem.

Say wrote very little besides brief species descriptions, but a quote in one of his books suggests that he subscribed to the then common notion that animals from the simplest to the most advanced (i.e., humans) could be organized into a more or less continuous series of morphological improvements, the so-called Great Chain of Being. The earliest North American naturalist to attempt to explain biological diversity with a process akin to an evolutionary succession was Rafinesque in 1832. Haldeman in 1844 and Pilsbry in 1892 expressed opinions supportive of the evolutionary theories of Lamarck and Darwin, respectively. Darwin cited both Rafinesque and Haldeman in the 1872 edition of *The Origin of Species*.

The opinions of Binney and Gould in *The Terrestrial Air-Breathing Mollusks of the United States*, the writing of which was started by the former prior to his death in 1847 and finished by the latter in 1851, were ambiguous. Explanations suggestive of evolution were given in parts of the book, only to be opposed by creationist ideas in other parts.

A phylogenetic and transcriptomic study of convergent evolution in bioluminescent squids

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The phenomenon of convergent phenotypic evolution fascinates biologists. Yet, the extent to which convergent molecular processes drive convergence at the phenotypic level remains unclear. Natural selection is frequently invoked to explain how taxa facing similar biotic or abiotic pressures may arrive at similar phenotypic solutions.

This study seeks to understand if the possibilities of 'molecular solutions' for a favored phenotype are similarly limited. Cephalopod molluscs include two distinct clades of squid that harbor closely related strains of luminous bacterial symbionts within elaborate, optically enhanced organs called "photophores". Using next-generation sequencing, we have generated transcriptomes to 1) construct a phylogeny of cephalopods with which to test hypotheses relating to convergence and life history correlates, and 2) characterize gene expression patterns for two symbiotic photophores that have originated independently in squid.

Comparisons between these transcriptomes have uncovered striking similarities in the molecular profiles underlying these distinct traits. Notably, homologous genes known to be involved in mediating pathogenicity, bacterial recognition, and light perception are highly expressed in both organs. This study contributes not only to symbiosis biology, but also to our understanding of how similarity in molecular profiles relates to morphological and functional similarity.

Galápagos bulimulids: diversification amongst a vanishing tribe

Christine E. Parent

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Why are island systems inhabited by remarkable adaptive radiations? Finches in Galápagos, Honeycreepers in Hawaii, Cichlids in the Great Lakes of East Africa--these species display a range of phenotypic variation equivalent to that of many vastly larger taxonomic groups. On Galápagos, bulimulid land snails have diversified to an unprecedented density of species richness. In this group there are over 70 described species representing a vast array of variation in form and ecology. This variation is the result of evolution in a fragmented landscape. Phenotypic diversity in these snails results from the combination of within-island speciation, between-island colonization and extinction.

During this talk I will first present a general overview of my research work on Galápagos bulimulid land snails. I will then focus on my latest work which aims at bridging the gap between the observed patterns of biodiversity at and above the species level and our understanding of how diversification proceeds at the population level. Although the patterns of adaptive radiations are increasingly well described, and the process of intraspecific diversification leading to speciation is better understood, the link between them remains to be studied in detail.

Conservation issues of terrestrial slugs

Megan E. Paustian

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The conservation of few terrestrial slug species has been evaluated, although general trends in gastropod conservation are known. Habitat loss, particularly for small-range endemics, island inhabitants, and species with narrowly-defined habitats, is the major form of threat, with much less known about the effects of introduced predators, pollution, *etc.*

I will review the conservation situations of threatened species from North America and the standards of evaluation by which the IUCN Red List and other organizations have named threatened slug taxa. The taxonomy and ecology (e.g., feeding mode) of species is strongly related to probability of endangerment, while conservation analyses may be focused on particular clades and geographic regions. I will recommend actions that should be taken, including further resolution of slug taxonomy, confirmation of range data, and reviews of existing data to establish conservation status.

The slugs of Pennsylvania: Analysis of species distributions and ecological correlates

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Terrestrial slugs, such as the endemic species of Philomycidae of eastern North America, are a traditionally understudied group. In Hubricht's land snail atlas of 1985, records of the native slug fauna across Pennsylvania are sparse in comparison to other states, and no publication has yet compiled records of invasive slugs across Pennsylvania. Establishing better range data and determining the habitat niche occupied by slugs is key to establishing conservation efforts, controlling populations of invasive species, and designing more informative studies of slugs' interactions with the environment.

Slugs were collected as part of another study to assess the likely effects of global warming on land gastropods. We systematically surveyed the land snails of Pennsylvania across twelve regional transects at regular 100 m intervals of elevation from 100 to 900 m. Slugs were identified according to the literature and our new observations. Multivariate analyses of region, elevation, latitude, urbanization, and other habitat factors were used to describe habitats occupied by species of philomycid and invasive slugs. The presence/absence of some philomycid slugs, such *Philomycus carolinianus*, from these statewide surveys support our theory that many museum specimens from this family are misidentified and consequently, ranges are incorrectly drawn.

Are Pennsylvania land snails susceptible to climate change?

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Climate warming has already altered distributions of some plants and animals and has potential to cause not just range shifts, but population extirpations in taxa that cannot easily move or adapt. Slow-moving snails might be susceptible to climate warming; indeed, the Aldabra banded snail (*Rhachistia aldabrae*) gained the distinction of being the first documented species extinction due to climate change. Two specific ways climate warming could threaten snails are (1) populations currently confined to mountaintops (habitat islands) might perish if the climate warms and they cannot move higher to cooler conditions, and (2) slow-moving land snails may be unable to disperse fast enough to stay within their shifting habitats.

Are snails of Pennsylvania, USA, susceptible to climate warming? In this study, we examine whether climate warming might threaten species due to upper elevation limitation, as well as the political boundary effect of species whose southern ranges might move northward out of Pennsylvania. Sampling included 108 sites across Pennsylvania, comprising 12 replicates at elevations in 100m increments from 100 to 900m elevation.

Numbers of species, abundances and Shannon diversity all decreased at higher elevations. Most individual species tended to occur more at lower elevations or throughout elevations, so they are probably not threatened by climate warming. However, some species occurred mostly at higher elevations, suggesting that their populations might decline with climate warming..

Evolution of asymmetrical larvae in freshwater mussels (Bivalvia: Unionoida: Unionidae)

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Freshwater mussels of the family Unionidae have a unique phoretic life history that utilizes specialized larvae called glochidia to parasitize freshwater fishes. Glochidia and their various morphological types have been important characters in freshwater mussel systematics for over a century and remain a phylogenetically informative criterion at most major taxonomic levels. Despite their demonstrated taxonomic utility, several glochidial morphologies have never been considered in an evolutionary capacity, including asymmetrical glochidia.

Asymmetrical glochidia are characterized by having a prominent marginal process on one of the two glochidial valves, dissimilar to all other know glochidial morphologies, which are consistently symmetrical. The genera bearing asymmetrical glochidia (i.e. *Contradens, Pseudodon, Solenaia, Trapezoideus,* and *Physunio*) are currently classified in two different subfamilies and the most recent phylogenies are inadequate to determine whether asymmetrical glochidium arose independently in two largely sympatric subfamilies or is a trait that evolved once in a common ancestor of these genera.

The objective of this research is to test whether asymmetrical glochidia are a product of a single evolutionary event (*i.e.* synapomorphic) or an adaptive convergence (*i.e.* homoplastic). This research uses a combined evidence approach that utilizes mitochondrial (CO1, 16S) and nuclear (28S) genes, as well as morphology to test the homology of asymmetrical glochidia. Tree estimation methods utilized include maximum parsimony, maximum likelihood and Bayesian inference. The results of this research will be discussed in the context of freshwater mussel larval evolution and classification.

Molluscan paleontologists at the National Museum of Natural History in the late 20th century

John Pojeta, Jr.

Research Associate, National Museum of Natural History
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The 1973 "Directory of Scientists at the National Museum of Natural History" listed ten men who were researching fossil mollusks. In addition to their study areas, I give various anecdotal information about their careers. Tom Gibson studied Atlantic Cenozoic mollusks; Mac Gordon studied late Paleozoic cephalopods of the midcontinent and Great Basin; Ralph Imlay studied Jurassic ammonoids; Erle Kauffman studied Mesozoic pelecypods; Harry Ladd studied Cenozoic gastropods and pelecypods; John Pojeta studied Cambrian and Ordovician pelecypods; Norm Sohl studied Mesozoic gastropods; Tom Waller studied Cenozoic pelecypods, especially scallops; Wendell Woodring studied Tertiary mollusks of the Caribbean; and Ellis Yochelson studied Paleozoic gastropods. Thus, we had very wide coverage both biologically and stratigraphically.

Of the ten, eight worked for the USGS and two worked for the Museum, but we formed a team. We also had five Museum Malacologists: "Father" Joe Houbrick who worked on *Cerithium*; Joe Morrison, who worked with fresh-water mollusks; Harald Rehder, who worked with Indo-Pacific mollusks; Clyde Roper, who worked with cephalopods; and Joe Rosewater, who worked in systematics and zoogeography of marine gastropods and pelecypods. Thus, we had an incredible group of 15 devoted to researching the Mollusca throughout Phanerozoic time.

The National Museum was a wonderful place to work and there was always someone to talk with about a problem or your latest brain storm before you turned it loose on the world. This large group of molluscan workers continuously attracted many colleagues, students, and visitors. As "the world turned on in the lathe of time," John Pojeta and Tom Waller are still active at the Museum; Doug Erwin joined the Museum staff in the 1990s, and Peter Wagner joined in the 21st century. *Inter alia*, they study Paleozoic gastropods; and there are four new faces in Malacology.

Comparative shell and shell microstructure of *Laternula truncata* and *L. cf. corrugata*

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While the taxonomy of laternulid bivalves at genus level appears resolved, there remains debate at the species level. *Laternula truncata* and *L. cf. corrugata* occur in close proximity in or along the margins of the mangroves of Kung Krabaen Bay, Thailand. *L. truncata* resides in sandy sediments nearer or within the interstices of mangrove roots, but in the more open portion of the mud flat. *L. cf. corrugata* lives deeper in the mangrove forest in more protected environs.

