

72nd Annual American Malacological Society

39th Annual Western Malacological Society

Abstracts and Program



University of Washington, Seattle, WA,
29 July-3 August, 2006

Edited by Roland C. Anderson

Conference logo:
Elizabeth Erickson
The Seattle Aquarium

Welcome to the 72nd and 39th Annual Meetings of the American Malacological Society and the Western Society of Malacologists, respectively, in Seattle, Washington. This year we have a joint meeting of the two organizations and the result is a meeting where we have an extremely strong program of of symposia, workshops, contributed talks, and posters. This year's program includes 142 registrants from 13 countries giving 102 presentations. Many of the presenters are students, which bodes well for the future of malacology

I'd like to thank my organizing committee and acknowledge the assistance of the following organizations for help with this meeting: The UW conference center, the Burke Museum, the Pacific Northwest Shell Club, and the Seattle Aquarium.

I hope you enjoy the meeting!

Roland Anderson, President

American Malacological Society
Western Society of Malcologists

SPECIAL EVENTS

Saturday night: reception at the Burke Museum, 7-9pm

Sunday afternoon, dissection of a large (75 pound, 34 kg) giant Pacific octopus SCC Room 316

Tuesday night, auction and reprint sale, McCarty Hall basement 6-10pm. Bring money to support this annual event that supports out student grants!

Wednesday afternoon, 3-3:30 AMS members meeting, 3:30-4 WSM members meeting, Room 316 SCC

Wednesday night, banquet 7-9pm, University Club, special guest speaker.

Thursday, 8:30-4pm, field trip to Deception Pass State Park, seats are limited..

Sunday, 30 August 2006, Rm 316 SCC, Cephalopod behavior symposium

TIME	PRESENTER	TITLE	RAPPORTEUR
830-9:20 AM	J.A. Mather	To boldly go where no mollusk has gone before: personalities, play, and consciousness in cephalopods	J.A. Mather
9:20-9:40AM	J. Voight	Observations of deep-sea octopodid behavior from undersea vehicles	
9:40-10:00AM	C. Huffard	Variation in behavior, population density, and sex ratio of <i>Abdopus aculeatus</i> (d'Orbigny, 1834)	
10:00-10:20AM		COFFEE BREAK	
10:20-10:40AM	T. Leite	Not just a chameleon: octopuses have a body pattern repertoire	
10:40-11:00AM	C. Lyons	Community structuring impacts of <i>Enteroctopus dofleini</i> in Prince William Sound, Alaska	
11:00-11:20AM	D. Scheel	Habitat selection and movements of <i>Enteroctopus dofleini</i> in Prince William Sound, Alaska: pilot studies with tagging and relocation	
11:20-11:40AM	F. Grasso	Sucker-Arm Coordination of Octopus in Grasping and Manipulation	
11:40-12:00N	Basil	Detection of underwater stimuli by <i>Nautilus pompilius</i>	
12:00N-1:00PM		LUNCH	
1:00-1:20PM	King	Respiration and behavior of na startle reaction in <i>Sepia</i>	
1:20-1:40PM	Williams	Chemical defense in hatchlings of the blue ringed octopus <i>Hapalochlaena lunulata</i>	
1:40-2:00PM	Cosgrove	Brooding of <i>Enteroctopus dofleini</i> females	
2:30-4:00	V. Gross, D. Newburn The Seattle Aquarium	Special feature! Giant Pacific octopus dissection	

TIME	PRESENTER	TITLE	RAPPORTEUR
9:20-9:40AM	C. Parent	Habitat variation predicts intraspecific shell shape variation in Galapagos bulimulid land snails	K. Hayes
9:40-10:00AM	K. Hayes	Genetic Characterization of Invasive Apple Snail Populations: Evidence of Multiple Introductions to SE Asia	
10:00-10:20AM		COFFEE BREAK	
10:20-10:40AM	T. Anderson	Genetic Characterization of Invasive Apple Snail Populations: Evidence of Multiple Introductions to SE Asia	
10:40-11:00AM	F. Borrero	The pearl oysters of the Colombian Caribbean—Historical fishery, current habitat characteristics and aquaculture potential	
11:00-11:20AM	R. Cowie	The horticultural industry as a vector of alien snails and slugs: Results of surveys in Hawaii	
11:20-11:40AM	N. Eckert	Freshwater mussel restoration efforts in Virginia's upper Tennessee River drainage	
11:40-12:00N	C. Grande	Gastropod mitogenomics: no support for a pulmonate clade.	
12:00N-1:00PM		LUNCH	
1:00-1:20PM	R. Dillon	Genetic relationships among populations of <i>Goniobasis</i> ("Elimia") from central Georgia	P. Bourdeau
1:20-1:40PM	C. Hickman	Evidence for predominance of constructional constraint in three common features of gastropod veliger larvae	
1:40-2:00PM	A. Kohn	<i>Conus</i> radular characters in taxonomy and phylogeny: Congruence with molecular genetics?	
2:00-2:20PM	C. Kitting	Native snails semi-isolated from other snail populations in small central California brackish marshes.	
2:20-2:40	G. Intoini	Evidence for predominance of constructional constraint in three common features of gastropod veliger larvae	
2:40-3:00	P. Bourdeau	Defensive trait integration in three sympatric, congeneric marine snails, <i>Nucella</i> spp	
3:00-3:20		COFFEE and octopus dissection	

Monday, 31 August 2006, 316 SCC, Chiton symposium

TIME	PRESENTER	TITLE	RAPPORTEUR
830-9:00 AM	D.J. Eernisse	Advances in Chiton Research	D.J. Eernisse
9:00-9:20	R.P.Kelly	Diverse patterns of gene flow in West Coast chitons with similar development	
9:20-9:40	B. Lieb	Hemocyanin meets chitons: Phylogeny of polyplacophorans revisited by hemocyanin genes	
9:40-10:00	H. Saito	Chitons (Mollusca: Polyplacophora) associated with hot vents / cold seeps around Japan	
10:00-10:20AM		COFFEE BREAK	
10:20-10:40AM	J. Pojeta, Jr.	<i>Echinochiton dufoei</i> (Polyplacophora): New reconstruction	
10:40-11:00AM	B. Runnegar	Paleontological evidence for the origin of valves in polyplacophoran molluscs	
11:00-11:20AM	J.-B. Caron	A radula-bearing animal from the Middle Cambrian Burgess Shale and the origin of mollusks	
11:20-11:40AM	M.J. Vendrasco	Aesthete canal morphology in nine chitons revealed by epoxy casts and a discussion of similar shell pore systems in Cambrian molluscs	
11:40-12:00N	J. Sigwart	Insights into the relationships within "basal" chitons (Polyplacophora: Lepidopleurida)	
12:00N-1:00PM		LUNCH	
1:00-1:20PM	R. Clark	Two new chitons of the genus <i>Lepidozona</i> Pilsbry, 1892 from the Monterey Sea Canyon	
1:20-1:40PM	J. Buckland-Nicks	The culture of iron limited chitons (Mollusca: Polyplacophora) as a method for observing the processes of radula mineralization.	
1:40-2:00PM	J.A. Shaw	The culture of iron limited chitons (Mollusca: Polyplacophora) as a method for observing the processes of radula mineralization.	
2:00-2:20PM	L.R. Brooker	Genes and biomineralisation in the radular teeth of chitons	
2:20-2:40	A. Rodriguez	Who says it's not easy to get around in L.A.: Palos Verdes Peninsula is an ineffective genetic barrier for chitons	

		and limpets	
2:40-3:00	D.J. Eernisse	Who says it's not easy to get around in L.A.: Palos Verdes Peninsula is an ineffective genetic barrier for chitons and limpets	
3:00-5:00		Poster session and special fossil chiton display	

TIME	PRESENTER	TITLE	RAPPORTEUR
9:00-9:20 AM	L. Puslednik	Systematics of the Australasian Lymnaeidae	F. Moretsohn
9:20-9:40AM	V. Rodriguez	Physiological tolerance and range limits of the congeneric sacoglossans <i>Alderia modesta</i> and <i>A. willowi</i>	
9:40-10:00AM	F. Moretsohn	Advances in digital imaging and Malacology	
10:00-10:20AM		COFFEE BREAK	
10:20-10:40AM	J. Voight	SEM observations of the siphons of wood boring clams of <i>Xylophaga</i> (Myoidea: Pholadidae)	
10:40-11:00AM	K. Roe	Taxonomic revision of endemic Nicaraguan freshwater mussels (Bivalvia Unionidae) Part II	
11:00-11:20AM	J. Serb	Building a comprehensive phylogeny of the scallops (Bivalvia: Pectinidae): what molecules say about taxonomy	
11:20-11:40AM	J. Smith	Agricultural Internet Monitoring System (AIMS) launch and results of mollusk hits	
11:40-12:00N	A. Walther	The case of the mystery limpet – is <i>Ferrissia fragilis</i> a cryptic invader of European freshwater ecosystems?	
12:00N-1:00PM		LUNCH	
1:00-1:20PM	T. Pearce	Updating knowledge of land snail distributions in New York State	T. Pearce
1:20-1:40PM	B. Watson	One Down, Thousands to Go: Virginia Completes the First Successful Eradication of a Zebra Mussel Population	
1:40-2:00PM	G.T. Watters	The intraspecific polymorphism in host attracting structures <i>Toxolasma parvus</i> (Barnes, 1823) (Unionidae)	
2:00-2:20PM	A. Wethington	Interplay between hosts genetic diversity and disease transmission in a host-parasite association	
2:20-2:40	S. Williams	Systematics, evolutionary history and biogeography of the vetigastropod genus <i>Turbo</i> and subfamily Turbininae	
2:40-3:00			
3:00-3:20		COFFEE	

Tuesday 1 August 2006, Rm 316 SCC, Opisthobranch Workshop

TIME	PRESENTER	TITLE	RAPPORTEUR
830-9:00 AM	S. Millen	Opisthobranch research in the last decade	S. Millen
9:00-9:20	J. H.R. Goddard	Developmental mode in opisthobranch molluscs from the eastern tropical Pacific	
9:20-9:40	J.Asif	Alien identification: tracking invasive <i>Philine</i> spp. using genetic techniques	
9:40-10:00	K.R. Jensen	The type collection of specimens described by Rudolph Bergh and housed in the Zoological Museum, Copenhagen.	
10-10:20		COFFEE	
10:20-10:40	P.J. Krug	Caribbean sacoglossans: Cryptic genetic divergence and phylogeography	
10:40-1100	A.V. Martynov	Opisthobranch mollusca of Russia: the neglected diversity of cold waters	
11:00-11:20	B. Dayrat	A taxonomic revision of basal Discodorididae (Nudibranchia, Gastropoda): What's next?	
11:20-11:40	V.A.Rodriguez	Physiological tolerance and range limits of the congeneric sacoglossans <i>Alderia modesta</i> and <i>A. willowi</i>	
11:40-12:00N	R.F. Johnson	<i>Cadlina</i> and the chromodorids	
12:00N-1:00PM		LUNCH	
1:00-1:20PM	T.P.Neusser	Computer-based 3D-visualization of <i>Tantulum elegans</i> Rankin, 1979, an enigmatic Caribbean freshwater acochlidian opisthobranch	
1:20-1:40PM	D.W. Behrens	Opisthobranch Mollusks from Diablo Canyon, California: a 25 year, quantitative record	
1:40-2:00PM	J. Greenamyre	Nudibranch Safari	
2:00-2:20PM	C. Trowbridge	Sacoglossan opisthobranchs on NW Pacific shores: <i>Stiliger berghi</i> Baba 1937 and <i>Elysia</i> sp. n filamentous red algae	
2:20-2:40	C. Stout	Phylogenetic reconstruction of the genus <i>Dendronotus</i> (Gastropoda: Nudibranchia) with insight into distribution patterns	
2:40-3:00	T.M. Gosliner	A decade later: what we know and still don't know about opisthobranch	

		biodiversity	
3:00-3:20		COFFEE	
3:20-3:40	A. Alejandro	Preliminary phylogeny of Aeolididina (Gastropoda: Nudibranchia) based on morphological characters and genes	
3:40-4:00	H. Bertsch	John Steinbeck, Bahía de los Ángeles, and Nudibranchs	
4:00-4:20	V. Smith	Two New Species of <i>Marionia</i> (Mollusca: Nudibranchia) from the IndoPacific Region	
4:20-4:40	M. Miller	Internet Branchology, Where have we been and where are we heading?	
4:40-5:00	T. Neusser	Interstitial nudibranch demonstration	
5:00-5:20			
5:20-5:40			