We have examined the shell and shell microstructure of these two anomalodesmatan bivalves with an eye towards taxonomic resolution. *L. cf. corrugata* is a small clam that often has a wrinkled shell structure, slightly thicker periostracum, and typically much greater umbonal erosion. The periostracum, at the ultrastructural level, is often seen to "accordion" along margins or sharp curves. The much larger *L. truncata* is thinner shelled, much more vulnerable to fracture, has "preformed" external shell spinules composed of flattened calcareous lathes, often has a glossy external appearance, and has a longer umbonal slit and deeper pallial sinus. Additionally *L. truncata* has a saddle-shaped lithodesma; a lithodesma is absent in *L. cf. corrugata*. The shell microstructure is prismatonacreous, typical of the group, but the prismatic layer is thin and appears truncated into small blocky columns and sometimes almost nonexistent. The bulk of the shell is tightly packed sheet nacre. Tall columnar myostracum is found under the adductor muscles emerging on the internal shell surface as irregular mounds. The obvious growth lines in *L. truncata*, more pronounced but fewer in number in *L. cf. corrugata*, appear as shallow rolling "hills" in the chondrophore, where they terminate as acute lathe-like tips.

Differences in shell microstructure in these two species must still be tested to confirm they do not represent biomineralization events that reflect habitat differences.

Characterizing the molecular basis of dispersed photoreception in the cephalopod *Octopus bimaculoides*

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Understanding the molecular basis of senses gives us insight into how sensory systems have evolved. Photoreception is excellent for exploring sensory system evolution, as we understand both the molecular basis and evolutionary histories of animal phototransduction cascade genes.

Cephalopod mollusks possess three distinct photoreception systems; most have camera-type eyes, light-sensitive brain regions, and likely some dispersed photoreception (Mathger *et al*., 2010, reviewed in Ramirez *et al*., 2011). The cuttlefish *Sepia officinalis* expresses r-opsin in the skin (Mathger *et al*. 2010). We have identified five r-opsin phototransduction genes expressed in the skin of the octopus *Octopus bimaculoides*, including r-opsin and G-protein α-q. These genes may be expressed at similar levels both dorsally and ventrally, suggesting similar numbers of photoreceptor cells on both sides. Although these data are limited, they suggest a common origin of dispersed phototransduction genes for these two cephalopod groups.

The sequences of dispersed r-opsins in both *S. officinalis* and *O. bimaculoides* are highly similar to the sequences of eye r-opsins, and the same cascades may mediate both photoreception systems. However, this may not be the case at broader taxonomic scales; dispersed photoreception responses in the gastropod snail *Lymnaea stagnalis* are abolished by a pharmacological agent that affects cyclic nucleotide gated (CNG) ion channels (Pankey *et al*., 2010). CNG is typically associated with the c-opsin pathway, rather than the r-opsin cascade we have identified in octopus skin.

Thus, dispersed photoreception may have evolved multiple times within different molluscan lineages. Overall these results suggest that dispersed photoreception genes may have been co-opted from existing systems in cephalopods, but that this is likely not true of all dispersed photoreception systems in molluscs.

Gastropods of caves in the Grand Duchy of Luxembourg

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Between 2007 and 2011, the fauna of 82 caves in the Grand Duchy of Luxembourg was studied. Altogether 90,000 individuals were collected, comprising 516 gastropods in 28 species. Most species were registered in low numbers and near the entrances of the caverns. Only three species were found regularly and abundantly within the caves and can be classified as limited cavernicolous. *Discus rotundatus* represents the most common species, with 45 % of the registered specimens. *Oxychilus cellarius* and *Helicodonta obvoluta* represented another 13 % each. The ten most common species contributed 93 % of the registered snail specimens.

Arion distinctus and *Discus rotundatus* were the species that were found at the furthest point of the entrance 250 m within the cave. Nine, or 32 %, of the registered species were found nearby the entrance. Another nine species entered up to 25 meters into the cave. Only 10 species were found in the rear areas of the caves. Especially members of the slug families (*Arion spp., Boettgerilla pallens*) were found deep within the caves. However, most of these specimens were juvenile, which made a determination to species level impossible.

All species that were found within the caves represent common and widespread species of the snail fauna in the Grand Duchy of Luxembourg.

Exploration at the verge of extinction – estimating diversity in the tropical land snail family Helicinidae (Neritopsina)

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Helicinids represent a family of classic tropical land snails with a distribution range limited to the subtropical and tropical zones of the New World, the Australasian and the Pacific region. Hot spots of helicinid diversity are typically found on different island sites, e. g. the Greater Antilles and certain Indo-Pacific islands.

Although not as severely threatened as other tropical land snail families such as Endodontidae, Partulidae and Achatinellidae, the Helicinidae are faced with extinction in some areas. As almost exclusively forest dwelling species with often high requirements for suitable habitats they suffer almost everywhere at least a dramatic loss of habitat. This not only results in limited available material, but highly fragmentary data on distribution, the documented range of variation etc.

Against this background, and based on case studies in the different parts of the world (Costa Rica, the Lesser Antilles, New Caledonia and Pacific islands), specific and general challenges in approaching diversity estimates are discussed. A critical review of the available data from the different regions will be presented with a new estimate of the worldwide diversity, which will help to expose poorly studied areas and highlight the main sources of new species.

In helicinids, the greatest specific drawbacks to systematic work, and thus to judging diversity, include: a limited number of recognised differentiating characters; still-questionable systematic concepts and the absence of a robust higher phylogeny, and intergrading shell morphologies and multiple cases of convergence, not only in shell shape but in radula characteristics as well. An annotated outline of the past research on Helicinidae will round off the presentation.

Teleplanic molluscan larvae, and the often specific substrata, hosts or prey of their postlarvae

Robert Robertson

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The meaning of the word “teleplanic” is newly refined to indicate a planktonic stage arbitrarily lasting more than about three months. After this, the larvae must be known to found distant recipient breeding (?) populations of adults. Teleplanicity is a character state grading from non-teleplanicity, and about nine major clades of mollusks have independently evolved the modes of life adapted to it.

Teleleplanicity is reported definitely in one genus of neritoideans, in 14 families of caenogastropods, in one "lower heterobranch," in one opisthobranch, and in two unrelated families of bivalves. Teleplanicity is newly inferred in the Nassariidae, and five of the other families are in the superfamily Tonnoidea. Doubtful teleplanicity is recorded in 12 additional families (all but two of them caenogastropods). They include notably the Cypraeidae, Strombidae and Conidae, each of which has some geographically widespread species. Thus these distributions do not reflect teleplanicity *per se*. Some are potentially teleplanic, but the data are insufficient to establish this.

A literature review shows that detritivorous, herbivorous and predatory gastropods ranging from foragers to symbionts have these specialized larvae, but parasites appear not to. Settlement responses are little known, and delayed metamorphosis is often involved. Many of the larval gastropod identifications in the literature are unreliable, and thus much taxonomic work is still needed.

Facing the onslaught of invasive snails and slugs: one country's defenses against the introduction and establishment of non-native agricultural and environmental pests

David G. Robinson

USDA APHIS PPQ

With increasing globalization of international trade, the threat of invasive snails and slugs is becoming apparent to most governments in the world. Within the United States Department of Agriculture (USDA), the responsibility to mitigate the risk of pest and disease introductions while adhering to obligations under international trade agreements is undertaken by Plant Protection and Quarantine (PPQ), a division of the Animal and Plant Health Inspection Service (APHIS). The agency uses an array of defenses to mitigate the risk of pest introductions.

Prevention of introduction: at all airports, seaports and land border crossings, containers and shipments of plants, fruits and vegetables are inspected, as well passenger baggage, in cooperation with other government agencies, and using a network of inspectors, port identifiers and national taxonomic specialists. Analysis of tens of thousands of mollusk interceptions and detailed pathway analysis indicate the focus of inspections. Infested shipments are fumigated, returned to country of origin, or destroyed. The agency also cooperates with governmental agricultural and environmental agencies in other countries, providing training, taxonomic support, and establishing preclearance and pre-departure programs.

Prevention of establishment: PPQ has coordinated programs to prevent pest establishment - surveys of higher risk areas such as ports, container yards, greenhouses and nurseries, pet shops, tile and marble operations, in cooperation with a network of domestic identifiers and individual state governments. Surveys include visual methods, using traps and specially-trained canine teams, as well as public education programs and coordination with academic institutions.

Once a pest is detected, and determined to be a threat, then suppression or eradication programs are initiated. These involve establishment of quarantine zones, modification of agricultural practices and commercial activity within zones, and integrated pest management (IPM). Control costs are justified by the greater costs to agriculture and the environment if a pest were to become established.

Sepiola atlantica: the mating behavior

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The reproduction of cephalopods includes various types of behaviour, comprising: agonistic, courtship, mating and any form of a parental care. Here, the mating behavioral pattern of the bobtail squid (*Sepiola atlantica*) was observed and described for the first time in laboratory conditions. A total of seven matings were recorded.

Our observations coincide with those on other sepiolid species; mating consists of five stages, and a possible female pre-copulatory behavior was observed. No courtship was noted in any of the mating events. In all the cases, the male moved quickly towards the female, holding her by the middle of the ventral region of the mantle with his arms. The male, situated below the female, introduced his dorsal arms (the left dorsal arm is hectocotylized and passes the spermatophores) into the mantle cavity of the female, while grasping her by the ventral region with his laterodorsal arms and by the neck with his lateroventral arms, sometimes introducing them into the female's mantle cavity. The male showed the same pattern of coloration during the entire mating process, whereas the female changed slowly and successively her chromatic pattern. The duration of the mating varied between 68 and 80 minutes.

Investigations into the systematics and conservation genetics of freshwater mussels

Kevin J. Roe

Iowa State University

Since 1995, when I received the research award from the society for investigating the molecular systematics of the freshwater mussel genus *Potamilus*, my research program has grown in terms of taxonomic breadth to include fishes and shrimps in addition to unionid mussels. In addition to incorporating changes in phylogenetic methodologies over the years, I have also added tools such as microsatellite markers and a population genetic perspective. These changes have allowed me to begin to address a wider range of questions than was possible for me 17 years ago.

Since a large number of freshwater mussel species are considered to be of conservation concern, much of my present research is driven by questions that are originally posed by conservation managers. These questions can involve the delineation of species, as was the case with *Potamilus* all those years ago and is still the case with other mussel species today. Understanding how genetic diversity of a species is distributed across the landscape can also provide valuable information regarding the processes that have affected those species and can provide guidance to managers as to how to best preserve them. I will use the allotted time to describe several such projects, including some that are currently being completed by graduate students in my lab.