TIME	PRESENTER	TITLE	RAPPORTEUR
830-9:00 AM	T. Frest	New frontiers in western U. S. freshwater malacology	T. Frest
9:00-9:20AM	D. Campbell	Molecular evidence supports revision of the genus <i>Juga</i> (Cerithioidea: Pleuroceridae: Semisulcospirinae)	
9:20-9:40AM	S. Clark	New insights into some freshwater pulmonate snails endemic to the western United States	
9:40-10:00AM	T. Frest	Advances in <i>Fluminicola</i> (Lithoglyphidae) research	
10:00-10:20AM		COFFEE BREAK	
10:20-10:40AM	D. Sada	Isolating factors affecting crenobiontic springsnail (Prosobranchia: Family Hydrobiidae) colonization of unoccupied habitats in arid lands of the western U.S.	
10:40-11:00AM	C. Kitting	Native snails semi-isolated from other snail populations in small central California brackish marshes.	
11:00-11:20AM	C. Davis	Another introduced mollusk discovered in San Francisco Estuary	
11:20-11:40AM	R. Guralnick	New approaches to documenting biodiversity in non-marine molluscs in western North America: A case study in the freshwater bivalve group <i>Cyclocalyx</i> .	
11:40-12:00N	K. Mock	Genetic subdivision in western <i>Anodonta</i>	
12:00N-1:00PM		LUNCH	
1:00-1:20PM	N.Duncan	Unprecedented Mollusk Data Collected as a Result of The Northwest Forest Plan	
1:20-1:40PM	T. Anderson	Life history of an ovoviviparous land snail, <i>Oreohelix cooperi</i> , and its relation to biotic and abiotic factors	
1:40-2:00PM	Brenden Holland	A geographic mosaic of passive dispersal: population structure in the endemic Hawaiian amber snail <i>Succinea caduca</i> (Mighels, 1845)	
2:00-2:20PM	Robert H. Cowie	The horticultural industry as a vector of alien snails and slugs: Results of surveys in Hawaii	
2:20-2:40PM	M. E. Hitchcox	Detection Surveys for Non-native Terrestrial Stylommatophoran of Agricultural Significance	
2:40-3:00PM	Robin Rosetta	The Pacific Northwest Nursery IPM website: An extension resource for gastropod information	
3:00-3:20			
3:20-3:40			

STUDENT PRESENTERS ELIGIBLE FOR THE CONNIE BOONE AWARD

Alejandrino
Bourdeau
Bush
Hayes
Hewson
R. Johnson
Meyer
Parent
Paustian
Puslednik
Sigwart
Stout
Walther

ABSTRACTS

Preliminary phylogeny of Aeolididina (Gastropoda: Nudibranchia) based on morphological characters and the mitochondrial 16s rRNA and COI genes

A. Alejandrino

Natural history Museum of Los Angeles County

One of four large infraorders of nudibranchs, aeolids are speciose due in part to synonymy and polymorphism. Traditional taxonomy involving morphological characters partially caused this problem due to the subjectivity of characters interpreted by different researchers. Recently molecular genetics has provided an added tool in taxonomy, through phylogenetic analysis. Valles' (2002) work on *Kaloplocamus* (doridina: Polyceridae) and *Plocamopherus* (Doridina: Polyceridae) was the first to combine the subfields for nudibranchs and is being used as the model for deriving a taxonomic treatment for aeolids. Currently, only four reviews (Rudman, 1980;1982; Gosliner & Kuzirian, 1990; Gosliner & Willan, 1991) have been conducted on the aeolids and no family level molecular phylogeny exists. Morphological characters and the large subunit (LSU) fragment of the mitochondrial 16s ribosomal RNA, approximately 1400bp long in nudibranchs (Valles, 2002) are being utilized for reconstruction of the aeolid phylogeny. The cytochrome oxidase I (COI) gene is brought into play as an additional molecular marker. Morphological and molecular phylogenetic relationships are being determined through PAUP* (Swofford, 2000) using maximum parsimony, and branch support is estimated by Bremer analysis (Bremer, 1994). Molecular relationships are being established with maximum likelihood as implemented in Mr. Bayes (Heulsenbeck & Ronquist, 2001). Bootstrap (Felsenstein, 1985) is applied to determine support for nodes on the trees. Preliminary molecular findings indicate some monophyly on the genus level but largely remain unresolved until more data (morphological and molecular) are obtained.

Life history of an ovoviviparous land snail, *Oreohelix cooperi*, and its relation to biotic and abiotic factors

T. Anderson, R. Guralnick

Few studies have focused on the life history of North American land snails. This is unfortunate not only from the standpoint of basic biological knowledge, but it also hinders evaluation, management, and monitoring of species of potential conservation concern. Species with relatively rare life history strategies, such as ovovivipary, that have been rarely studied in any pulmonate worldwide, and those trying to manage such species are forced to make assumptions based on species with entirely different life histories. This study focuses on life history in the ovoviviparous land snail *Oreohelix cooperi*, a species with some conservation concern, that resides primarily in the Black Hills of South Dakota and Wyoming. Recent work allows this data to be evaluated within the context of known information about the genetics, morphology, and ecology of the species. The 205 individuals examined from the Black Hills had an average brood size of 3.3 offspring per adult. Individuals were most likely to contain broods during May or October and least likely to carry broods in June. Adult size strongly influenced the reproductive output, although large individuals were not more likely to have broods. Both the number of offspring within a brood and offspring size illustrated a weak tradeoff when adult size was included as a factor. Birth order did not influence offspring size. Both density and elevation influenced the per-clutch reproductive output. These results are similar to results from studies of oviparous pulmonates despite the difference in egg-production strategy. Whether these results vary across the ovoviviparous genus, *Oreohelix*, or with latitude or a wider elevation range is still being investigated.

Cataloguing diversity in the genus *Conus*

T. R. Anderson, A. J. Kohn
University of Washington

A further progress report of a project designed to improve and modernize the classification and systematics of the unusually diverse marine gastropod genus *Conus*, with a look at some of the methods and tools developed to create, organize, and provide access to results. As a first and necessary step the project catalogued all available species-group names. The project has used this catalogue as a framework to organize and add information. For each species-group name, an interface combines present taxonomic status, type information, species description, literature records of fossils, and morphometric and geographic data on individual specimens, with GIS maps of localities and display of associated images, pdf's of original descriptions, and videos. The connections linking all this disparate information support the current effort to monograph the Western Atlantic *Conus*. The underlying organization and overall appearance is mirrored on The *Conus* Biodiversity Website (<http://biology.burke.washington.edu/conus/>), with the working data of the project forming the basis of web content through automatic updates. Since our last progress report many more type images and pdf's have been made available on the website, and a page of videos displaying *Conus* feeding biology and a new section for literature records of fossil *Conus* have been added.

Alien identification: tracking invasive *Philine* spp. using genetic techniques

J. Asif, P. Krug
California State University

Non-indigenous marine invertebrates are invading estuaries at an alarming rate after introduction via ballast water, hull fouling, or mariculture. Recognizing incipient and historical invasions is critical to management and containment strategies. Morphological identification of marine invertebrates can be difficult, however, due to a lack of diagnostic characters and phenotypic variability. As a result, many biological invasions go undetected for decades because invaders are not recognized as alien species. Both native and invasive species of the cephalaspidean opisthobranch genus *Philine* are found on the west coast of the United States. Gosliner proposed in 1995 that the New Zealand endemic *P. auriformis* had been introduced into San Francisco Bay and subsequently spread along the coast, but this identification was controversial; other authorities claimed the invader was not *P. auriformis* based on morphology of the gizzard plates, penis and shell. It was subsequently proposed that up to 4 different *Philine* spp. may have invaded the northeastern Pacific, but confirmation has been lacking. On local mudflats and in deep water trawls of the Los Angeles Harbor, *Philine* spp. are the most abundant mollusc, prompting our assessment of species composition in this group using molecular methods. We obtained specimens of the two native New Zealand species, *P. auriformis* and *P. angasi*, and collected slugs from the intertidal and subtidal in southern California. Portions of the mitochondrial 16S and cytochrome oxidase I genes were sequenced from all specimens. To date, all shallow-water *Philine* sequenced from southern California were genetically identical to *P. auriformis* from New Zealand, confirming Gosliner's initial report. We will present additional data on the identity of deep-water *Philine* spp. and discuss DNA bar-coding approaches to identifying cryptic invasive species in taxonomically challenging groups like opisthobranchs.

Opisthobranch Mollusks from Diablo Canyon, California: a 25 year, quantitative record

D. W. Behrens, J. Steinbeck, M. D. Behrens, J. Goddard
California Academy of Sciences, Tenera Corporation, Pacific Lutheran University, UC
Santa Barbara

Environmental monitoring programs designed to determine the effects of construction and operation of the Diablo Canyon Power Plant on the adjacent coastline have amassed 25 years of data on the flora, fauna, and physical oceanographic characteristics of the region. Population information on opisthobranch mollusks present during this monitoring is presented here. 876 individual specimens representing 32 species were found subtidally, and 1642 individual specimens of 41 species were recorded intertidally. Of the total 47 species, six species were observed exclusively in the intertidal, while 12 species were found only in the subtidal. The effect of the power plant operation on the assemblage was seen only in the addition of two species, which became common in close proximity to the plant's thermal discharge. Seasonal populations dynamic will also be reported.

John Steinbeck, Bahía de los Ángeles, and Nudibranchs

H. Bertsch
Natural History Museum of Los Angeles County

Bahía de los Ángeles, Baja California, on the Sea of Cortez, has been a site of molluscan interest since the first native Cochimí lived there—supporting themselves from the fresh water springs, the abundance of the ocean, and by plant and animal products from the land.

A seminal event in our knowledge of Bahía de los Ángeles invertebrates was the 1940 visit of John Steinbeck and Ed Ricketts, immortalized in the scientific collecting data, and the literary and philosophical text of Sea of Cortez: A Leisurely Journal of Travel and Research.

In the six decades since their visit, numerous oceanographic expeditions have studied this unique faunal region.

Early gastropod and pelecypod surveys by James H. McLean and Eugene V. Coan provided more detailed, yet preliminary, data bases of molluscan biodiversity.

Recent intensive and long-term studies have made significant contributions to the natural history, biogeography, and taxonomy of opisthobranchs, clarifying our understanding of the marvelous marine life of Bahía de los Ángeles, so eloquently described by Steinbeck and Ricketts.

The pearl oysters of the Colombian Caribbean—Historical fishery, current habitat characteristics and aquaculture potential

F. J. Borrero, J. Manuel Díaz

Cincinnati Museum of Natural History, Instituto de Investigación de Recursos Biológicos
Alexander von Humboldt

A long but intermittent fishery of pearl oysters existed on the Guajira Peninsula of the northern Colombian Caribbean Coast. Obtaining natural pearls from the mother-of-pearl oyster, *Pinctada imbricata* Röding, 1798 was the aim of a fishery that spanned approximately 400 years between the mid 1500's and its final interruption in the 1940's. We synthesized information on temporal and geographic extent, extractive intensity, and the various human groups involved in the pearl oyster fishery. Our modern surveys reveal that: 1) Two pearl oyster species were affected by the fishery, *P. imbricata*, and the winged pearl oyster, *Pteria colymbus* (Röding, 1798); 2) locations of extraction roughly correspond to the current extent of “pearl oyster beds” in the region, but were not permanent at individual locations; 3) the pearl oysters' habitats are not ecologically distinct units, but general areas of marine bottom with certain common characteristics including depth and presence of specific hard substratum elements; 4) the 2 species coexist in 3 of 5 types of habitats, but do not share 2 habitats where either species is found exclusively. Intense intra- and inter-specific competition for substratum appears as a key factor in their population dynamics. Underwater video clips of pearl oyster habitats, sampling locations and on-land shell middens will be presented.

To provide alternative sources of income to coastal inhabitants of the Colombian Caribbean coast, experiments on the aquaculture potential of both pearl oyster species were carried out. Seasonal variation of larval abundance and spat recruitment onto artificial collectors were monitored, and growth rates and survival of pearl oysters in hanging culture were evaluated. Pearl oysters represent a promising aquaculture resource for cultured pearls and meat in Colombia, but developments are needed to prevent intense predation and fouling, as well as to develop markets.

Defensive trait integration in three sympatric, congeneric marine snails, *Nucella* spp., differentially distributed across a predation-risk gradient.

P. E. Bourdeau
Stony Brook University

Predation by shell-crushing predators is thought to be a major driver of the evolution of marine gastropod shell forms. I examined whether defensive shell traits, including plastic responses to shell-crushing predators, differ among three closely-related, sympatric marine snails in the genus *Nucella*. *N. ostrina*, *N. canaliculata* and *N. lamellosa* are differentially distributed across a predation risk gradient and differ in their susceptibility to their common crab predator, *Cancer productus*, as measured by the force required to fracture shells. I reared all three species in the presence and absence of caged crabs feeding on congeneric snails to determine the relationship between susceptibility to crab predation and the magnitude of plastic behavioral and morphological responses to cues associated with crab predation. All three species respond behaviorally and morphologically to cues from feeding crabs however these responses differ among species. *N. lamellosa*, the species experiencing the highest predation risk exhibits the strongest expression of defensive traits including predator-induced behavior and morphology (trait cospecialization). *N. ostrina* and *N. canaliculata*, which inhabit less predator intense habitats and are not as well defended morphologically are less plastic for both behavior and morphology. The species which invests most heavily in constitutive shell defense (*N. lamellosa*) also exhibits the greatest plasticity for this defense suggesting a 'runaway' scenario for investment in constitutive defense and inducibility of that defense. Interestingly, *N. lamellosa* greatly increases its resistance to crushing without increasing the overall weight or thickness of its shell, suggesting the alternative strategy of changing overall shell shape or shell material properties to decrease susceptibility to crab predation. Taken together, these results may have important implications for the evolution of shell form in marine gastropods.

Genes and biomineralisation in the radula teeth of chitons.

L.R. Brooker, L. Gardner, D.J. Macey, A. Elizur
University of the Sunshine Coast, Murdoch University

Chitons are marine molluscs that feed by rasping food from the rocks on which they live. They achieve this with the aid of teeth that are hardened through the incorporation of iron and calcium biominerals. The chiton radula is comprised of teeth at various stages of maturation, and the different minerals are incorporated into specific teeth at very precise stages of radula development. While much is known about the minerals that are deposited and the process of radula mineralisation, to date there have been no studies undertaken to identify the genes that control the mineralisation process.

A molecular approach has been employed to further our understanding of radula biomineralisation in the chiton *Acanthopleura hirtosa*. The radula sac was collected from 20 chitons and RNA extracted and used as a template for cDNA synthesis followed by PCR amplification and cloning, thus generating a suite of expressed sequence tags (ESTs). 1152 of the ESTs have been sequenced, and 500 unique sequences further selected for inclusion in a 'Combimatrix' oligo microarray. This array will be hybridized with probes from discrete tissue sections of the radula sac, corresponding to specific mineralisation stages. A high level of sequence divergence has been identified between most of the ESTs and sequences available from other organisms. It is anticipated that this study will identify genes associated with specific radula biomineralisation events, and thus shed light on the molecular aspects of this process. In addition, the sequencing of over 1000 ESTs from chiton provides valuable genomic information that could be useful for the study of the biology of this species.

Fertilization biology elucidates chiton evolution

J. Buckland-Nicks
St Francis Xavier University

Studies of gamete structure and fertilization biology have revealed much about the phylogeny of molluscs. Recent studies of chitons support the view that the basal group of chitons fertilized eggs, as most molluscs do, by fusing the entire sperm with the egg using a perforatorium and transferring chromatin, mitochondria and centrioles to the egg cytoplasm. Whereas, all members of the order Chitonida, apparently inject only chromatin into the egg. These chitons, which include the controversial family Callochitonidae, share a series of synapomorphic characters based on their fertilization biology that makes them unique. The taxon containing *Callochiton* sp. is likely basal to this order. The remaining families in the order separate into two groups, which roughly correspond to the suborders Chitonina and Acanthochitonina.

Within Chitonina one group has pores in the hull (*Chaetopleura apiculata*, *Ischnochiton albus*), whereas a second group has an extra dense layer on the surface of the hull (*Chiton tulipa*, *Stenoplax conspicua*). All these chitons have spiny-hulled eggs with narrow bases and are quite different from the second suborder, Acanthochitonina, which have large hull cupules with wide bases. Within Acanthochitonina, some families have open cupules and others have closed cupules. Open cupule species lack micropores for sperm entry, whereas several closed cupule species exhibit micropores in the egg hull.

Taken together, the current knowledge of gamete structure of individual species and their known fertilization biology, it is now possible to revise preliminary analyses (Buckland-Nicks 1995) and achieve a more accurate phylogeny of chitons, which differs in some key aspects from other recent publications.

Why do deep-sea squids release ink in the dark?

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Despite previous long-standing assumptions, squid ink release is not limited to shallow, sunlit waters. Ink release by several meso- and bathypelagic squid species was observed to depths greater than 2000 m. In order to understand deep-sea ink use, direct observations and video recorded from remotely operated vehicle dives were reviewed to examine species, depth, ink-type, and behavior associated with inking. Six patterns of ink release were observed: pseudomorph, pseudomorphs released in series, ink trail, cloud/smokescreen, diffuse puff, and mantle fill. Each species released ink throughout all or most of its depth range. Although most species released a particular ink-type more often than any other form, none was limited to a single type. Ink-type usually correlated with the individual's behavior. Pseudomorphs and pseudomorph series were generally associated with escape behaviors while ink trails, clouds, and puffs normally involved the animal remaining adjacent to or amid the ink.

Aplacophores (Caudofoveata and Solenogastres) of the southern California Bight

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The close chiton allies in the Caudofoveata and Solenogastres (collectively called the aplacophores) are scaled shell-less mollusks known mostly from bathyal or abyssal depths. They comprise a significant portion of the biota there. It has been suggested they fill the ecological role played by polychaete worms in shallower communities. Their identification has always been difficult and reserved for specialists. In an effort to simplify identification we used the collections from a regional survey of the Southern California Bight in 2003 to test a new approach using external morphology only. We had a good deal of success, but found that external morphology alone was not enough. There was sufficient convergence in external features of Caudofoveata that radular dissections were needed for confirmation of some taxa. In the Solenogastres, the identity of the animals could not be determined without sectioning and close inspection of the internal anatomy, but morphotypes could be reliably separated at species level in most cases. Tools were created to aid routine determination of aplacophore species from the region, primarily based on external morphology. The report summarized in the poster is available for free down-load at scamit.org.

Molecular evidence supports revision of the genus *Juga* (Cerithioidea: Pleuroceridae: Semisulcospirinae)

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The current classification of *Juga*, the freshwater cerithioidean in northwestern North American drainages from central California to Washington, largely reflects traditional assessments of shell morphology. Phylogenetic analysis of sequence data for the *cox1* and *16S* genes indicate that the currently recognized subgenera are not monophyletic and that many more species exist than are recognized in current classifications. In particular, detailed sampling of the upper Sacramento system, including the Pit River drainage, found species-level variation between many populations currently treated as *J. acutifilosa* and *J. nigrina*. The newly recognized clades are largely concordant with biogeographic regions and with new anatomical data. The large increase in the number of species raises the conservation priority of most populations. The current molecular data also support previous studies that placed *Juga* closer to *Semisulcospira* and other northeast Asian genera rather than to eastern North American genera.

New insights into some freshwater pulmonate snails endemic to the western United States

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The genera *Lanx*, *Fisherola*, *Vorticifex* and *Carinifex* are freshwater pulmonate snails endemic to the western United States. *Lanx* and *Fisherola* have limpet shaped shells and have either been placed in their own family or as a subfamily of the Lymnaeidae. *Vorticifex* and *Carinifex* have relatively large bulbous shells and have been placed in the Planorbidae. There has been much taxonomic confusion with these snails since Haldeman and Lea described the first species, particularly with regards to their systematic relationships, generic placement and how many species should be recognized. Recent anatomical and molecular studies have revealed new insights into these enigmatic snails.

(Vetigastropoda: Trochidae), in Bermuda

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Cittarium pica (Linnaeus, 1858), is the largest gastropod inhabiting rocky intertidal shores of the Caribbean region and Bermuda, reaching shell heights on the order of 150 mm. Also referred to as a “whelk,” “wilk ”or“ magpie shell,” it has been exploited heavily by humans for food and fish bait throughout its geographic range. It suffered local extinction in Bermuda some time between the late Pleistocene and mid-1600’s. Reintroduction of the species to Bermuda in the mid 1980’s is a remarkable conservation achievement, with what appear to be among the healthiest remaining populations of the species throughout its distributional range.

Research on the basic biology of *C. pica* in Bermuda was initiated by the Bermuda Ministry of the Environment as part of a program to manage and protect marine resources. We report some of the results to date from a long-term program to monitor population structure as well as results of recently-initiated studies to examine growth rates and longevity and to characterize reproductive biology of the species. Findings include considerable variation in growth rates among individuals and over time as well as indications that spawning is not synchronous. Investigations of alleged broadcasting of sperm by some individuals when disturbed show unequivocally that the peculiar white fluid exudate does not contain gametes and is a hypobranchial gland secretion of as yet undetermined function. Proposed documentation of the population genetics of *C. pica* will be undertaken to illuminate the history of insular populations throughout the Caribbean and Western Atlantic as well as to develop a model for management and protection of extant populations.

The horticultural industry as a vector of alien snails and slugs: Results of surveys in Hawaii

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Alien species are being moved around the world at unprecedented rates as a result of globalization of trade and travel. Understanding the causes and mechanisms of spread is important in order to improve quarantine measures, increase awareness among those transporting these species, and halt their spread to new areas. Reports from various countries identify the horticultural industry as perhaps the most important vector of snails and slugs, as also appears to be so in Hawaii. We surveyed nurseries, botanical gardens and similar facilities on the six largest Hawaiian Islands. We recorded 30 species of terrestrial snails and slugs, of which all but two (*Tornatellides* sp., *Philonesia* sp.) are alien; four, a phylomyxid, an assimineid and two succineids, all as yet undetermined, had not been previously recorded in Hawaii. In total, 39 non-native terrestrial snail and slug species are now established in Hawaii. In addition to the four newly recorded species, the following constitute new records of species on particular islands: *Deroceras* sp. (Lanai), *Liardetia doliolum* (Kauai), *Ovachlamys fulgens* (Kauai, Maui), *Polygyra cereolus* (Molokai, Lanai), *Gastrocopta servilis* (Lanai), *Euglandina rosea* (Lanai), *Subulina octona* (Lanai, Maui), *Paropeas achatinaceum* (Lanai), *Veronicella cubensis* (Kauai, Molokai, Lanai, Maui, Hawaii), *Laevicaulis alte* (Kauai, Maui). Excluding the presumed native *Tornatellides* sp. and *Philonesia* sp., 22 species were found on Oahu, 19 on Kauai, 8 on Molokai, 9 on Lanai, 15 on Maui, and 10 on Hawaii. The number found at each location ranged from one to 14. The 28 introduced species recorded in the survey are from many parts of the world. One is a Pacific island species, four are African, two European, four North American, one is holarctic, six are Asian and/or Australasian, five are South and/or Central American or Caribbean, and the natural ranges of five are unknown because their specific identities are unknown.