Rogers-Bennett, L., Stierhoff, K. & Butler, J.

Canceled

The endangered White Abalone (*Haliotis sorenseni*) on the edge of extinction

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There are seven species of abalones (genus *Haliotis*) along the west coast of the United States, of which two are endangered, three are species of concern with one proposal pending and just one has abundant populations supporting a recreational fishery in northern California.

Abalones were overfished during the fishery from the 1950-1980s. The fishery for white abalone was closed in California in 1996. White abalone was a minor component in the fishery, with a total catch of 275 mt in California. The majority of white abalone landings came from San Clemente Island, where populations are now extremely low. In 2001, white abalone became the first marine invertebrate to be federally listed as an endangered species. A recovery plan for white abalone was adopted in 2005 focusing on enhancing populations using captive rearing and continued monitoring of wild populations. The captive rearing program has been impacted by a bacterial disease that can cause mortality when coupled with warm water. Today, the wild population in California is centered on offshore banks, where populations continue to decline despite protection from fishing. The existing population is made up of old, large individuals and there has been no sign of recruitment of juvenile or mid-size individuals for more than two decades. Mortality estimates made comparing densities using a ROV at one offshore bank are high; on the order of 14% per year. Estimates of population size for white abalone in 2011 in the California portion of the range number just 5,300 individuals left in the wild. In order for conservation actions to move forward, we need to increase the numbers of white abalone through captive rearing and stocking, coordinate with abalone conservation efforts in Mexico, conduct research to quantify recovery and increase support to implement the recovery plan.

What is the magnitude of known diversity of Recent mollusks?

Gary Rosenberg

Academy of Natural Sciences of Philadelphia, Pennsylvania

The total magnitude of Recent species-level diversity in the Mollusca is often estimated at 100,000 to 200,000 species, including both known and unknown species. Prerequisite to estimating what remains to be discovered is understanding what has already been described, *i.e.* named.

Lydeard et al. (2004) estimated that 24,000 terrestrial and 7,000 freshwater species have been described, and Bouchet (2006) estimated 52,500 for marine mollusks, suggesting an overall total of about 85,000 (allowing for more species having been named since those estimates were made). As efforts towards explicit enumeration proceed, it appears that these estimates might be too high.

The World Register of Marine Species (WoRMS) currently records only 40,250 species of marine Mollusca, yet several methods of semi-random sampling suggest that it is more than 90% complete for most taxa and geographic areas. Remaining gaps in coverage, for South Africa and in Tellinoidea, Pyramidelloidea and Nudibranchia, are unlikely to add another 30% to the tally for marine mollusk species. Also, the WoRMS database has 2-3% duplication (species listed as valid in more than one genus), which will reduce the overall total as duplicates are removed. Further uncertainty arises in that many species have not been treated taxonomically in over 100 years or are known only from their type localities.

The number of described marine mollusks may be as low as 45,000 species, and total described molluscan diversity may be around 75,000 species.

A brief history of Malacology at the Academy of Natural Sciences of Philadelphia

Gary Rosenberg

Academy of Natural Sciences of Philadelphia, Pennsylvania

The Academy of Natural Sciences, founded in 1812, was the birthplace of molluscan studies in North America. Thomas Say (1787-1834), one of the Academy's founders, is regarded as the father of American Malacology and Conchology: he was the first American to name species of mollusks. Before his time material had been sent to European scientists for naming. Since Say began building the Academy's collections, there have always been malacologists affiliated with the Academy. Among them are Charles Alexandre Lesueur (1778-1846), Constantine Schmaltz Rafinesque (1783-1840), Isaac Lea (1792-1886), Samuel Stedman Haldeman (1812-1880), Timothy Abbott Conrad (1803-1807), George Washington Tryon (1838-1888), Henry Augustus Pilsbry (1862-1957), Horace Burrington Baker (1889-1971), and R. Tucker Abbott (1919-1995).

Many of their works on mollusks, and in other areas of natural history, were published in a variety of scientific journals founded at the Academy: *Journal of the Academy of Natural Sciences*, *Proceedings of the Academy of Natural Sciences*, *American Journal of Conchology*, *Manual of Conchology, The Nautilus*, and *Indo-Pacific Mollusca.*

The Academy has recently been awarded a grant from the National Science Foundation to create digital images of type specimens of more than 12,000 nominal species in its Malacology collection and make them available online. These images will make it easier to evaluate the taxonomic legacy of Academy malacologists and will also provide access to type material from more than 600 other authors held by the Academy.

Amber Snail management in Pacific Northwest nurseries

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Oregon State University and FarmForest Research

The amber snail species *Oxyloma sp*. and *Oxyloma retusa* (Gastropoda: Succineidae) are established in some nursery production sites in the Pacific Northwest and occasionally become plant shipment contaminant pests. The goal of this research was to investigate strategies to disinfest nursery plants prior to shipment.

Two separate chemical trials were conducted: Trial 1, in September of 2010, and Trial 2 in March of 2011. In each trial, six treatments were compared to an untreated control for their effect on snail mortality 24 hours after treatment. The treatments were carbaryl, methiocarb, cinnamon oil, metaldehyde, capsaisin + mustard oil, and limonene. In Trial 1, each treatment had five replications, which consisted of four-inch containers filled with potting mix simulating a nursery plant. One day prior to treatment 20 snails were applied to the potting media of each container. In Trial 2, each treatment had eight replications and naturally infested nursery plants were used. In Trial 1, carbaryl and methiocarb, provided effective control of amber snails within 24 hours (90% and 88% mortality respectively).

Two of the botanically-based products, limonene (78%) and capsaisin + mustard oil (71%), demonstrated good activity against the snails. Percent mortality of metaldehyde (37%) and cinnamon oil (27%) were not statistically different than the untreated control (17%). In Trial 2 with the naturally infested plants, only carbaryl, methiocarb, and metaldehyde were significantly different from the untreated control.

The influence of diphenhydramine HCl and caffeine on embryonic development and reproductive success of *Helisoma trivolvis*

Diana Sanchez

Montclair State University

Serotonin (5-HT) plays important roles in the mediation of embryonic development in *Helisoma trivolvis*, a locally abundant freshwater snail. The increase of 5-HT concentrations can increase embryonic rotation and double the embryonic development timeframe. The expression of 5-HT1 and 5-HT7 receptors in *H. trivolvis* may further specify the expression of the mediating neural activities of 5-HT during embryonic development in *H. trivolvis*.

As one of the common pharmaceuticals detected in New Jersey (USA) waterways, diphenhydramine HCl (DH) can increase the concentration of serotonin in *H. trivolvis* by inhibiting the reuptake of serotonin. The inhibition of serotonin can also occur in the presence of caffeine. In US waterways and drinking water nationwide, the commonly high concentration and detection frequency of caffeine can increase the influx of calcium (Ca2+) in *H. trivolvis* by inhibiting the reuptake of adenosine. Caffeine acts as a competitive inhibitor with adenosine, a regulator of Ca2+ release. The inhibition of adenosine can produce the presence of high intracellular Ca2+ concentrations, which in turn can mediate the inhibition of serotonin. Consequently, a pharmacological exposure to DH or caffeine may influence developmental regulations and create embryonic changes in *H. trivolvis*.

Low concentrations of DH or caffeine allow average embryonic development; yet, high concentrations may influence embryonic development within egg capsule rate of development, hatchings, and number of viable offspring hatched. The reproductive success of adult *H. trivolvis* may also be influenced when exposed to high concentrations of DH or caffeine. Diphenhydramine is a major component of one of the most common over-the-counter antihistamines, and caffeine is a major component of many commonly consumed beverages. Both could have important implications to the health and reproductive success of helisomid and other freshwater molluscs.

Sanchez, K., Nadler, S. &
Caswell-Chen, E. P.

Poster

The role of terrestrial mollusks in phoresis and vectoring of plant parasites, bacteria and fungal pathogens

Kristi Sanchez, S. Nadler & E. P. Caswell-Chen

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Department of Plant Pathology, Nematology, and Entomology

Terrestrial mollusks are common and important pests in California nurseries. They damage succulent plant material and young seedlings or foliage, and damage during early plant growth can cause severe reductions in the value of commodities such as ornamental plants and flowers. The Brown Garden Snail *Helix aspersa* is estimated to cost California over $7 million every year through damage to ornamental plants and fruit trees. Little is known concerning the potential of these mollusks to serve as transport hosts or vectors for nematodes, bacteria, or fungi.

Our research has revealed a range of bacterial, fungal, and nematode taxa that are common associates of *Helix aspersa*, including species that are plant pathogenic. The associates vary with the environment from which the snails were collected. Approximately 90% of the snails we sampled carried a diversity of nematodes, including the plant-parasitic nematodes *Aphelenchoides fragariae, Aphelenchus avenae* and *Xiphinema index*. *A. fragariae*, the foliar nematode, is a pathogen in ornamental and floriculture production. We also recovered bacterial-feeding nematodes such as *Caenorhabditis elegans* and *Panagrolaimus spp*. The fungal associates isolated from snails and slugs included *Rhizoctonia spp*., *Pythium spp*., *Fusarium oxysporum*, *Aspergillius versicolor* strain, and *Mucor hiemalis*. The bacterial isolates include *Sphingobacterium kitahiroshimense*, *Pseudomonas putida, Stenotrophomonas maltophilia, Arthobacter spp*., and *Enterobacter spp*.

The majority of the fungal and bacterial isolates (85%) were recovered from the foot muscle, followed by the feces (75%), digestive gland (50%), and shell (35%). The potential use of terrestrial mollusks as bioindicators for plant pathogens is discussed. Improved understanding of the role of mollusks in dispersal of microbes may aid in the development of new and effective pest management strategies. We contend that terrestrial mollusks likely play an important role in the dissemination of plant pathogens in California agriculture.

Reflections on the current status of living populations of *Nautilus* and *Allonautilus*

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There have been few efforts to document the occurrence of living populations of *Nautilus* and *Allonautilus* in the Indo-Pacific. Indeed, most data on living populations historically derive from indigenous artisanal fisheries information. Few accounts document new occurrences of living populations or fruitless trapping efforts indicating that *Nautilus* is not present at specific locales. Confounding the issue is the postmortem distribution of the drifted shells. The overall range of living *Nautilus* and *Allonautilus* reflects the distribution of the best-known species, *N. pompilius* Linnaeus. While the two genera are thought to include as many as six or seven species, all but *N. pompilius* seem to be geographically isolated endemic species (*e.g. N. macromphalus*, New Caledonia-Loyalty Is; *N. stenomphalus*, Great Barrier Reef; *N. belauensis*, Palau; *N. p. suluensis*, Tubbataha Reef, Philippines; *N. repertus*, W. Australia; *A. scrobiculatus*, Admiralty Is., Papua New Guinea, and *A. perforatus*, W. Indonesia?).