Another introduced mollusk discovered in San Francisco Estuary

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San Francisco Bay contains the largest introduced fauna on the Pacific Coast of the United States, with over 250 invasive species, including many mollusks, documented in marine, brackish and fresh water tidal areas of this estuary. Patchy, previously unrecorded populations of aquatic cochliopid snails were recently discovered in two restored tidal marshes and a non-tidal pool in southern Suisun Bay, San Francisco Estuary, during a habitat-monitoring program (1999-2001). Another population of these tiny gastropods subsequently was found

(2005) in a marsh in San Pablo Bay, northern San Francisco Bay. Morphologic and mtDNA evidence was used to identify this snail as *Littoridinops monroensis*, an estuarine-freshwater species distributed in coastal habitats from Georgia to Mississippi. Core samples obtained at one of San Francisco Estuary sites suggest the longstanding presence of a second cochliopid species whose taxonomic status is currently being investigated. This unidentified snail was the most abundant species at some tidal sites, but spatial patterns were evident at one site and *L. monroensis* was the only cochliopid detected at the non-tidal site. Populations of *L. monroensis* have persisted at the southern Suisun Bay sites for more than four years, surviving sometimes freezing ambient winter temperatures; which is surprising given that native populations of these snails are associated with warm climates. MtDNA evidence suggests that *L. monroensis* from the San Francisco Estuary is little differentiated relative to native populations and probably represents a recent introduction. The possible mode of introduction of *L. monroensis* is still under investigation.

A taxonomic revision of basal Discodorididae (Nudibranchia, Gastropoda): What's next?

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Basal Discodorididae, especially *Discodoris* and *Peltodoris*, were revised for the first time: nearly 200 nominal species were considered; all type specimens available were re-examined; hundreds of non-type specimens were dissected and described for their entire anatomy. I will use this work to illustrate the idea that taxonomic revisions are by no means an ending, but rather are new starting points for research projects. Indeed, taxonomic revisions are critical in helping us sort what we know from what we do not know in a particular taxon. This is true for species boundaries as well as for supra-specific relationships. So, if taxonomic revisions are invaluable syntheses of past studies, they also deliver very important messages to future generations. In particular, taxonomic revisions unveil all the questions that will require further investigation, e.g., which species should be dealt with through an integrative approach (i.e., different kinds of data), and which are the parts of the tree that are still very poorly supported. Contrary to what many non-taxonomists may think, taxonomic revisions are a perfect illustration that taxonomy is, as all scientific disciplines, a dynamic process.

Genetic relationships among populations of *Goniobasis* (“*Elimia*”) from central Georgia

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Little consensus exists regarding evolutionary relationships among populations of the pleurocerid genus *Goniobasis* inhabiting the Atlantic and Gulf drainages of Georgia. Some authors have recognized multiple species endemic to the region, while others view the fauna as a mixture of species with larger ranges north and south. Here we report the results of a survey of gene frequencies at 10 allozyme-encoding loci in 11 populations of *Goniobasis* from central Georgia representing seven nominal species: *boykiniana*, *caelatura*, *darwini*, *mutabilis*, *viennaensis*, *timida*, and *induta*. These were compared to control populations of *G. proxima* and *G. catenaria* from South Carolina and *G. floridensis* from Florida. The levels of genetic divergence we uncovered did not distinguish the first five nominal species in the list above from populations of *G. catenaria*, widespread in Atlantic drainages of the piedmont north to Virginia. Nor were *timida* and *induta* populations distinct from *G. floridensis*, ranging through Atlantic and Gulf drainages to the south. Our data suggest that central Georgia has been a region of repeated biotic exchange between Atlantic coastal and Gulf faunal provinces, and that the level of endemism in its freshwater mollusk fauna may have been overestimated.

Ordovician chitons and cephalopods from Wisconsin

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Milwaukee Public Museum, Smithsonian Institution

This exhibit represents 15 years of collecting by DuFoe. The fossils are from a 7-15 centimeter thick, mollusk-rich bed at Bauer's Quarry west of Beloit, Wisconsin. Information about three species of chitons was published (Pojeta et al., 2003; Hoare and Pojeta, 2006). The first information about the cephalopods is given herein by Catalani. The fossils are from the Forreton Member, Grand Detour Formation of Turinian (Middle Ordovician) age (about 457 Ma). Most fossils are found parallel to bedding in "pockets" of accumulation.

The cephalopods range in size from a few centimeters to over three meters. To date have been found representatives of all three known subclasses of lower Paleozoic cephalopods, and eight of the 11 recognized orders belonging to 11 genera. Thus, this thin bed has yielded 44% of the known genera found in the Forreton Member.

The primitive Ellesmerocerida are represented by the small breviconic genus Cyrtocerina. The large Endocerida is known from Endoceras. The Actinocerida, having expanded siphuncles, are known from the genera Actinoceras and the flat-fish-like Gonioceras. Anaspyroceras represents the straight-shelled Orthocerida. Pseudorthocerids, another straight-shelled group, is known from the genus Monomuchites. The truncated conchs of the Ascocerida are known from the genus Redpathoceras. The curved shells of the common order Oncocerida belong to Beloitoceras, Richardsonoceras, and Zittelloceras. The planispirally coiled Tarphycerida is known from Plectoceras.

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Unprecedented Mollusk Data Collected as a Result of The Northwest Forest Plan

N. L. Duncan
Bureau of Land Management

With the implementation of the Northwest Forest Plan for managing federal forest lands in the Pacific Northwest began in 1997, a new era of mollusk awareness was set in motion. The Survey and Manage provisions in the plan require surveys for rare or little known species, including 48 species of mollusks, prior to any habitat-disturbing activities. This provision generated never-before-seen interest and data collection efforts on federal land in the region, including training hundreds of wildlife biologists in mollusk identification and survey techniques, development of a regional spatial database for all survey records, and ultimately the documentation of over 25,000 locations for these species in Oregon, Washington and northern California.

As the program nears its end after almost ten years, its surveyors and researchers have covered more than 1,557,915 acres of habitat, discovered dozens of new, undescribed species, found that some species once thought to be quite rare are actually quite common, funded research on fire effects to mollusks and done molecular DNA work to clarify the taxonomy of several genera. A regional voucher collection now exists containing over 2300 specimens, with digital images for most, which are available for research and training. Many management recommendations or Conservation Assessments have been developed which contain summaries of the information available for each species, including range, descriptions, and habitats.

The Northwest Forest Plan has been recognized as cutting-edge in the world of biodiversity management. Many little known species have been studied, but the biggest gains have been in terms of the amount of knowledge gathered about native mollusks. Once ignored or detested as slimy pests in the garden, a whole new generation of land managers now think of forests in terms of mollusks – amazing!

Pacific Northwest native freshwater mussel workgroup

N. Duncan
Bureau of Land Management

On February 19, 2003, a workshop on freshwater mussels was held in Vancouver, Washington that consisted of presented papers, a panel discussion and discussion of future activities. The workshop was attended by 91 participants of very diverse backgrounds. Out of this meeting the Pacific Northwest Native Freshwater Mussel Workgroup was founded. The goal of the Workgroup (including eight objectives) is to “Ensure that freshwater mussel research, management, and educational activities are coordinated, prioritized and are consistent with identified information needs”. The Workgroup meets at least four times annually. Outreach accomplishments so far include establishment of a website (<http://www.fws.gov/columbiariver>) and three annual symposia. Well-published mussel scientists from the U.S. and Scotland have given presentations at the symposia. In 2005, the Workgroup published *Mussels of the Pacific Northwest*. Several Workgroup members have given presentations on freshwater mussels at professional society meetings, university classes and other natural resource groups. The status of the seven species of freshwater mussels in the Northwest has received very little attention from biologists, let alone the public. The Workgroup intends to raise the awareness of the status of freshwater mussels and assure that the knowledge base about these mollusks continues to build.

Keywords: Animal Ecology, Conservation Biology, Environmental Education

Freshwater mussel restoration efforts in Virginia's upper Tennessee River drainage

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The Virginia Department of Game and Inland Fisheries established the Aquatic Wildlife Conservation Center (AWCC) in 1998 to aid in recovery of large concentrations of endangered freshwater mussels in the Upper Tennessee River System of Virginia. The facility is located along the South Fork Holston River (SFHR) near Marion, Virginia. The AWCC draws water from the SFHR that passes through a 5-acre pond to increase temperature and algal productivity. Adult mussels are held in circular fiberglass tanks that allow us to provide optimal habitat conditions for each species. Thirty-seven species of freshwater mussels have been held at AWCC with 23 spawning in captivity to provide viable glochidia. Seventeen species have been propagated producing over 500,000 juveniles. A portion of juveniles are held to grow-out in a flow through system supplied with filtered river water, six species have been raised to over one year of age in this system. To date, we have released over 150,000 mussels ranging in age from 1 week to 6 years. In addition to mussels, the spiny riversnail, *Io fluviialis*, is raised at AWCC. These species are released in 6 designated augmentation reaches in the Powell, Clinch, and Holston rivers of the upper Tennessee River System of Virginia.

A comprehensive method for freshwater mussel sampling at long term monitoring sites

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The number of attempts at recovery of freshwater mussels through laboratory propagation has dramatically increased over the last decade. Before releasing specimens into the wild, a long term monitoring plan is needed to determine recovery success. The Virginia Department of Game and Inland Fisheries (DGIF) established a mussel restoration plan that incorporates monitoring at each of its' 6 designated restoration reaches in the upper Tennessee River drainage. The objectives are to delineate mussel aggregations, determine mean density, species richness and identify areas suitable for release of laboratory-cultured juveniles within a site. The survey protocol requires a site to be systematically sampled using one meter quadrats that covers a total of 5% of total habitat. Sampling in this manner determines the areas of highest mussel density. In these areas, 0.25m quadrats are randomly excavated and sieved to determine the surface and subsurface component of the mussel aggregation and examine recruitment through the presence of juvenile mussels. Finally, a qualitative visual sample is conducted to determine the presence or absence of any species that was not collected during quadrat sampling.

Advances in chiton research

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Chitons have long been subjects of detailed anatomical study while monographs and revisions have distinguished 900+ living and 480+ fossil species worldwide. More recent morphological and molecular phylogenetic analyses have better resolved chiton phylogenetic relationships, as partly reflected in Sirenko's newest classification (2006; *Venus* 65:27-49). Most familiar living chiton species belong to Chitonida, which is supported by shell, gill, egg hull, sperm, and molecular synapomorphies. Other living chitons are mostly deep water and belong to Lepidopleurida, which I provisionally regard as monophyletic and sister taxon of Chitonida. More basal Paleozoic chitons grouped as "paleoloricates" are still poorly resolved and almost certainly paraphyletic. Recent exciting discoveries have substantially expanded the disparity of what is considered a chiton, and significantly relate to the earliest evolution of Mollusca. Within Chitonida, my most recent molecular analyses support the basal position of Callochitonidae as sister taxon to an unnamed clade whose monophyly is supported by derived sperm and egg hull features. This clade is divided into Chitonina and Acanthochitonina (*sensu* Sirenko). I first reported in 1984 a striking corroboration of this division based on correspondence between egg hull and gill arrangement patterns. Members of Chitonina have spiny egg hulls whereas Acanthochitonina have cup-like egg hulls and derived abanal gill placement, and both are supported by molecular evidence. Relationships within Chitonina are largely unresolved while my molecular analyses robustly support subclades within Acanthochitonina, partly in conflict with Sirenko's (2006) classification. Specifically, it will be necessary to reassign *Tonicella*, *Cryptochiton* and *Dendrochiton* to the predominantly northern Pacific Mopaliidae, removing the more southern *Plaxiphora* and *Nuttallochiton* to a basal position within Acanthochitonina. Lepidochitonidae includes the northern Atlantic/Mediterranean *Lepidochitona* spp., sister of remaining lepidochitonids including two separate northern Pacific radiations: *Nuttallina* spp., etc., and *Cyanoplax* plus *Schizoplax*. These changes imply largely endemic radiations of separate northern Pacific chiton lineages.

New frontiers in western U.S. freshwater malacology

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Western U.S. non-marine mollusks have long been recognized for their diversity and peculiarities of biogeography and distribution. Application of molecular methods and careful detailed study of several at the genus and species levels indicates that diversity estimates of Frest and Roth (1995) may have to be drastically revised up or down, depending on genus. The first mtDNA phylogenies very recently have become available for some of the most prominent and characteristic western freshwater snails, slugs, and shelled terrestrial forms. Diversity at the species level has often been underestimated; but no single pattern or model can accommodate all western endemic forms. Examples are given from western springsnails (*Pyrgulopsis* and *Fluminicola*). Western freshwater habitats differ from Eastern in that headwater (spring) diversity collectively far exceeds that of downstream sites. In a semi-arid environment, springs may be more stable and persistent than streams.

Advances in *Fluminicola* (Rissooidea: Lithoglyphidae) research

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Among the most widespread freshwater gastropods in the western U. S. is the lithoglyphid rissooidean *Fluminicola* (*s.l.*). This group was reviewed using traditional shell and anatomical features as recently as 1996. Hershler & Frest (1996) recognized nine extant taxa, with the genotype likely extinct. A cladistic analysis indicated that „*Fluminicola*“ was distinct from European *Lithoglyphus* and eastern U. S. *Gillia* and *Somatogyrus* but was a composite of at least two phylogenetically distinct lineages (paraphyletic). Continuing research over the last decade has somewhat clarified the phylogenetic position of this group. Detailed study of Upper Sacramento-Pit River taxa indicated that at least 13 distinct taxa were present in this single drainage. Perhaps four major lineages are represented. Previous morphological examination had indicated a similar number of species-level taxa: but morphospecies were not necessarily identical to DNA entities, and results of analyses using molecular criteria for first-cut discrimination seemed preferable. The preferred methodology was analysis of mitochondrial DNA followed by description as species of monophyletic lineages that were also morphologically distinct. Detailed survey of the drainage immediately north, portions of the middle Klamath in the Cascade-Siskiyou National Monument, indicates the presence of an additional 14 or more morphospecies, none likely identical to Upper Sacramento system forms. DNA study over the whole range will likely discriminate many more relatively strongly endemic taxa.

Developmental mode in opisthobranch molluscs from the eastern tropical Pacific

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Little has been published on mode of development in benthic opisthobranchs from the eastern tropical Pacific Ocean. In late February 2006, we found 51 species of opisthobranchs at intertidal and subtidal sites near Puerto Vallarta, Mexico. The egg masses of 21 of these were positively identified in the field and collected, along with the adults, for observation in the laboratory. An additional 15 species, including a new species of *Eubranchus*, were collected and laid egg masses in captivity in the laboratory. Based on observations of uncleaved eggs, developing embryos, or hatching larvae from these egg masses, all 36 species were determined to hatch as planktotrophic larvae. One species, *Elysiella pusilla*, deposited irregular strands of extra-capsular yolk in its egg mass. The veliger larvae of *Pleurobranchus areolatus*, like those of other pleurobranchs (but not most other opisthobranchs), hatched without an operculum. Combined with previously existing data, mode of development is now known for 67 species of benthic, shallow-water nudibranchs from the eastern tropical Pacific. Two of these species hatch as juveniles, three as lecithotrophic larvae, and the remaining 62 species as planktotrophic larvae. The prevalence of planktotrophic development in the eastern tropical Pacific is similar to that in the northeast Pacific Ocean, but appears to be much higher than in either the Indo-Pacific region or western tropical Atlantic Ocean and Caribbean Sea.

A decade later: what we know and still don't know about opisthobranch biodiversity

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A decade ago, the status of knowledge of Indo-Pacific opisthobranch biodiversity was reviewed. At that time, it was estimated that approximately one-third of the Indo-Pacific opisthobranch biodiversity was undescribed. Since then, many new opisthobranch taxa have been described globally, with the majority of new taxa being named from the tropical Indo-Pacific. A review of that progress is presented within biogeographical, taxonomic and phylogenetic contexts. Current estimates of biodiversity of the Indo-Pacific are updated as are estimates for the eastern and western Atlantic, the eastern Pacific, and southern Africa. Recent studies of the opisthobranchs collected from below normal scuba diving depths are suggestive of the fact that deep-water biotas contain a large percentage of undescribed taxa. New collecting methods employed in shallow-water also greatly increase estimates of overall biodiversity. Recent extensive surveys of Philippine opisthobranchs, employing different collecting techniques, have produced surprisingly rich collections involving many new taxa. Additional field work from Madagascar also provides another rich data set, from which estimates of the current status of biogeographical and systematics are made for the western Indian Ocean. Recent systematic reviews of several opisthobranch genera, namely *Hypselodoris*, *Platydoris*, *Okenia*, *Roboastra*, *Tambja*, *Nembrotha*, *Aegires* and *Trapania* provide case-studies of the current state of knowledge of different opisthobranch taxa that can be used to make extrapolations for other lesser known opisthobranch groups.

Gastropod mitogenomics: no support for a pulmonate clade.

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In an effort to improve our knowledge of the phylogeny of gastropods, we have sequenced anew the complete mitochondrial genomes of five species of gastropods including one representative of Opisthobranchia (*Ascobulla fragilis*), one of Heterostropha (*Pyramidella dolabrata*), and three representatives of Pulmonata (*Siphonaria pectinata*, *Onchidella celtica*, and *Myosotella myosotis*). The new sequences have been aligned with all available complete mitochondrial genomes of gastropods from GenBank and subjected to different phylogenetic analyses. We discuss the phylogeny of gastropods, with special emphasis on the lack of support for the monophyly of Pulmonata and the evolution of mitochondrial gene order arrangement.

Sucker-Arm Coordination of Octopus in Grasping and Manipulation

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In the natural settings octopuses use their arms and suckers in a variety of dexterous manipulation tasks, such as extracting prey from crevices and burrows, opening bivalve shells and arranging middens in front of den entrances. Octopuses use their suckers for fine manipulation of objects smaller than the sucker by opposing the rims in “pinch”, they also use multiple suckers onto a single surface for a power grasp that supports locomotion or movement of larger objects. Like squids engaged in prey capture octopuses can also project an arm from their body, attach a group of distal suckers and pull an object toward them by shortening the arm. We have investigated octopuses’ use of suckers in similar tasks under controlled, reproducible laboratory conditions. Because larger suckers can generate larger adhesion forces we hypothesized that the larger suckers toward the base of the arm would be preferred in tasks requiring the arm to employ greater forces. We found, that a simple squid-tentacle like strategy approach of applying suckers of appropriate force generation to a surface and lifting or pulling the arm was not commonly used. Instead, in many cases the animals used a combination of arm movements in combination with different functional groups of suckers dynamically assigned to different rolls. When animals were restricted to the use of a single arm they preferred significantly, to use suckers in the middle reaches of the arm to support this coordinated arm-sucker activity. These results are consistent with a pattern of complex sucker-arm coordination and perhaps planning and are contrary to a view of suckers as passive agents reflexively reacting to surface contact.

Nudibranch Safari

J. Greenamyre, M. Miller

Nudibranch Safari is a twenty minute underwater video presentation, set to quiet background music, showing nudibranchs and sacoglossans in their natural habitat. It was edited by videographer John Greenamyre and Slug Site webmaster Michael Miller. John filmed the footage in October 2005 while visiting Papua New Guinea and Thailand, areas of enormous Opisthobranch diversity. Many of the species seen in this clip are undescribed! This film shows the animals moving in their natural habitat and captures many behaviors such as mantle flapping, gill vibrating, cerata pulsating as well as feeding and mating.

New approaches to documenting biodiversity in non-marine molluscs in western North America: A case study in the freshwater bivalve group *Cyclocalyx*.

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University of Colorado

Many ubiquitous, cosmopolitan non-marine western North American molluscs are also poorly understood taxonomically. Because of this, our understanding of diversity, distributions and ecology of these groups is limited or, when comparative inferences are made using faulty systematics, wrong. I advocate and show using a case study one reasonable approach to documenting regional biodiversity that can be applied to other taxa. The group I use as a case study is the genus *Cyclocalyx*, a ubiquitous, but small-sized freshwater clam. My approach is to use genetic data from sampled specimens across the western United States and a synoptic set of data already available to infer lineages throughout the region. I then examine if shell shape is diagnostic for those documented lineages. In particular, 16S rRNA genes were sampled from multiple habitats across western North America, focusing on an elevation gradient from sea level up to 3400 m and a phylogenetic hypothesis was constructed and lineages delineated, leading to an estimate of regional biodiversity. Morphometric analyses of shell outlines were used to test whether lineages from the gene tree were significantly different in shape from one another, and whether shell shape can be used to predict lineage affiliation. Finally, broad habitat variables were plotted onto the trees and examined in an evolutionary context. The results uncovered unnamed, genetically and morphometrically distinct lineages, remarkable range extensions, and an unexpected lack of abundance of some lineages. The results also show patterns with basal lineages restricted to high-elevation lakes and more nested lineages at lower elevations or with very wide tolerances. This work challenges almost all previous concepts of regional biodiversity of this group, while providing a foundation for future ecological and evolutionary hypothesis testing.

Genetic Characterization of Invasive Apple Snail Populations: Evidence of Multiple Introductions to SE Asia

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The freshwater apple snail genus *Pomacea* (family Ampullariidae) has a native range covering most of South and Central America and the southeastern U.S. *Pomacea* spp. have been introduced widely throughout southern and eastern Asia, Hawaii, many Pacific islands, and elsewhere in the mainland U.S. In their introduced ranges they have become major pests of wetland crops, notably rice and taro. The taxonomy of *Pomacea*, including the identity and precise geographic origins of invasive populations, is poorly understood. This lack of understanding has implications for research on many aspects of ampullariid biology, as well as the development of effective pest management programs. Apple snails have been sampled from more than 200 locations throughout their introduced and native ranges. Phylogenetic analyses of 1000 mitochondrial COI sequences representing 24 *Pomacea* species suggest that at least 4 *Pomacea* species have been introduced into southern and eastern Asia from multiple geographic origins in South America. This is contrary to anecdotal accounts of a single introduction of *P. canaliculata* followed by range expansion throughout the region. Argentina is clearly the source of the most widespread invasives, *P. canaliculata* and *P. insularum*, as well as the less common *P. scalaris*. *Pomacea diffusa* (previously thought to be *P. bridgesii*) likely originated in the Amazon region of Brazil. Clarification of systematic relationships and geographic origins of apple snails should prove valuable in developing management strategies by linking accurate species identities to ecological information and life history factors that control the distribution and abundance of these species.

Chiton (Mollusca: Polyplacophora) species known to Hispaniola Island

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The present paper offers a list of 23 species of chitons known to Hispaniola Island. For Dominican Republic the present compilation updates the last national marine biodiversity inventory that was done seven years ago and adds 5 species. A total of 23 species are now known for this part of the Island. For Haiti 5 species are listed. The localities where the collections have been done and the museums that harbour material from Hispaniola, are also offered. In comparison with the other islands of the Greatest Antilles the knowledge of the polyplacophoran species of Hispaniola could be considered very advanced.

Key words: Chitons, Hispaniola, biodiversity, Polyplacophora.

Phylogeography of two northeastern Pacific limpets: *Lottia strigatella* (Carpenter, 1864)
and *L. paradigitalis* (Fritchman, 1960a)

W. Hewson
California State University

Recent authors investigated the biogeography and phylogeny of two northeastern Pacific limpets, *Lottia strigatella* and *L. paradigitalis*, with DNA sequence comparisons. The results suggested that the strikingly similar morphology and ecology of these two limpets are not homologous and are, instead, the result of convergent evolution. Additionally, Point Conception, California, was identified as the southern range endpoint for *L. paradigitalis* and the northern range endpoint for *L. strigatella*. Approximately 1200 km of coastline encompassing Point Conception, however, were not sampled, indicating the need for further testing of the conclusions reached by the authors. I will use mitochondrial DNA sequences of the COI and 16S genes sampled from a more inclusive set of locations throughout the range of these two limpets to test the null hypotheses that: (1) *L. strigatella* and *L. paradigitalis* are not sister species; (2) the ranges of these two limpets are disjunct at Point Conception, California; and (3) previously unidentified species do not exist within the Southern California Bight. Preliminary results based on 16S sequences support the null model that *L. strigatella* and *L. paradigitalis* are not sister species and that their ranges are disjunct. However, sequences of specimen identified as "*L. strigatella*" from the Southern California Bight and Point Sal in Central California group into a well-supported clade that is distinctly different from sequences of *L. strigatella* from nearer the type locality of this limpet on mainland Mexico. The well-supported clades indicate the possibility of an undescribed Lottiid species in Southern and Central California. Further, the sequence data indicate that the ranges of *L. paradigitalis* and the novel Southern/Central Californian species do overlap North and South of Point Conception. The findings presented here are part of an ongoing study and additional sequences will be added to further refine our understanding of these ecologically important limpets.