Nautilus and *Allonautilus* have been recently shown to exhibit phenotypic and genetic variation between and among geographically isolated populations. Additionally, fisheries data, particularly from the Philippines, indicate that overfishing has resulted in regional stock depletions. Thus, it is not presently possible to answer such questions as: "How many species of *Nautilus* and *Allonautilus* are there? Should any populations or species be considered as overfished generally or at specific locales? Should *Nautilus* and *Allonautilus*, or any of the component species, be listed as endangered in CITES?"

Our view is that it would be premature to recommend summary listing of *Nautilus* and *Allonautilus* as threatened or endangered at this time. While we believe that individual, small, isolated populations of *N. pompilius* may be susceptible to overfishing and depletion, and that endemic species restricted to isolated archipelagoes (e.g., *N. belauensis*, Palau; *N. p. suluensis*, Tubbataha Reef) could be depleted to the point of extinction, there is simply insufficient knowledge of DNA, fisheries pressure and natural stock sizes to make an informed decision at this time.

How octopuses choose their prey

David Scheel & Diana Stanley

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The diets of some octopuses are well described from midden data, but prey choice by octopuses is poorly understood. In Prince William Sound, Alaska, the giant Pacific Octopus *Enteroctopus dofleini* consumes at least 52 species of prey, but middens are dominated by several species of crab. Relative to local abundance, some crab species are over-represented in middens (preferred) while others are under-represented (avoided by octopuses).

We examined characteristics and behaviors of preferred or avoided crabs to better understand how octopuses choose from apparently suitable and available prey. The size distribution of crab remains in middens was shifted towards larger species and larger individuals relative to crabs in the habitat, indicating a preference for larger prey. The crab *Lophopanopeus bellus* was avoided by octopuses relative to its abundance. This species was commonly parasitized by the rhizocephalan barnacle *Loxothylacus panopaei*, which interrupts crab growth and sexual maturation. Parasitized *L. bellus* were smaller but had higher energy per gram dry weight than non-parasitized *L. bellus*, while the whole body energy of parasitized crabs was not significantly different from that of the larger non-parasitized crabs.

The size distribution of *L. bellus* in octopus middens matched that of the larger non-parasitized crabs, indicating that avoidance of *L. bellus* by octopuses was due size selection by octopuses, but was not explained by energy density or whole body energy contents of the crab. Several crab species are adorned with bristles or decorations, which function as visual and possibly tactile crypsis. These prey are not preferred, and the more adorned species are avoided by octopuses. However, octopus choice does not reflect differences in shelter-seeking behavior of the crabs (in kelp versus burying or under rocks). Thus octopuses choose their prey largely based on size, but some aspects of prey detectability also influence octopus choice of prey.

Novel insights on the prevalence of gender conflict in *Biomphalaria glabrata*: autosperm buildup not a likely factor

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The freshwater, gastropod *Biomphalaria glabrata* is an important study organism because of its role as an obligate intermediate host for *Schistosoma mansoni*. Gender conflict, known as the preference for both snails in a mating situation to mate as male, is a unique mating behavior among simultaneous hermaphrodites. Earlier research on the freshwater pulmonate species *Lymnaea stagnalis* and *Physa heterostropha* has shown that gender conflict is more likely to occur as the period of isolation prior to mating increases. These studies suggested that gender conflict arises because of autosperm buildup. However, little information exists regarding the effects of pre-copulatory isolation of snails on the prevalence of gender conflict in *B. glabrata*.

The purpose of this study was to determine if gender conflict was more likely to occur among snails isolated prior to mating, and if the autosperm buildup hypothesis can explain the occurrence of gender conflict. Snails were either placed in separate containers, or placed in a common container with a porous barrier that prevented movement of snails between compartments but allowed for the free exchange of water between the snails. Over an eight-week period, we found that gender conflict was more frequent among snails that had been completely isolated prior to pairing. The snails that were only physically separated from other snails experienced gender conflict at a significantly lower frequency than the snails completely isolated prior to pairing, suggesting that the autosperm buildup hypothesis does not explain the prevalence of gender conflict among *B. glabrata*. Additionally we also tested to see if gender conflict is a time-sensitive phenomenon. We found that the frequency of gender conflict increased as the period of isolation prior to pairing increased. These results suggest that factors affecting gender conflict in *Biomphalaria glabrata* may differ from those seen in other species studied to date.

Phylogenetics and evolution of Jamaican Pleurodontidae

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The pulmonate family Pleurodontidae (formerly placed in Camaenidae) is one of eight endemic-rich families of land snails in Jamaica. Thirty endemic Jamaican pleurodontid species are currently classified in the genera *Pleurodonte*, *Dentellaria*, *Thelidomus* and *Eurycratera*, but their evolutionary history within the family has not been rigorously examined with molecular phylogenetics. We obtained partial sequences of mitochondrial cytochrome *c* oxidase subunit II (COII) gene, 16S ribosomal RNA (rRNA) gene, and nuclear 28S rRNA gene from 70 Jamaican pleurodontid individuals, 24 non-Jamaican pleurodontid individuals, and twelve outgroups including Cochlicellidae, Helminthoglyptidae, Hygromiidae, Sagdidae, and Scolodontidae.

Phylogenetic analysis strongly supports the monophyly of Jamaican species and the polyphyly of the genus *Pleurodonte*. Jamaican *Pleurodonte* did not group with *Pleurodonte* (*sensu stricto*) from the Lesser Antilles, but with *Dentellaria* from Jamaica. These results suggest that a single colonization event with subsequent radiation established the Jamaican pleurodontid fauna. The large degree of sequence divergence within some Jamaican pleurodontid species suggests some taxa described at the varietal level need to be elevated to full species status. In addition, some supposed ingroup taxa (*Caracolus*, *Solaropsis*, *Zachrysia* and *Parthena*) grouped strongly with Jamaican Sagdidae. This suggests that Pleurodontidae is not monophyletic and that the subfamily Polydontinae might be more closely related to Sagdidae.

Phylogenetic analysis of four protein-encoding genes largely corroborates the traditional classification of Bivalvia (Mollusca)

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Revived interest in molluscan phylogeny has resulted in a torrent of molecular sequence data from phylogenetic, mitogenomic, and phylogenomic studies. Despite recent progress, basal relationships of the class Bivalvia remain contentious, owing to conflicting morphological and molecular hypotheses. Marked incongruity of phylogenetic signal in datasets heavily represented by nuclear ribosomal genes versus mitochondrial genes has also impeded consensus on the type of molecular data best suited for investigating bivalve relationships.

To break this impasse, we evaluated the utility of four nuclear protein-encoding genes—ATP synthase β, elongation factor-1α, myosin heavy chain type II, and RNA polymerase II—for resolving the basal relationships of Bivalvia. We sampled all five major lineages of bivalves (Archiheterodonta, Euheterodonta [including Anomalodesmata], Palaeoheterodonta, Protobranchia, and Pteriomorphia) and inferred relationships using maximum likelihood and Bayesian approaches. To investigate the robustness of the phylogenetic signal embedded in the data, we implemented additional datasets wherein length variability and/or third codon positions were eliminated. Results obtained include (a) the clade (Nuculanoida + Opponobranchia), i.e., the traditionally defined Protobranchia; (b) the monophyly of Pteriomorphia; (c) the clade (Archiheterodonta + Palaeoheterodonta); (d) the monophyly of the traditionally defined Euheterodonta (including Anomalodesmata); and (e) the monophyly of Heteroconchia, i.e., (Palaeoheterodonta + Archiheterodonta + Euheterodonta).

The stability of the basal tree topology to dataset manipulation is indicative of signal robustness in these four genes. The inferred tree topology corresponds closely to those obtained by datasets dominated by nuclear ribosomal genes (18S rRNA and 28S rRNA), controverting recent taxonomic actions based solely upon mitochondrial gene phylogenies.

Structure and function of the fused tentacles in ommastrephid squids: dissertation research funded by the Conchologists of America

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The tentacles of ommastrephid squids fuse during embryonic development, remain fused as they grow through hatching, then separate to become two fully functional adult tentacles. The anatomy of the fused tentacles was examined in four species of ommastrephid squids at the gross, tissue, cell, and molecular levels of organization at multiple ontogenetic stages. The process of separation was described morphologically, and the mechanism of separation was identified as pre-programmed cellular death, or apoptosis. The role of the fused, separating, and post-fusion tentacles in feeding was explored, and a hypothesis of tentacle use was proposed.

The Conchologists of America provided funding that expanded the toolbox available to do this research by supporting the purchase of expendable supplies for scanning electron microscopy. The intangible benefits of the award were equally important, and included new technical experiences, new relationships with other outside faculty, learning to craft a compelling grant application, and experiencing the peer-review process.

A re-description of the du Pont Trophy (Shell Show Award: Outstanding Exhibit), with notes on distribution and ontogeny

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The du Pont Trophy for the overall outstanding exhibit at a shell show has been awarded by the Delaware Museum of Natural History (DMNH) since 1970. The Trophy symbolizes the important contributions that amateur naturalists have made and continue to make in popularizing the study of mollusks, and has been presented more than 600 times in the last 42 years. To mark the 40th Anniversary of the opening of DMNH, the du Pont Trophy was re-imagined and updated for the fourth time. This poster describes the history of the du Pont Trophy and introduces the justification for and design of the newest Trophy.

Significance of *Kuphus* tube morphology and microstructure for understanding the growth, taxonomy and ecology of a poorly known teredinid bivalve

John A. Sime & Gary Rosenberg

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Bivalves belonging to the genus *Kuphus* (Guettard) construct elongate, calcareous tubes that line the interior of their burrows within the sediment. The tubes, which may be more than a meter in length, evoke the common term "stove-pipe shells". The valves encased within the tube reveal their relationship within the Teredinidae or "shipworms," a group of otherwise xylophagous, wood borers.