Evidence for predominance of constructional constraint in three common features of gastropod veliger larvae

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The traditional explanation of organismal form and structure under the paradigm of modern evolutionary theory is selection for optimal performance. However, adaptation is not the only factor contributing to the features of living and fossil organisms. Although the gastropod veliger larva is a structurally complex life stage that must function efficiently in the plankton, it has puzzling features that suggest the operation of other constraints. A predominance of constructional constraint is hypothesized to explain three such features: (1) sinusigeral shell apertures, (2) velar lobe asymmetries, and (3) reticulate mesh works of aragonite shell sculpture.

The adaptive explanation of the sinusigeral aperture is that the beak evolved to protect the head of the veliger and that the notches evolved to accommodate the velar lobes. An alternative hypothesis is that shell secretion is retarded by the continuously-deployed velar lobes and proceeds unimpeded in the region between the lobes to produce a beak. Thus the beak and notches are a *consequence* of progradation along a margin of constraint and permission. Likewise, asymmetry of right and left velar lobes is the consequence of a growth imperative to achieve hydrodynamic balance for a shell and body mass that are displaced asymmetrically beneath the velum. Reticulate aragonitic mesh works that recur on the surfaces of larval shells have never been observed on adult shells and are inconsistent with the programs by which shell features are modeled in classical theoretical morphology. A hypothesis of weak biological control of shell mineralization during early ontogeny is supported by close similarity of aragonitic mesh works on larval shells and self-assembled mesh works produced experimentally in biliquid foams by materials chemists. Bioinorganic materials chemistry offers a foundation for a new understanding of the molluscan shell as a balance between what is induced and what is controlled by the organism.

Detection Surveys for Non-native Terrestrial Stylommatophoran of Agricultural Significance

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Non-native snails are frequently intercepted through routine cargo inspection of maritime shipping containers at U.S. ports of entry. Hygromiid and helicid species such as *Theba pisana*, *Candidula intersepta*, *Xerotri cha conspurcata*, and *Cerņuella virgata*, are notorious hitchhikers on shipping containers, and have established new populations throughout the world, and in some cases become serious notorious agricultural pests. In conjunction with port inspections, detection surveys are a tool to uncover new exotic mollusk infestations that may have established. Early detection allows proactive control activities to occur before the new population becomes a widespread pest. From fall 2004 to spring 2006, a detection survey was conducted in Oregon to safeguard several agricultural industries from the possible establishment and spread of certain exotic terrestrial mollusk species. Through import investigations, several sites were identified and prioritized for risk of receiving high-risk materials from regions of the world with known populations of the target species. Visual survey was conducted at each site to determine presence or absence of target species. An overview of targeting, detection survey methods and results of the Oregon survey will be discussed.

A geographic mosaic of passive dispersal: population structure in the endemic Hawaiian amber snail *Succinea caduca* (Mighels, 1845)

B. Holland
University of Hawaii

Despite poor active dispersal and limited sea water tolerance, a number of land snail families have distributions spanning ocean barriers. We used 264 cytochrome *c* oxidase subunit I (COI) and 84 16S large ribosomal subunit (16S) sequences to evaluate geographic patterns of variation in 21 populations of the endemic Hawaiian land snail *Succinea caduca* spanning its range on six Hawaiian Islands. Haplotype networks, pairwise molecular divergence and F_{ST} matrices and gene tree topologies suggest substantial geographic genetic structuring and nonlinear population expansion patterns. Low nucleotide diversity (COI $0.003 \leq 0.03$; 16S $0.002 \leq 0.03$) and low within population molecular divergence (COI mean $D_{xy}=0.9\%$) coupled with higher between population values (COI mean $D_{xy}=2.8\%$) suggest multiple inter/intra-island founder events. High haplotype diversity (COI $h=0.987$; 16S $h=0.977$), particularly on younger islands, suggests mechanisms of diversification involving fragmentation by historical lava flows and seasonal bottlenecks. AMOVA revealed that within island population comparisons ($\sigma_C=0.544$; $V_b=48.11\%$) accounted for the majority of molecular variance rather than between island comparisons ($\sigma_T=0.115$; $V_a=11.5\%$). Although *S. caduca* populations were consistently differentiated (98% of 128 COI haplotypes private by population), a Mantel test showed no evidence for isolation by distance ($R^2=0.0876$; $P<0.05$). Mismatch distributions and population partitioning patterns suggest that genetic fragmentation has been driven by punctuated, passive dispersal of groups of closely related haplotypes that subsequently expanded and persisted in isolation for prolonged periods (average >2 Ma). Historical availability of mesic coastal habitat, together with effective dispersal may explain the unusual multi-island distribution and long-term persistence of this species.

Keywords: *Succinea caduca*, Hawaiian Islands, founder events, population structure, mtDNA, passive dispersal

Variation in behavior, population density, and sex ratio of *Abdopus aculeatus*
(d'Orbigny, 1834)

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University of California

Changes in the operational sex ratio and population density can affect the rates at which males encounter both potential sexual competitors and prospective mates. In turn, these factors can shape mating and aggressive behavior. *Abdopus aculeatus* are found at fairly high densities (for octopus) with male-biased sex ratios. They demonstrate the most complex mating behavior among any octopuses observed to date, involving mate-guarding, mate-competition, sex identification, a female-typical display, and female-mimicry by males. Mating and aggressive behavior of *Abdopus aculeatus* were studied in the wild to document possible effects of sex ratio and density on plasticity of these behaviors. In five 200m² plots, density ranged from four to ten adult octopuses. The ratio of male to female *A. aculeatus* of reproductive size (males and females \geq 30 mm ML) in these plots ranged from 1:1 to 3.5:1. Mate guarding, mating, displays of black and white stripes (most common during aggression or in the presence of females), and pairing behavior (males and females occupying holes within arm's reach) were observed at all densities and sex ratios. Using Principal Components Analysis, rates of aggression by paired males and the duration of mating bouts by unpaired males appeared to vary with sex ratio and density. The duration of mating bouts by paired males did not vary according to sex ratio or density. These responses might reflect the ability of individuals to detect the local abundance of other male octopuses and the possibility of sperm competition.

Spermatozoan morphology of *Anomalocardia brasiliiana* and *Tivela mactroides* (Mollusca, Bivalvia, Veneridae)

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We investigated the ultrastructural characteristics of the spermatozoa of two bivalve species, *Anomalocardia brasiliiana* and *Tivela mactroides* (Veneridae), from the Brazilian coastline, and examined the relationship between spermatozoan shape and environmental conditions. *Anomalocardia brasiliiana* and *T. mactroides* live on beaches and sand flats that vary considerably in their physical characteristics. *Anomalocardia brasiliiana* burrows 5 cm deep in soft mud and in muddy beaches in quiet waters, with little disturbance of the bottom sediment. *Tivela mactroides* occurs in the intertidal zone where it burrows 5 cm deep in sand or muddy sand in areas with significant disturbance of the bottom sediment that results in a high concentration of suspended material. The sperm cells of both species were of the primitive type or ect-aquasperm form. The spermatozoan head consisted of a curved nucleus with a short, cone-shaped acrosome. An invagination penetrated almost the entire length of the conical acrosome. The middle piece had a pair of orthogonally arranged centrioles surrounded by spherical mitochondria, and the flagellum had the typical 9+2 structure. The sperm of *A. brasiliiana* had a slightly curved nucleus, while that of *T. mactroides* had a prominent curved nucleus that was quite long. The mitochondria were equally distributed around the centrioles in the middle piece of *A. brasiliiana* sperm, whereas the middle piece of *T. mactroides* sperm was rotationally asymmetrical and contained clusters of glycogen. These findings indicate that the sperm of *T. mactroides* have a hydrodynamic shape adapted to environments with wave movements and a large amount of suspended material.

Predatory induced morphology and life history responses of a freshwater snail in reaction to leeches

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Chowan University

Physa acuta, a prominent member of freshwater ecosystems, is known to have both morphological and behavioral responses to both fish and crayfish predators. However, very little has been done on physids' response to leech predators. We tested how the snail responded to leech presence and leech water with regards to shell shape and onset of egg laying against the null hypothesis that there was no effect. There were two treatments: snail + leech water, snail + leeches along with a control (snail only). There were two tanks per treatment/ control, 10 snails per tank, and a middle row of cups (that either contained a leech or was empty). For the leech water treatments, 100 ml of water was added from a tank that housed leeches that were fed snails, before topping off the tank each week with fresh pond water. In the leech treatments each individual leech (of five) was fed one snail per week. Each week, we measured both length and width of each individual shell. We also counted the number of eggs per individual snail per week. We found a significant length by width effect with regards to snail + leech and snail + leech water when compared to the control, Kruskal-Wallis $p=0.027$. We also found a significant onset of egg laying effect (ANOVA, $p<0.02$) between treatments/control. In conclusion, there seems to be a chemical produced by leeches that affects both shell shape and onset of egg laying in *Physa*.

Poster

The type collection of specimens described by Rudolph Bergh and housed in the Zoological Museum, Copenhagen.

K. R. Jensen
Zoological Museum

The Danish anatomist and medical doctor Rudolph Bergh described more than 500 species-level taxa, the majority of which were opisthobranch molluscs. Despite his detailed anatomical descriptions and figures of different parts of the anatomy, there are some major taxonomic and nomenclatural problems associated with the species he described. First, he was not a taxonomist. He put names of new taxa in foot-notes of several papers, sometimes with one descriptive character, but usually without any description at all. This has left his successors with a suite of *nomina nuda* and/or species descriptions that are almost impossible to find, not to say useless for identification of the species. Also, he did not select types. This may be excusable since nomenclatural rules were non-existent at the time. But most of his contemporaries did select types, which were deposited in private or public collections. Second, he was not a "museum-person". In fact, he was apparently *persona non grata* at several European museums because he had the habit of splitting unique specimens into separate organs, and either discarding them after meticulously having described and drawn them, or leaving them inadequately labelled in his private laboratory. In the present talk I will describe the attempt at locating those type specimens that are found in the Zoological Museum in Copenhagen.

Sexual Role Determined by Size in *Helisoma trivolvis*

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College of St. Catherine

Helisoma trivolvis, a freshwater snail found in North America, is a simultaneous hermaphrodite. While *H. trivolvis* are not commonly observed during copulation, work on snails in the genus *Physa* has shown smaller snails acting as male and larger ones as female during copulation. Since body size and egg production are linked in members of both genera, larger snails should have the energy resources to produce eggs and act the female role while smaller snails would benefit energetically to act as male during copulation. We hypothesized that when two *Helisoma trivolvis* of different size mate, the larger of the two would assume the role of the female and the smaller would adopt the role of male. We isolated and measured 60 snails and kept them in reverse light and dark conditions (10L:14D, with lights on at 1:00 PM) in order to observe them during their active period. The average size of small snails was 8.3mm and that of large snails was 12.6mm, with the average difference in size 4.9mm. After three weeks of isolation, the snails were paired and observed for copulation. Once copulation occurred, snails were placed under a dissecting microscope to determine gender role of each snail. A small proportion of snails mated reciprocally. When snails mated non-reciprocally, the smaller snail typically acted as male and the larger as female. These data are consistent with a size-advantage model of copulatory behavior.