However, the biology of *Kuphus* species remains poorly known by comparison to other members of this group. In particular, few descriptions of the tube exist in the scant literature. Preliminary observations suggest that a detailed description of tube morphology and microstructure could begin to elucidate basic facts about the growth, taxonomy, and ecology of the genus. We report our observations of the tubes of *K. polythalamia* (Linnaeus) in the collection of the Academy of Natural Sciences from the Philippines and "East Indies." The tubes show evidence of episodic growth; rest periods are demarcated by the edge of older tube segments overlapping the next extension. During a hiatus in growth a "cap" is secreted over the anterior end of the tube, sealing the animal off from the surrounding sediment, only to be resorbed prior to further growth.

Sections were made through the tube to clarify the type of contact between growth segments. Further sectioning showed the sculpted interior of the tube where the pallets insert to close the posterior end, which may be of taxonomic importance. Comparison with tubes of *K. incrassatus* (Gabb) from the Gulf Coast and Caribbean (Eocene to Miocene) shows clear differences in morphology separating these species, although this may be attributable to habitat or substrate preferences. In all *Kuphus* species the tube's external surface records characteristics of the substrate, such as the presence of wood, bioclasts, or coarse sediment, as agglutinated particles or molds..

Giant African Land Snail in Florida: introduction and state response

Paul E. Skelley

Florida Department of Agriculture and Consumer Services, Gainesville, FL

The Giant African Land Snail *Lissachatina fulica* (Bowdich) has been discovered in Miami-Dade County, Florida. This talk introduces the snail and discusses what the state is doing to eradicate the pest.

Discovering land snail diversity faster than a snail's pace: DNA barcoding helps reveal secrets hidden within the shell

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There are approximately 25,000 described species of land snail, with an estimated 10,000-40,000 species awaiting discovery. Uncertainty about the diversity of these snails reflects their high endemism, incomplete sampling, and limited revisionary taxonomy. DNA barcoding efforts designed to generate sequence data for species identification also provide data that can inform morphological studies. For example, the terrestrial littorinoid genus *Tropidophora* from Madagascar, East Africa and Indian Ocean islands is renowned for high levels of intraspecific variation in genital anatomy as well as shell sculpture, color, and pattern, leading some researchers to assume the group is composed of a few highly variable widespread species that are taxonomically over-split.

However, CO1 sequence data suggests that intraspecific variation may appear remarkably high because there are numerous cryptic species, many of which are sympatric and bear subtle but consistent morphological differences. As another example, in the genus *Daedalochila* (Stylommatophora, Polygyridae) from North America, the two largest species are differentiated by a few apertural characters and the shells are otherwise fairly variable. Sequence data suggest that both are species complexes. This is confirmed with genital characters and subtle shell characters.

These comparisons and others suggest that a great deal of cryptic diversity exists in many groups of terrestrial snails, both in the poorly known tropics as well as in better sampled areas. Sequence data can offer a quick way to highlight problematic species and groups for targeted morphological and genetic investigation. Uncovering hidden diversity within terrestrial snails is particularly important given that non-marine mollusks have suffered the highest numbers of extinctions of all animal groups in historic times.

Vermeij Crushing Analysis: analyzing crushing predation in Miocene mollusk communities

Emily S. Stafford* & Lindsey R. Leighton

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The Miocene (~11 million years old) St. Mary's Formation of Maryland consists of an extraordinarily well-preserved assemblage of marine mollusks. At Little Cove Point, we collected four to six adjacent six-liter samples at four separate exposures and sorted the fossils by genus. Claw fragments of crushing crustacean predators indicate that durophagy occurred in the community, although the poor preservation of most crustacean material makes it difficult to estimate the abundance of crushing crustaceans. Evidence of drilling predation by gastropods is more apparent: naticid drillholes are very common on both bivalve and gastropod prey, including naticids themselves.

Vermeij Crushing Analysis (VCA) (Vermeij, 1982; Stafford and Leighton, 2011) is a method of estimating crushing mortality in both modern and fossil gastropod assemblages. While some crushing damage is distinct (e.g., aperture peeling by crabs), taphonomic (port-mortem) damage may mask or mimic much predatory fragmentation. VCA uses shells with complete naticid drillholes to establish a baseline of taphonomic damage. Drilled gastropods have a known cause of death, so additional damage is taphonomic. This baseline is subtracted from the total damage on undrilled shells, isolating the damage from crushing predation.

We applied VCA to fossil gastropods from the St. Mary's Formation. As with modern *Olivella* (Stafford and Leighton, 2011), certain types of damage occurred more frequently in undrilled shells than drilled shells, indicating predatory origin. These damage categories (aperture chips 10-90^{o} and 90-180^{o} around the whorl) are consistent with known crustacean attacks. Furthermore, VCA indicated predatory origins of less distinctive damage, including shallow aperture chips and columella damage, which can result from crustacean attack but are more difficult to distinguish from taphonomic damage. Vermeij Crushing Analysis is a promising tool for assessing predation in gastropod assemblages, and merits further research.

Size-based predation on shortfin squid *Illex illecebrosus* in the northwest Atlantic Ocean

Michelle Staudinger

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The short-finned squid *Illex illecebrosus* is one of the most recurrent species of cephalopods found in the diets of dolphinfish, wahoo, tunas, billfish, and sharks that forage in offshore waters of the Northwest Atlantic. Despite their importance as a primary prey species, there is a lack of information on size-dependent relationships between short-finned squid and their predators.

In this study, size-based patterns in predation on short-finned squid were evaluated among 12 species of finfish and elasmobranchs, and three marine mammals. Stomach content analysis determined that squid body sizes ranged from 1.3 – 35.7 cm mantle length (ML), and the majority of squid sizes consumed by predators were 4 – 18 cm ML. Overall, marine mammals, sharks, and swordfish consumed the largest sized squid, while tunas consumed the smallest sized squid.

Linear and quantile regression were used to evaluate changes in mean, minimum, and maximum sizes of squid consumed by predators over ontogenetic scales; prey body sizes were found to increase in dolphinfish, wahoo, and tuna diets with increasing predator body size, but generally decreased in billfish, sharks and marine mammals. The majority of predators consumed squid that were ≤ 20% relative to their own body size, and overlap among predators for squid resources appeared to be high. Comparisons of resource use between large pelagic predators that forage in offshore waters and smaller demersal predators that forage in waters over the continental shelf, revealed that although large pelagic predators consumed greater amounts of short-finned squid, patterns in size-based predation were similar between the two groups.

Results provide information on how predation pressure is distributed over the life span of short-finned squid, as well as the portion of the short-finned squid population that is most important to supporting predator growth in the Northwest Atlantic Ocean.

The influence of litter species, chemistry and diversity on snail communities

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Snails and other elements of aquatic communities are strongly influenced by inputs of leaf litter, which often provide essential energy and nutrients. However, we have a poor understanding how different litter species, which can range widely in chemistry, specifically influence wetland communities. In addition, knowledge regarding the effects of mixed litter species remains poor, although it is predicted that chemical dissimilarity among litter species should increase secondary production.

We investigated the effects of litter, litter chemistry and litter mixtures in two outdoor mesocosm experiments where diverse communities were introduced that included controlled amounts of two snail species, *Physa acuta* and *Helisoma trivolvis*, in addition to algae, zooplankton, arthropod detritivores and tadpoles of multiple species. In the first experiment, treatments consisted of ten common deciduous leaf litter species, a no-litter treatment, and a complete-mixture treatment. In the second experiment, treatments consisted of either chemically similar or dissimilar litter species mixtures. Snail biomass, density, and egg production, and multiple other biotic and abiotic variables were measured over four months for each experiment.

In the first experiment, *P. acuta* response variables exhibited the most dramatic variation among all treatments, while *H. trivolvis* exhibited little response. In both red maple (*Acer rubrum*) and tulip poplar (*Liriodendrum tulipifera*) treatments, *P. acuta* were nearly absent from communities. In addition, *P. acuta* responded antagonistically to the litter mixture treatment, and responses were often associated with specific chemical aspects of litter treatments, predominantly soluble carbon and phenolic content. However, in the second experiment *P. acuta* exhibited little response to gradients in mixture chemical dissimilarity.

We conclude that the species of leaf litter provided to forested pond or wetland habitats may play a significant role in determining secondary production, particularly among snail populations. However, this role is determined more by individual litter species and not necessarily by litter chemistry.

How over-named are the ceriths? New species *vs*. digging in the graveyard of synonymy

Ellen E. Strong

Smithsonian Institution, National Museum of Natural History

The gastropod family Cerithiidae is a primarily shallow-water, marine group. The family contains ~185 species currently recognized as valid. They are typically abundant and gregarious grazers in intertidal to subtidal habitats around the world, with a center of diversity in the tropical and sub-tropical Indo Pacific. Several species are known to inhabit bathyal depths to ~1200 m.

The family is essentially subdivided into two subfamilies: the generally small-sized Bittiinae, and the Cerithiinae with large, solid shells. High levels of conchological variability within and between species have confounded efforts to understand the biodiversity of the family. The ruling paradigm has been of common, highly-variable, broadly-distributed species, each with often many synonyms. Intensive sampling programs targeting under-explored offshore hard bottoms in coral reef environments, coupled with new morphological and molecular data, are challenging this paradigm and revealing complexes of geographically circumscribed species, even from within large, familiar shallow water forms.

Currently, molecular data has been obtained for ~70 cerithiid species from the Indo Pacific. Of the ~40 species sampled from more than one locality, only 22 comprise a single species, including all those from deep water; the remaining 18 “species” comprise 46 deeply divergent molecular lineages. On average, two to three molecular lineages are recovered within these “species”, but some include as many as six unrecognized cryptic species. With the benefit of hindsight, these cryptic lineages are often easily diagnosable conchologically. Actual diversity of the family is estimated to be two to three times higher than currently recognized, requiring the description of many new species, and rescue of some of the roughly 1000 available names that have been sunk in synonymy or have fallen from use.

Chemosymbiosis feeds diversification of Lucinidae from the intertidal to the deep sea: new discoveries of the last 20 years

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Following the discovery in the 1980s of their obligate chemosymbiosis with sulphide-oxidising bacteria housed in the ctenidia, lucinids emerged from relative obscurity to become the focus of much biological research. With a depth range from the intertidal to around 2500 m and often associated with organic-rich habitats such as seagrass beds, mangrove, sunken vegetation, O_2 minimum zones and hydrocarbon seeps, they are also abundant and diverse in oligotrophic environments of IWP coral reefs and atolls.

Although by far the most speciose of the six families of chemosymbiotic bivalves, it was soon recognized, following this new attention, that the diversity of Lucinidae had been severely underestimated. Increased taxonomic effort over the last 20 years has resulted in descriptions of 40 new genera and 120 new species and more are in progress. Some of these new taxa result from critical examination of existing collections, but most have come from the increased sampling effort of the last 20 years particularly in tropical regions.

Notable are the intensive collecting expeditions to reefal habitats organized by Philippe Bouchet and colleagues, but also increasing attention to outer shelf and bathyal environments and the continuing discoveries of deep water hydrocarbon seeps and mud volcanoes. From the centre of IWP diversity in the Philippines, the 2004 and 2004 PANGLAO expeditions (NMHN), 14,670 lucinid specimens, both live and dead shells, were collected from the intertidal to 1200 m, totaling 71 species, including 23 new species and 3 new genera.

New molecular phylogenies of lucinids are being used to understand their diversification patterns, for example highlighting the predominance in deeper water habitats of two subfamilies, the Myrteinae and Leucosphaerinae.

The Pterioidea: diversity and disparity

Ilya Tëmkin

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The Pterioidea is a morphologically diverse group of marine bivalves with a fossil record extending as far back as the lower Middle Ordovician. Throughout the Phanerozoic, the pterioideans have occupied a remarkable variety of epifaunal and semi-infaunal habitats in tropical and subtropical continental shelf regions around the globe, and have been and continue to be integral components of different marine ecosystems, forming byssal attachment to diverse substrata.

The Recent Pterioidea have received much attention as a commercial source of pearls and nacre over the centuries, a model system for bone regeneration studies, and as invasive species. Despite its ecological and economic significance, the taxonomy of the group was greatly confused and little was known about its evolutionary history until a concerted research effort to address these questions was launched with impetus provided by the Conchologists of America grants to Malacology program.

This presentation discusses the significance of the COA contribution to the study of the Pterioidea and reviews most recent advances in understanding the diversity of the group. More specifically, it focuses on the current view of evolutionary relationships among major pterioidean lineages and highlights novel comparative morphological work on the hinge ligament and postlarval byssus.

Exploring cockles: where do we stand and who gets it done? A European perspective from a non-professional

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Among bivalves, cockles are generally known as one of the best studied families. Being a large family with a worldwide coverage and of considerable economic importance, this does not come as a surprise. With reviews at genus and subfamily level, phylogenetic studies and regional monographs being carried out in the past decades, one would expect that a point of saturation will be reached soon.

A closer look at the time scale and intensity of taxonomic cardiid research of the past 250 years reveals that the documentation of the cardiid fauna is far from settled. 25% of the currently accepted valid species have been described after 1980. Results from the past few decades make clear that diversity is much more focused in the Indo-Pacific than ever thought before. Until 1975, 45% of the described valid species originated from the Indo-Pacific, whereas 74% of the cockles described after 1975 come from this fauna province. Moreover, the number of described cockles has increased enormously since 1980 and alpha-taxonomic work is now almost exclusively being carried out by amateurs.

As an example, the cardiid fauna of Western Australia, a supposedly well documented region, showed an increase in diversity from 29 species in 1977 to 53 in 2012.

Also at higher taxonomic levels much remains to be done as evidenced by the currently undertaken 'Bivalves in Time and Space' (BiTS) project. Extensive morphologic and molecular phylogenetic research shows that our current evolutionary picture needs to be firmly adjusted. Thanks to the combined workforce of professionals, students and amateurs, studies like these can be undertaken.

Conservation Status of Freshwater Snails of the United States and Canada

Jeremy S. Tiemann

Freshwater Mollusk Conservation Society's Gastropod Distribution and Status Committee
Illinois Natural History Survey

After almost a decade of work the American Fisheries Society (AFS) gastropod conservation status review is almost complete. The document covers all native species in Canada and the United States and includes updated taxonomy and state distributions in addition to current conservation status. Also included are brief descriptions of each family, plates of shells with representatives of each family, and some photos of live individuals and brief discussion of threats and imperilment patterns. Also of interest to readers are several examples of recent gastropod recovery success stories.

Six hundred ninety eight species, representing 16 families are recognized. Of those, 67 are considered likely extinct, 275 endangered, 102 threatened and 71 vulnerable. Only 157 species (26%) are considered currently stable and 26 are of unknown status. The manuscript has been through a lengthy review process and should go to press early in 2012. In an agreement with AFS the gastropod and forthcoming revised mussel databases will be hosted on the Freshwater Mollusk Conservation Society's website.

Damn those dams - their negative effects on stream ecosystems

Jeremy S. Tiemann

Illinois Natural History Survey

Dams have been used for a variety of human purposes for more than 5,000 years. However, impoundments are one of the major sources of anthropogenic disturbances on streams. Dam building has resulted in highly regulated and severely fragmented stream ecosystems. Dam effects include converting lotic habitats to lentic habitats, changing flow regime, altering physicochemical parameters, increasing siltation upstream from and scouring substrates downstream from the dam, altering aquatic assemblages (e.g., reduced native species richness and abundance, and increased non-native species richness and abundance), and/or blocking movement of certain species, which results in restricted distributions and isolated populations. I have been investigating the effects of lowhead dams on Midwestern streams for the last 10 years and report on these outcomes for habitat, aquatic insects, fishes, and freshwater mollusks.

Spermatozoa morphology of *Brachidontes rodriguezii* (d'Orbigny, 1846) (Bivalvia)

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Brachidontes rodriguezii has a wide geographic distribution along the Argentinean coast, from 36º 32´S to Patagonia at 42º45´S. It is the most abundant species in the intertidal benthic community associated with rocky shores. In recent years, following the growth of the cities along the coast and the introduction of hard substrates as docks, sandy beaches have become a new habitat for this species.

The ultrastructure of spermatozoa is a useful tool to study bivalve phylogeny. We used transmission electron microscopy to study the structure of mature spermatozoa from *Brachidontes rodriguezii* and compared them with those of other bivalves, particularly other mytilids.

The spermatozoa of *B. rodriguezii* contained a spherical nucleus capped by a conical acrosome with an anterior extension. The chromatin was electron-dense, homogenous and compact. The mid-piece region consisted of 5 spherical mitochondria grouped in a ring around a pair of short cylindrical centrioles. The flagellum exhibited the typical 9+2 microtubule structure (9 double outer tubules + 2 single central tubules). Comparison is made with another *Brachidonte*s.

Ecology of *Gouldia californica* Dall, 1917, and *Olivella cocosensis* Olsson, 1956 in Isla del Coco

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The Isla del Coco National Park (5°32'N-87°04'W), is a Pacific oceanic island belonging to Costa Rica. The island lies 500 km from the mainland, and 630 km from the Galápagos Islands. The island is a Human Heritage Site (1997) and has high biodiversity. The number of mollusks reported is 428, with 135 species inhabiting sand bottoms.

In the present study the sand bottom was sampled with 135 van Veen Dredge runs at 27 stations in April, 2010. The species *Gouldia californica* Dall, 1917, (Veneridae) and *Olivella* (*Olivella*) *cocosensis* Olsson, 1956 (Olividae) were the most common in the sand. *G. californica* is characterized by its large anterior lateral tooth, reticulate sculpture, prominent concentric ribs in the middle, and small pallial sinus. The shell varies in the number of brown spots. This is a new report for Isla del Coco. The density was 33 (0-230) ind. per m^2. This species increased in abundance with depth (Spearman $r=0.50$, $p<0.05$), carbonates ($r=0.58$, $p<0.05$), grain size ($r=0.60$, $p<0.05$), sorting of sediment ($r=0.60$, $p<0.05$), and increased at fine skewness of sediment ($r= -0.55$, $p<0.05$).

O. cocosensis have a color pattern of white with amounts of brown. This snail has an upper dark band bordering the suture. The white porcellaneous inner lip extends near the suture of the last whorl. The main population in the Pacific occurs in Isla del Coco. The density was 3 (0-19) ind. per m^2. This snail showed an increase in abundance at lower organic matter % ($r= -0.36$, $p<0.10$), grain size ($r=0.45$, $p<0.05$), and at fine skewness ($r= -0.35$, $p<0.05$). Both species increased abundance offshore with low organic matter, and highly carbonates, and depth.

The poorly sorting increase the size of interstices (facilitate excavation of bivalves), and the food availability is high in fine skewness (benefiting the abundance of infaunal preys of *O. cocosensis*).

The vast frontier: exploring the unusual world of galeommatoidean bivalves

Paul Valentich-Scott

Santa Barbara Museum of Natural History

Often overlooked due to their diminutive size, galeommatoidean bivalves are one of the last great frontiers in bivalve natural history and taxonomy. Most species live in association with other invertebrates and many have elaborate morphologies to accommodate living with a host.

While hundreds of species have been described in the past 150 years, the past two decades have yielded an explosion of new descriptions and documentation of bizarre lifestyles. This presentation will emphasize the unusual body shapes and unorthodox lifestyles of these unusual clams, and highlight the unexplored diversity of galeommatoideans globally.

Causes of ecotypic variation in the dogwhelk *Nucella lapillus*

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Nucella lapillus has been extremely well studied as an important predator in intertidal systems and as a model organism in studies of phenotypic plasticity and ecotypic variation. While it is widely known that dogwhelks exhibit morphological variation, phenotypic plasticity and chromosomal polymorphisms, these aspects of variation have not been examined in concert. Differences in shell architecture, color, and patterns have been attributed to site-specific factors, gradients of wave exposure and induced defenses to crab predation.

Dogwhelks in Europe have a chromosomal polymorphism in which 2n ranges from 26 to 36. Here we provide results of a large-survey of shell morphological traits and preliminary results of karyotyping. There is significant variation in morphology between exposed and protected areas and among sites nested within areas. Exposed sites are morphologically far less variable than protected sites. Earlier reports state the karyotype in Maine is monomorphically 2n = 27; we found karyotypes range from 26 to 32. We will discuss the possibility that morphological variation and differences in karyotypes may act synergistically to produce observed patterns in phenotypic plasticity and ecotypic variation.

Cephalopod observations during the 2012 cruise of the *Okeanos Explorer* in the Gulf of Mexico

Michael Vecchione

NOAA/NMFS National Systematics Lab., National Museum of Natural History

From 19 March through 29 April 2012, a dual-body submersible system was used almost daily to conduct high-definition video observations at bathyal/bathypelagic depths in the northern and eastern Gulf of Mexico.