Cadlina and the chromodorids

R. F. Johnson

California Academy of Sciences, University of California

In my work, I use morphological and molecular tools to untangle relationships within and among the chromodorid nudibranchs. This work has led me to further investigate the relationship between the chromodorids and the rest of the dorid nudibranchs. The chromodorids are the most diverse group (family) of nudibranchs with over 300 described species. Some authors consider species of *Cadlina* to be chromodorids and others have placed *Cadlina* in its own family. Species of *Cadlina* are found in temperate or polar seas and are mostly white, whereas chromodorids are primarily found in tropical or subtropical waters and have an amazing array of colors and patterns. *Cadlina* and the chromodorids have been traditionally united by the presence of mantle glands. Recent work has highlighted the tenuous nature of our hypotheses on *Cadlina*-chromodorid-dorid relationships and the need for comprehensive investigation into the basal chromodorid problem. I will present my preliminary hypothesis of relationship using mitochondrial DNA and morphological characters. I will also discuss some interesting intra and inter specific biogeographical patterns found within different groups of chromodorids

Phylogenetic relationships of Japanese species of the genus *Semisulcospira*
(Caenogastropoda: Pleuroceridae)

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The genus *Semisulcospira* (Caenogastropoda: Pleuroceridae) is a group of freshwater snails widely distributed in Eastern Asia. Approximately 30 species live in Japan, and 15 of them live endemically in Lake Biwa (Shiga Pref.) which is known as one of the ancient lakes in the world. These endemic species have been considered as a species flock, based on taxonomical studies and fossil records. However, the detailed phylogenetic relationships and evolutionary patterns of them have remained unsolved. In the present study, we investigated the phylogeny of 16 species of the genus *Semisulcospira*, including 13 endemic species in Lake Biwa water system and three non-endemic species, *S. (S.) libertina*, *S. (S.) reiniana* and *S. (S.) kurodai*, using allozyme analysis.

As a result, the endemic species were divided into three groups (*S. (B.) decipiens* group, *S. (B.) niponica* group and *S. (B.) habei* group) based on their genetic features. The *S. (B.) niponica* and *S. (B.) habei* groups are closely related to the non-endemic *S. (S.) libertina* and *S. (S.) reiniana* groups, and the non-endemic species *S. (S.) kurodai* is included in the *S. (B.) decipiens* group. On the other hand, the *S. (B.) decipiens* group is genetically different from any other groups. Considering these results, it is presumed that the living endemic species did not directly speciated from a common ancestral species and form a polyphyletic group. It is probable from the genetic distances and the topology of the phylogenetic tree that the *S. (B.) decipiens* group has evolved independently of any other groups, and the *S. (B.) niponica* and *S. (B.) habei* groups speciated from the *S. (S.) libertina* group.

Diverse Patterns of Gene Flow in West Coast Chitons with Similar Development
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University, Fullerton

Many studies have contrasted marine species with different developmental types and shown varying gene flow patterns associated with those developmental differences. Here, we report widely variable patterns of gene flow for 28 species of chitons (Mollusca: Polyplacophora) with highly similar development from the eastern Pacific and detail an apparent latitudinal gradient in gene flow across species along the coast. These results have broad implications for marine genetics, decoupling developmental mode from pattern of gene flow and challenging the view that gene flow can be easily inferred with cursory knowledge of a species' biology. Instead, we recognize phylogenetic trends in population connectivity that may be useful in predicting species level patterns.

Cephalopod behavior provides insight into circulatory function

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Dalhousie University

The power output of the coleoid cephalopod heart has been calculated to increase to almost mammalian levels during exercise. Many hypothesize that the mantle might help the systemic heart to achieve such high power outputs. The coleoid cephalopod mantle encloses the hearts, the large arteries and the large veins. When the mantle contracts, it produces pressures in the mantle cavity which could potentially drive blood flow through the veins. However, results from our studies using non-invasive imaging ultrasound on resting cuttlefish (*Sepia officinalis*), suggest that mantle cavity pressures do not drive venous return; venous contractions were inconsistent with the pressures supposedly created by the mantle. Data from cuttlefish showing pre-jetting behavior, however, suggest that the mantle could create forces within its own tissues that aid circulation. During the hyperinflation that precedes jetting, cuttlefish hearts stopped or slowed, suggesting increased peripheral resistance. Previous studies report that radial mantle muscles contract strongly to hyperinflate the mantle before jetting. Their contraction could compress the many capillaries in the mantle wall that are oriented perpendicularly to them. The capillaries are oriented parallel to the circular mantle muscles, and would not be compressed when these muscles contracted to constrict the mantle and expel water. The alternating contractions of the radial and circular mantle muscles could create a bellows like effect in the peripheral circulation, providing propulsive forces for circulation during normal ventilation and jetting, but stopping circulation when the cuttlefish engaged in pre-jetting behavior.

Native snails semi-isolated from other snail populations in small central California brackish marshes.

C. L. Kitting, C. L. Davis
California State University

California estuarine marshes experience wide salinity fluctuations, seasonally and spatially, from freshwater during winter storms to hypersalinity during dry summer evaporation in marsh pannes. Certain restored and historical marshes yield numerous tiny, ~5-mm-long snails, virtually year round, such as adult hydrobiid snails. Natural dispersal appears limited, as these tiny adults brood young in the mantle cavity. In the laboratory, individuals tolerate wide salinity fluctuations. Non-destructive, standardized close-up photographic mini-quadrats, in the field, assist in comparing abundances of these tiny snails while exposed to view, and active, even during daylight. These animals otherwise are easily overlooked among dense vegetation and soft sediment. In several small, semi-isolated marshes, native hydrobiid snail population densities reach over 50 snails per 100cm². Other sites can yield comparable population densities of NON-native snails plus other invertebrates, instead.

In outer Elkhorn Slough, near Monterey Bay, a tiny hydrobiid snail, Tryonia imitator, “the California brackish-water snail,” has been a candidate for the endangered species list, and only a few dead snails now are detected at most sites previously reported with these snails, live. Introduced Asian mud snails, Batillaria attramentaria, instead are common among those sites, now. We found that two semi-isolated marsh areas with few if any Batillaria averaged over 15 active T. imitator per 100cm² in December, 2005.

Semi-isolated habitat restoration or conservation areas, even if small, may be particularly valuable in preserving or restoring vulnerable, often native species such as tiny hydrobiid snails. Especially if weeding of invasive animals (and possibly plants) is exercised during intensive monitoring, such semi-isolated native populations could remain relatively isolated from typical populations of invasive species. Some small, naturally variable, possibly tended, patches of native habitats might be the most practical way to avoid loss of entire, unusual native populations, otherwise vulnerable to extinction among invasive species.

Conus radular characters in taxonomy and phylogeny: Congruence with molecular genetics?

A. Kohn and C. Meyer
University of Washington

Conus radular teeth are independently operating structures that are sufficiently complex to provide a number of discrete and quantitative characters useful in evaluating the range of intraspecific variation and interspecific differences among closely related species. These include size, shape, number and configuration of barbs and blades, and presence or absence of a waist, spur, cusp, and serrated edges. In a 1999 study, Nishi and Kohn showed that nine quantitative characters were sufficient, either singly or in combination, to distinguish a set of 11 molluscivorous *Conus* species, concluded to be distinct but closely related on the basis of shell characters, from one another. Species-level molecular phylogeny suggests that all extant molluscivorous *Conus* species arose from a single common ancestor. Phylogenetic analysis of radular tooth characters in this clade also indicates a high degree of congruence with the molecular phylogeny. We then posed the question, do radular tooth characters in two other *Conus* species groups lead to a taxonomy that is consistent with that derived from shell characters and a phylogeny consistent with that based on molecular genetics. In one group, that of piscivorous species, molecular genetic evidence suggests multiple origins within the genus. Preliminary analysis indicates consistency with taxonomy based on shell characters but a lower degree of congruence with molecular phylogeny than in the molluscivorous group. The other group, vermivorous species of the Western Atlantic region, is being analyzed and will be reported on at the meeting but results are not yet available.

Caribbean sacoglossans: Cryptic genetic divergence and phylogeography

P. J. Krug, R. A. Ellingson and E. Hidalgo
California State University

Sacoglossan opisthobranchs show remarkable flexibility in development; larval type can vary between closely related species and even within a species. Development mode can be a valuable taxonomic character; however, as poecilogony occurs in sacoglossans, larval traits may be unreliable for species identification without supporting molecular data. The Caribbean *Costasiella ocellifera* was posited by Clark to represent a cryptic species complex, because distinct populations from the Florida Keys exhibited benthic or planktotrophic development. Molecular and developmental data from 8 Caribbean sites show instead that *C. ocellifera* is a single poecilogonous species. Lower Keys (benthic) haplotypes formed a distinct clade nested within the Upper Keys (planktotrophic), with a shallow genetic divide suggesting recent colonization of the Lower Keys by a planktotrophic ancestor. Surprisingly, a deep phylogeographic break distinguished Florida specimens from the rest of the Caribbean, suggesting a one million year separation. A single Bahamian haplotype in Florida indicated present-day larval exchange, despite the historical block to migration between regions. In the main Caribbean clade, both development modes were present in several populations, and individuals differing in development shared haplotypes. *Costasiella ocellifera* is therefore the third poecilogonous sacoglossan, with an intraspecific divide delineated by geography rather than development mode. A different pattern was evident for *Elysia* spp. with reduced dispersal potential. *Elysia tuca* (short-lived larvae) and *E. crispata* (no dispersing larvae) showed evidence of widespread population crashes followed by recolonization out of Panama, which harbored extensive ancestral diversity. In *E. crispata*, private ancestral haplotypes were also recovered from most sites that were 6-8% divergent. Floridian specimens of *E. crispata* were recently described as a new species based on local adaptation and genetic distance, but our data suggest each island cluster may harbor a derived lineage, making descriptions premature until a full phylogeographic analysis can be completed.

Not just a chameleon: octopuses have a body pattern repertoire

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For the first time, we systematically analyzed the body patterns using a proposed new species in the *Octopus vulgaris* complex, based on locations of chromatophore nerve projection. Although cataloguing and describing cephalopod body patterns can be very useful to characterization and distinction of species, taxonomists have always thought that these patterns were too variable to be used as a systematic character. We believed that a systematic analysis would bring order to this complex system, allowing future detailed comparisons among groups of species. This approach would also establish links between its body patterns and particular behaviours and the underlying physiology of the chromatophore system. Body patterns of the proposed new species from northeastern Brazil were characterized in terms of percentage of occurrence, areas of location, and numbers of components in each pattern, based on under water photographs. To verify the distribution of chromatic components, skin patterns and colors among areas of the body, we ran a cluster analysis based on occurrence of the components. We found a total of 16 chromatic, 5 texture and 9 skin units, 6 colors and 9 chronic body patterns, and the cluster analysis showed twelve distinct areas. Smaller fields were found in areas with complex patterns, especially around the eyes, while larger ones were found in the areas with simple patterns. This important finding reflects a division into different morphological and physiological units in these. The strong degree of similarity among photographs supports previous taxonomic studies that pointed to morphological similarity within the species from oceanic islands of northeastern of Brazil. This new approach also can be used to compare photographs from other species, and, in addition to morphological and DNA analyses, it could be a strong framework to differentiate and describe new species.

Hemocyanin meets chitons: Phylogeny of polyplacophorans revisited by hemocyanin genes

B. Lieb, K. Streit, R.P. Kelly, and D. J. Eernisse

Johannes Gutenberg University, Columbia University, American Museum of Natural History, California State University

Molluscan hemocyanins are ancient respiratory proteins estimated to have evolved ~700-800 MYA. The native molecules are formed from 10, 20 or more identical subunits of which each possesses a molecular mass of 350 - 400 kda. The subunits show a repetitive structure of 7 (a-g) to 8 (a-h) functional units. Each domain-coding exon is separated from a paralogous neighboring exon by an intron of variable size. These introns are likely as ancient as the Precambrian duplication events that led to the repeated exons, because all these introns are in phase 1 and are also located at the same positions within the orthologous hemocyanin genes across Mollusca. In contrast to the case of gastropods, bivalves and cephalopods, in which paralogs of the entire hemocyanin gene region can be observed, chitons possess only one type of hemocyanin, and this forms ~4,000 kda homodecamers. We assessed the phylogenetic utility of hemocyanin for selected chitons that were also sequenced for standard mitochondrial (COI, 16S) and nuclear (18S) markers. Particular coding regions were compared across diverse chitons, and results were consistent with expectations for high-level relationships based on recent morphological and molecular studies. In particular, Chitonida was robustly subdivided into two clades, Acanthochitonina and Chitonina, although these results are preliminary due to still limited taxonomic sampling. We also analyzed 30+ individuals of *Lepidozona* for a 670+ bp region comprised of an intron along with portions of each flanking functional unit, f and g, where our primer regions were located. This intron region was not variable enough in *Lepidozona* to reveal phylogeographic structure within species but was very effective in resolving species relationships within *Lepidozona*, including support for previously unrecognized species. Our goal is to employ sequences from this and the other molecular markers in a combined phylogenetic analysis of *Lepidozona*.