The system includes the *Seirios* camera sled attached to the ROV *Little Hercules*. I was interested in these dives because a resident population of sperm whales resides in this area, presumably feeding on cephalopods. Both vehicles recorded HD video of cephalopods on several dives. I will present excerpts from these observations, including long, detailed views of little-known deep-sea squids and octopods.

Equatorward increase in naticid gastropod drilling on bivalves across four ecoregions in Brazil

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Naticid drilling predation provides important evidence for the hypothesis of escalation, an evolutionary arms race of predator-prey interactions. Temporal trends can be explored using paleontological deposits, but evaluating the effect of geographic variation on apparent evolutionary patterns is challenging due to limited outcrops. Modern molluscan assemblages allow examination of latitudinal variation in drilling frequency (DF) with implications for the fossil record. Available spatial data on drilling are mostly limited to the Northern Hemisphere and are contradictory, supporting either a peak in drilling at mid-latitudes or an increase or decrease in DF with latitude.

We examined patterns in naticid drilling predation across 4000 km of coastline in Brazil from 6°S - 34°S. Bulk samples of modern shells were recovered in April 2009 every few degrees in latitude from 28 sandy beaches (in proximity to the usual habitat of infaunal naticids). Fieldwork covered tropical (Brazilian Province) and temperate (Argentinean Province) marine environments represented by the following smaller ecoregions from south to north: Rio Grande, Southeastern Brazil, Eastern Brazil, and Northeastern Brazil. All samples were picked and sorted with bivalves identified to at least genera. Abundance and drilling data were restricted to valves >85% intact; only taxa exhibiting infaunal and semi-infaunal life habits were analyzed for naticid drillholes (~24,000 specimens).

Comparison of assemblage level DFs indicated greater drilling in tropical (12%) vs. temperate (5%) provinces. The increase in drilling equatorward was further noted across ecoregions (<1%, 10%, 11%, 15%), but differences between Southeastern and Eastern Brazil were not significant. Rank correlation of DFs for all localities as well as combined for the 15 latitudes sampled yielded similar patterns ($p < .05$). Taxa commonly drilled in multiple ecoregions included *Anadara, Anomalocardia, Chione, Codakia, Divalinga, Mulinia, Strigilla,* and *Tivela*. Most DFs calculated at the genus level were greater also among lower latitudes within the Brazilian Province.

Continuing species discovery at hydrothermal vents and comparable habitats

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The deep sea covers over 67% of the planet Earth. Dominated by sedimented abyssal plains, we consider the largely unexplored deep sea to be typified by cold, oxygen-rich water. Once thought to rely exclusively on energy fixed by photosynthesis far above, deep-sea animals typically are diverse, but small and few. In 1977, however, discovery of hydrothermal vents and abundant animal life sustained by chemosynthesis revolutionized our view of the deep sea. At vents, super-heated, chemically reduced fluids emerge from the seafloor. Bacteria convert the chemical energy to forms that are available to animals. Comparable fluid chemistries exist at cold seeps, often fueled by petroleum or reduced organic deposits. Mollusca, Annelida and Arthropoda dominate the fauna in these habitats, surviving exposure to low-oxygen, high-sulfide or methane-rich fluids that would likely be lethal to non-specialized taxa. Vent and seep habitats can be dominated by a limited number of species that occur in great abundance.

A new vent species was described every ten days for 30 years after vents were discovered, a testament both to the distinctiveness of the fauna and the excitement of its discovery. Today, the rate of description has slowed but ongoing taxonomic refinements and the increasing exploration of new ridge systems continue to reveal new species. Even within well-explored areas, species likely remain undiscovered as marginal habitats tend to be under-collected and rare species are poorly represented in museum collections.

Detailed morphological and genetic studies currently underway will increase our knowledge of species diversity; this information is instrumental in enhancing our understanding of the history of the spreading ridges and of biotic exchanges among “cognate” habitats that may be generated by cold seeps, and whale and wood falls in the deep ocean.

Peeping through the keyhole: endoscopy of the mantle cavity of *Diodora aspera*

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The gastropod mantle cavity serves as the site of gas exchange, waste management, and gamete dispersal. The principle organs of the mantle cavity, the gills or ctenidia, drive the flow of water through the cavity and thus control these exchanges. Because they are housed within the body whorl of the shell, the mantle cavity and its organs have been difficult to observe under normal functioning conditions.

I used a mini boroscope (a type of endoscope) to peer inside the mantle cavities of living individuals of the keyhole limpet *Diodora aspera*. Video recordings indicate that the gills are inflated and fill the visible volume of the mantle cavity. When disturbed, individual leaflets can contract but quickly recover their original inflated positions. The restricted spacing between leaflets appears to correspond to the minimum space required for ciliary and water movements, maximizing the output of flow through the gill. Flow between the leaflets is extremely laminar; excurrent streams marked with dye maintain their integrity well beyond the apical opening of the shell and away from the mantle cavity.

Wadleigh, J. K., Absher, T. M. &
Bennett, K. F.

Poster

A sixth species within the scorched mussel (*Brachidontes exustus*) cryptic species complex

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Molecular phylogenetic analysis can uncover cryptic diversity in what had previously been considered a single species. The nominal *Brachidontes exustus* species complex is such an example, with five species identified by mitochondrial and nuclear gene trees. Each of the five species has a well-defined core regional distribution.

Previous analyses included specimens collected from the northwest Atlantic, Cape Verde Islands, Caribbean Sea and Gulf of Mexico, as well as transisthmian geminate species from the eastern Pacific. However, individuals from the south Atlantic portion of the range had not been included.

Cytochrome *c* oxidase subunit I (COI) sequences of nominal *Brachidontes exustus* specimens collected from Ilha do Mel, Paraná state, Brazil were incorporated into a gene tree along with representative sequences of specimens from the entire western Atlantic range of *B. exustus*. The Brazilian specimens cluster as a distinct clade, suggesting a sixth species within the complex.

Housekeeping through the Carychiidae (Eupulmonata, Ellobioidea) - DNA barcoding scours the rust of species splitters, lumpers and synonomies

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In an era of parsimony and streamlining, the terrestrial Holarctic ellobioid taxon Carychiidae provides an excellent case study for addressing the plethora of historical species designations. It is also a group demonstrating a severe paucity of morphological characters. Since the Carychiidae are hermaphroditic microgastropods (<2mm) inhabiting permanently moist aphotic zones of epigeal (*Carychium sp*. in leaf litter) and subterranean habitats (*Zospeum sp*. in karst caves), studies of their reproductive system for species delimitation have been futile.

Many microgastropod species designations were established during the mid-eighteenth to twentieth century heydays of species discovery. The rampant quest for glory led naturalists to either split ("splitters") species by recognizing them according to trivial differences in shell morphology or to group them ("lumpers") based upon common morphological traits. Conchological features such as shell length, shell width, ratios of shell dimensions, number of whorls, striation and structure as well as position of the lamellae comprising the columellar apparatus have been signatory in carychiid species classifications. Evolutionary mechanisms such as phenotypic plasticity (i.e. environmentally-driven shell variability for *Carychium spp*.) and morphological stasis (in *Zospeum spp*.) were not considerations then, but need to be now.

By integrating DNA barcodes (650 base pair fragments of the Cytochrome C Oxidase Subunit 1 (CO1)) to identify and delineate carychiid microgastropods, we were able to separate over 90% of the taxa. Cryptic and incipient speciation was found in the cave-dwelling genus *Zospeum* and the putative species *Carychium stygium*. In a retrospective morphometric application, we investigated historically established conchological characters of DNA-barcoded individuals of two European *Carychium* species. Revealed was a continuum of intraspecific conchological variability indicating wide areas of overlap between taxa. The conventional practice of separating species based on shell morphology alone was sufficient for a qualitative species assignment whereby the most characteristic morphotypes were selected for analysis. Molecular analyses enabled a quantitative species assignment for sympatric populations, intermediate morphotypes and juveniles. A revision of the Carychiidae considering this genetic data, conchology and the fossil record in a complementary, integrative approach beyond the visual level of taxonomic descriptions is in progress.

Sound nomenclature: how to find reliable names for the diversity

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The presence of millions of animal species creates the need to use unique names for trouble-free communication. In the electronic age this means that a species should always be spelled identically, as well as its authorship. In cases of variant spellings it is useful to have fixed rules. For Malacology the ICZN Code serves for this purpose. Its main message is that the taxonomist has to consult the original source and derive the correct spelling from there.

One problem is that, like many legal works, the Code was not written in a service guide language, and that insider knowledge is often needed for its interpretation. Another problem is the difficulty of finding the original sources. To facilitate our research we can look up moderately reliable names in secondary resources created by people who spent much time in finding the original sources. They provided helpful tools, but we always have to pay attention, as they may have made mistakes or worked under outdated rules.

The molluscan families were perfectly presented by Bouchet & Rocroi in 2005, under the most modern standards. For the genera, *Nomenclator Zoologicus* is a most useful online tool. Much more problematic are the specific names. For names established before 1800 we can use AnimalBase, and until 1850 Sherborn's *Index Animalium* (1902-1931), which is less reliable. The world's non-marine species are contained in Pfeiffer's various compilations until 1881, Palearctic non-marine species in Westerlund's "Fauna" until 1890. Between 1890 and the internet era there are no published global compilations any more. Some online services (Encyclopedia of Life, World Register of Marine Species, GBIF) work as aggregators and contain data from various sources, mostly for marine species. Other web services are more directly community controlled (AnimalBase, Wikipedia). The advantages of these services are in the direct links to the original sources and in the space for comments to explain the reliability of the name.

Distributional differences in the freshwater pulmonate snails *Physa gyrina* and *P. acuta*

Amy R. Wethington

Chowan University

Experiments were designed to test the effects of water quality and competition on two congeneric species of freshwater Pulmonate snails, *Physa acuta* and *Physa gyrina* in order to understand their distributional patterns in the Griffy Lake reservoir and surrounding wetland areas in Bloomington, Indiana.

It was my intent to discover what ecological factors restrict the former snail to the reservoir and the latter to an adjacent wetland area (Griffy Pond). I conducted three different water treatments (lake water and pond water), each treatment containing ten cultures of four snails. These results suggest that *P. acuta*'s superior competitive ability keeps *P. gyrina* from spreading into the lake and *P. gyrina*'s high tolerance to heat and desiccation keeps *P. acuta* from invading and taking over the more productive pond.

Reduced tillage systems for slug management in no-till field corn

Joanne Whalen & William Cissel

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Management of slugs in no-till corn systems continues to present major challenges to producers and threatens the viability of no-till production systems. Since no-till has been identified as important for maintaining the quality of the watersheds in the region, the identification of strategies that maintain a viable agriculture, reduce damage from slugs and maintain a healthy environment are needed.

Vertical tillage was identified by producers and NRCS at the local level as one way to potentially address all of these issues. Results of our 2011 tillage demonstration and preliminary observations from 2012 will be discussed. In 2011, the use of vertical tillage resulted in improved soil health benefits and improved slug management in most locations.

Systematics and egg laying evolution of Pleuroceridae (Gastropoda: Cerithioidea)

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Pleurocerid gastropods are integral to freshwater ecosystems throughout the southeastern United States, but they suffer from high rates of imperilment. Management efforts for imperiled species are complicated by a lack of modern systematic and life history studies for most pleurocerid genera. This study utilizes a multi-loci approach and extensive taxon sampling—focused primarily on the genus *Leptoxis*—to phylogenetically test generic and species, and it is the first to include extinct *Leptoxis* species and the extinct genus *Gyrotoma*.

For DNA extractions of extinct species, dried tissue left in shells from before the species went extinct was procured from collections at the University of Florida Natural History Museum and the North Carolina Museum of Natural Sciences. Gene sequencing of two mitochondrial genes (16S rRNA and COI) and one nuclear gene (28S rRNA) were done following standard procedures with slight modifications for dried tissue. The phylogeny used to test the monophyly of *Leptoxis* and the position of *Gyrotoma* was inferred with MrBayes 3.2.1. *Leptoxis* was resolved as non-monophyletic and forthcoming taxonomic changes will be discussed.

Within Pleuroceridae, species exhibit a wide range of egg laying strategies that varies from ovipositing single eggs to large super-clutches. Egg laying was documented for all *Leptoxis* species and at least one species from all other resolved clades except for *Gyrotoma*. A time calibrated tree was inferred in the Bayesian phylogenetics package BEAST, and further Bayesian methods that incorporate phylogenetic uncertainty were utilized for ancestral state reconstruction.

Laying clutches has evolved multiple times in Pleuroceridae and no reversals from clutches to single eggs were resolved. This indicates that clutches may be selectively advantageous compared to laying eggs singly, or in a line.

Maintaining snail-free status in California nurseries with emphasis on the European Brown Snail

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UC Statewide IPM Program and UC Cooperative Extension

Cornu aspersum, the European brown snail, is a widely spread land snail of agricultural pest importance. Although this species is native to the Mediterranean and would be expected to survive in areas with similar climates worldwide, it has actually established in the UK and is found in the U.S.A. as far north as New Jersey.

As a pest, this species has a wide host range for feeding, including fruit and leaves of citrus, vegetables, turf grass, and woody and herbaceous ornamentals. Damage includes holes in fruit, unmarketable fruit and vegetables, and loss of crops due to snail feeding on seedlings. Within the nursery industry, a find of a single brown snail can result in the shipment being rejected. Many states where *C. aspersum* may establish have enacted quarantine restrictions on plants being brought in from other states. Because California has the strictest standards for clean nursery stock in regard to *C. aspersum*, most states will accept shipments from California nurseries designated as "Snail-Free" under the Snail-Free Master Permit Compliance Agreements for shipping to states that regulate the European Brown Garden Snail.

While there is a cost to the nursery for snail management and regulatory inspections, these costs often outweigh the costs that may be incurred for additional inspections and held shipments on the receiving end. Basic compliance includes: 1. Stopping introduction of new snails 2. Eradication of snails and retaining snail-free conditions throughout the nursery, and 3. Ensuring snail-free shipments into snail-free states. Nurseries can develop their own plan for "guaranteeing" snail-free shipping. This can include maintaining snail-free holding areas for plants to be shipped, use of copper barriers, applications of molluscicides, and additional inspections.

Possible alternative strategies for nudibranchs navigating in variable flow

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Sluggishness has important implications for navigation behavior. Like so many gastropods, the nudibranch *Tritonia diomedea* primarily uses odor plumes to guide its locomotion. Considerable effort has been spent understanding how animals respond to attractive odor plumes by crawling upstream, following the flow to an odor source. Yet, in nature, flow directions can frequently change, creating a potential problem for slow-moving animals. However, we know little about the consequences of this flow and odor variability for animal navigation, in mollusks or otherwise. Thus, our goal is to explore strategies for odor-based navigation in variable flow. Here, we consider two possibilities.

First, as odor plumes shift, a lingering chemical trace will remain trapped in the boundary layer above the substrate. We have begun tests of whether *T. diomedea* can use this chemical information to find or avoid odor sources. Our initial results indicate that although the slugs can respond to such an odor trace, they do not necessarily use it for navigation.

Second, after an odor plume shifts, rather than continuing to follow the flow, animals may be better off continuing in the upstream direction from which odor was last detected. We have used simulations of slug movements to show that this could indeed improve navigation success. Since *T. diomedea* can detect the Earth's magnetic field, our next step will be test whether this strategy actually occurs in nature and whether magnetoreception is involved.

Together, these experiments are pursuing a more realistic view of navigation in *T. diomedea* (and presumably other gastropods), by incorporating both careful consideration of the sensory cues available to animals and the multiple navigation strategies they can employ. In addition, they form a foundation for studying the proximate basis of navigation behavior in this species used as model system in neuroethology.

Hawaiian land snail biodiversity: conservation status of a vanishing fauna

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The Hawaiian Islands support the world's most spectacular radiation of land snails. These species have distinctive evolutionary, ecological and cultural legacies and play an important role in our understanding of land snail evolution in general and island taxa in particular. They provide key ecosystem services, e.g. litter decomposition and nutrient cycling, and are flagship indicator species for intact mid-elevation rain forest, key to watershed maintenance. Unlike many invertebrates, they leave behind shells providing a record of colonization and evolutionary events, allowing inference of historical processes.

Taxonomically, the Hawaiian land snail fauna is disharmonic, with only ten of the ca. 90 recognized land snail families. Estimates of the number of species ranges from 752 to 1461. However the real number is unknown as most have not been studied in a comprehensive systematic manner for almost a century. Despite this uncertainty, even the most conservative estimates indicate that Hawaii is an incontrovertible gastropod diversity hotspot. Even more spectacular is that >99% of the species are endemic, many to single islands.

We have recently begun to undertake the monumental task of cataloging what remains of the Hawaiian land snail diversity, and placing that within the larger framework of their evolutionary origins. Preliminary data confirm that much has been irretrievably lost, but there also remains a great deal of cryptic diversity that can still be saved. We present an overview of what remains and offer suggestions for what information is needed to develop effective conservation strategies to save this biodiversity treasure before it vanishes.

Undergraduate research in Malacology

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Mollusks are the second largest phylum of animals in terms of described species, and this diversity provides an incredible range of research foci (*e.g*. taxonomy, ecology, evolution, biomedical studies). With more than 100,000 described species and an estimated 100,000 more yet to be described, Malacology provides a diverse base from which to develop inquiry-based and constructivist approaches for training the next generation of undergraduate students in science. Unfortunately, global biodiversity is declining rapidly, and no group has been more impacted than mollusks. Similarly, the numbers of scientist focusing on Malacological issues has also declined in recent decades. To stem both these declines, creative approaches must be found that address the critical need for a well-trained scientific workforce, and one that fosters a passionate interest in Malacology.

Compared to traditional lecture-based approaches, education-research programs that engage students through the development of independent research projects have been shown to be more effective at helping students develop a thorough understanding of science, apply principles of critical thinking to societal and scientific problems and retain knowledge. Additionally, these approaches foster the development of skills such as teamwork, effective communication, global perspective on environmental problems, independence, and many others that are vital to successful scientists. We have begun applying such an approach to training another generation of engaged scientist by focusing on a broad range of fundamental questions in Malacology. To demonstrate this approach, we provide an overview of six ongoing undergraduate research projects being conducted at the University of Hawaii. These projects address a range of questions in Malacology that span from developing effective ecological survey protocols to comparative phylogenetics and systematics. Using this approach we hope to foster a passion for science and an appreciation for methods that allow one to understand the world in very profound ways.

Phenotypic structure of the land snail *Ponsadenia duplocincta* in the Tian-shan Mountains

Asel Busuioc Zhetigenova

The peculiarity of the mountain climate, as well as a variety of malacofauna of this system, is of particular interest to study the population structure of land snails in the mountains. In the Terskey, Kungey Ala-Too Mountains (Northern Tian Shan), in the Issyk-Kul Lake area, the spatial phenotypic structure of the endemic land snail *Ponsadenia duplocincta* (*Gastropoda: Bradybaenidae*), which is polymorphic in banding pattern, color, and shell shape, was investigated.

During the 3 years of research in the canyons and on the lake shore, 233 samples were taken, out of which 11,148 individuals were examined and marked as “typical”, “rare” and “very rare” morphs. The spatial structure of *P. duplocincta* was studied using phenetic markers to evaluate patterns of morphological variation in mountain conditions. It was given schema, names and short descriptions of morphs. From the variety of morphs and their frequencies, two complexes were determined, in Terskey and Kungei Ala-Too:

1) Eastern complex, where the climate is mild and humid, and there is a greater variety of morphs

2) Western complex with a dry climate and a lesser variety of morphs.

As a result, a connection was found between the diversity, density and morph frequency and the climatic, physical and geographical conditions. And within the same species there have been cases of transition from the wide polymorphism to almost complete monomorphism of shell morphology. The marked polymorphism and monomorphism is apparently set by the joint interaction of climate, physical and geographical factors of mountains conditions, relief, and all types of isolation and genetic drift. Therefore, polymorphism can be used for the detection of natural populations and the study of population structure.

The USDA's response to the latest south Florida Giant African Snail infestation

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USDA, APHIS, PPQ

The United States Department of Agriculture (USDA) has responded in a variety of ways to the South Florida introduction of *Lissachatina fulica* (Bowdich). The USDA coordinates with the efforts of the state government and other local groups toward the eradication of this destructive pest. Providing financial resources has its limitations and requires supplemental efforts including: establishing a Federal quarantine order, educating the public and inspection personnel, surveying, research to determine how the pest entered the United States, and field research to understand the pest's reproductive potential.

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