Community structuring impacts of *Enteroctopus dofleini* in Prince William Sound, Alaska

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Enteroctopus dofleini, the giant Pacific octopus, is a large mobile predator that frequently dens and hunts in the low intertidal zone of shorelines in Prince William Sound, Alaska. To shed light on the role of molluscan predators in intertidal structuring, two intertidal rocky reefs were surveyed. The two sites were similar in habitat characteristics known to affect octopus abundance (slope, kelpcover, cobble size, boulders and substrate), but differed in that octopuses were removed by harvest from one reef but not the other. At each site species richness, abundance and unevenness (Berger-Parker Index) of epibenthic fish and invertebrates were recorded along transects monthly from May to August 2005.

Overall abundances were similar on control and harvest sites. However, abundance of crabs at the harvest site increased; while that of all species except crabs declined. This pattern was reversed at the control site where crabs showed little change and other species increased. Richness overall was higher at the control site, but otherwise exhibited similar patterns to abundance, with crabs declining at the control site and increasing at the harvest site. Berger-Parker Index (unevenness) was lower overall at the control site, where there was a non-significant increasing trend throughout the season for crabs while exhibiting a slight declining trend for non-crab species.

The decrease in richness and abundance all species except crabs at the harvest site suggests a trophic cascade with the removal of octopus followed by high crab survival and subsequent declines in the invertebrate prey of predatory crabs. These results support the contention that *Enteroctopus dofleini* can exert a top-down community control through the removal of crab predators.

Sperm morphology of *Mytella charruana* (Mollusca, Bivalvia, Mytilidae)

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The mytilid species *Mytella charruana* is found throughout the Atlantic shoreline from Venezuela to Argentina and throughout the Pacific coastline, from Mexico to Peru. It has a significant ecological and economic importance. *Mytella charruana* populations occur generally in rocky shores as crevice dwellers. The shell length of the adult samples is usually around 50 mm. The difficult to provide characters with taxonomic value has been explained by the intraspecific variation and by the shell plasticity of *M. charruana*, which is largely determined by the crevice dwelling. Several studies of comparative sperm morphology have been published within the Bivalvia, and collectively these help to confirm the usefulness of sperm features for taxonomic and phylogenetic analysis at and above the species level. In this study, transmission and scanning electron microscopy were used to examine the sperm structure of *M. charruana*. The *M. charruana* sperm consists of a short conical head, a midpiece containing four mitochondria and a simple flagellum with a 9+2 microtubular pattern. The conical acrosome exhibits a perforatorium, which is anchored in the nucleus. The morphological structure exhibited by *M. charruana* sperm conform to the primitive type as well as to the pattern of morphology described for free-spawning bivalve mollusks. The sperm features described here for this mytilid species are very similar to those of other members of the subfamily Mytilinae.

Opisthobranch mollusca of Russia: the neglected diversity of cold waters

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Traditionally in Russia little attention was devoted to the study of opisthobranch molluscs. This neglect is undeserved, since the first known nudibranch mollusc from Russian seas – *Limax tetraquetra* was described by the St. Petersburg's scientist Peter Simon Pallas almost in Linnean times, in 1788. Recently, several scientists, among them Yuri Minichev and especially, the prolific worker Irina Roginskaya have contributed to the knowledge of Russian opisthobranchs. Despite certain progress, information on Russian opisthobranchs is still scanty.

Starting in 1987, an integrated taxonomic study of opisthobranch molluscs from almost all Russian seas (from the Barents Sea to the Japan Sea, including the Black Sea) has been ongoing. The presence of most of the opisthobranch families in the Russian fauna has been discovered.

The seas of Russia are characterized by mean summer surface temperatures below 10¼ C. Subtropical waters influence only two, the Japan and the Black Seas. Surface winter temperatures in the Russian part of the Japan Sea are below the freezing point and only few species from the rich Japanese fauna can adapt under these conditions. There are several pairs of cryptic species, one member of which lives in the northern part of the Japan Sea, while the other preferentially inhabits the southern part. Some of these pairs are: *Japonacteon* sp. – *J. nipponensis* (Yamakawa, 1911), *Leostyletus pseudomisakiensis* Martynov, 1998 – *L. misakiensis* (Baba, 1960), *Trinchesia* sp. – *T. pupillae* (Baba, 1961), presumably speciation was based on differences in comfortable temperatures.

Despite the general cold-water appearance of the fauna of Russian seas, 155 species of opisthobranchs are currently known. At least about 12 additional species await description, for instance from the genera *Archidoris*, *Adalaria*, *Cerberilla*, and others. Another feature of the Russian opisthobranch fauna is the presence of numerous archaic taxa from different families.

Finally, there is confusion regarding the name *Limax tetraquetra* Pallas, 1788. According to present study, *Tritonia diomedea* Bergh, 1894 is a junior subjective synonym of *Limax tetraquetra* Pallas, 1788, non Bergh, 1879. The oldest valid name for *Tochuina tetraquetra* sensu Bergh, 1879, non Pallas, 1788 is *Tritonia gigantea* Bergh, 1904, which is used here in the combination *Tochuina gigantea* (Bergh, 1904) comb.nov.

Archaic Tergipedidae of the Arctic and Antarctic: a new genus from the Barents Sea and revision of the genus *Guyvalvoria* Vayssiere with descriptions of two new species

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Most species of the family Tergipedidae possess a slender body with simple branches of the digestive gland tending to reduce, sometimes up to single ceras per row. Only few taxa, for instance the type species of the genus *Cuthona*, *C. nana* have a relatively broad body and highly branched digestive gland. Most Tergipedidae, with minor exceptions, have the anus in the acleioproctic position, high in the interhepatic space. A notal ridge is not known for tergipedids. The present study examines two tergipedid genera which possess numerous branches of the digestive ducts, an elevated lateral ridge, a posterior anus and other atypical characters for the family Tergipedidae.

One of these taxa is a new genus and species from the Murman coast of the Barents Sea (depth 60-300 m). It is characterized by having a wide body, numerous branched rows of the digestive gland ducts and an elevated notal ridge. The radular teeth of the new genus possess unusual clusters of lateral denticles. The other taxon, the Antarctic genus *Guyvalvoria* Vayssi re, 1906 is revised. Based on new material and the type specimen, the type species of the genus, *G. francaisi* Vayssi re, 1906 is redescribed. Two new species of the genus *Guyvalvoria* are described from the Davis Sea and the sub-Antarctic Kerguelen Id. The Antarctic genus *Guyvalvoria* and sub-Arctic new genus have some similarities in their external appearance, both have numerous branches of the digestive gland and have a tendency to shift the anus caudally. Morphological peculiarities of the new taxa suggest a new interpretation of the head, which differentiates it from the typical head of other aeolids. Transformation of the digestive gland branching pattern within the family is also explored. Both the new genus and *Guyvalvoria* Vayssi re, 1906 are considered basal within the Tergipedidae.

To boldly go where no mollusk has gone before: personalities, play and consciousness in cephalopods

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The recent rise in interest in animal minds and comparative cognition have given us an opportunity to look at mollusks in different ways. With their large brains and learning capacities, cephalopods are the ideal group about which to ask new kinds of questions. First, do molluscan animals have personalities? Mather and Anderson (1993) showed the temperaments of *Octopus rubescens* vary on three dimensions called Activity, Reactivity, and Avoidance, similar to “higher” vertebrates. Do cephalopods play? Mather and Anderson (1999) showed that *Enteroctopus dofleini* used an empty pill bottle to do the marine equivalent of “bouncing a ball.” Kuba (2003) extended this with *Octopus vulgaris* to show that they do not play mostly as juveniles, in contrast to vertebrates, and the behavior seemed to peak five days after object introduction. Do cephalopods have consciousness? Mather (in submission) argues that this depends on how you define consciousness. While Moynihan (1985) suggested that squid might make a visual language on their skin, the relatively low sophistication of this communication system to not seem to bear this out. But if one uses Baar’s (1993) idea of a global workspace on which animals can bring information to attend to and from which to make decisions, it is easy to make a case for octopuses having consciousness. Sleep, clam shell opening techniques, visual stimulus attributes for learning, habituation, and play are all arguments for octopuses using such a workspace.

Where next? Having opened a Pandora’s Box of behavioral flexibility in cephalopods, we can look at similar ideas in other mollusks. Perhaps you do not need a big brain to have some of these attributes. Flies sleep and snails have been seen “playing” with bubbles. It’s only if we try to look that we have the chance to see.

Genera of the *Crepidula*-group: revised definitions based on characters of the shell muscle and septum

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The limpet form is known at various levels throughout gastropod evolution. Major groupings within limpet families have traditionally been based on distinctions in shell muscles and muscle scars, which enables placement of fossil species. There are a number of possible combinations of shell muscles among calyptraeid limpets, as was recognized by early authors, who provided a number of generic-level names. K. E. Hoagland (1977) revised the genus *Crepidula*, but recognized no subgenera. R. Collin (2003, several papers), conducted phylogenetic analysis, but did not define genera based on muscle configurations. Because access to the environment is controlled in limpets by shell muscles, it follows that muscles and muscle scars are basic to function and provide conservative characters important to the classifications of all limpets. Here I outline an alternative classification for the *Crepidula*-group of genera, based on shell muscles and morphology of the septum. Species previously assigned to the broadly defined genus *Crepidula* have three conditions for shell muscles: 1) one oval muscle on the right side (of either large or small size), 2) two equally sized muscles with a narrow connection between (actually comparable to the horseshoe-shaped muscle of limpets in other families), or 3) lack of shell muscles. Caenogastropods generally have a single columellar muscle, which suggests that the single muscle condition (which applies to *Bostrycapulus*, *Crepipatella*, *Grandicrepidula*, and a new genus) should be basal. Two other two conditions, the two-muscle condition (which applies to *Garnotia* and *Maoricrypta*), and the no-muscle condition (which applies to *Crepidula*, s.s., *Verticumbo*, and *Siphopatella*), are separately derived conditions. Collin's (2003) phylogeny recognizes some of the genera that are apparent to me, but her trees place some species of all three shell-muscle categories within a broadly defined genus *Crepidula* (which would require intra-generic character state reversals). A further phylogenetic analysis should be performed to test the relationships among genera defined on character sets for the septum and shell muscles.

The impact of alien predators on native snails; distribution and prey choice of the predatory snail *Euglandina rosea* and *Oxychilus alliarius*

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The introduction of two predatory land snails, *Euglandina rosea* and *Oxychilus alliarius*, has been implicated as a major factor in the decline of native Hawaiian land snails. However, little attention has been focused on the ecology of these species, making predictions of their future effects difficult. In order to address the possible effects of these two predators on the Hawaiian land snail fauna, a survey of the distribution of the two species in relation to the distribution of native species was undertaken along an elevational gradient on the island of Hawaii; and prey-selection experiments were performed in the laboratory. The highest densities of *O. alliarius* were in habitats occupied by native snails, while *E. rosea* was found primarily at lower elevations in habitats that native snails no longer occupy. Prey preference experiments with *E. rosea*, using abundant introduced snails (*Succinea* sp., *Achatina fulica*, *Paropeas achatinaceum*) and slugs (*Veronicella cubensis*) showed that it preferred the snails to the slug but showed no preference among the three snail species. In prey-size selection experiments, using different sized *A. fulica*, *E. rosea* always preferred smaller snails. Experiments with *O. alliarius* were less extensive but indicated that *O. alliarius* will consume *Succinea* spp. less than 3.0 mm in shell length, although they will not consume succineid eggs. When offered snails and slugs of various species smaller than this 3.0 mm size limit, it consumed all snails offered (*Succinea* spp., *Tornatellides* spp., *Philonesia* sp., *P. achatinaceum*) but did not consume the slugs (*Deroceras* sp., *Arion intermedius*). These results suggest that both *E. rosea* and *O. alliarius* are generalist snail predators feeding preferentially on smaller snails, but that they rarely eat slugs.

Opisthobranch Research in the last Decade

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They say, as you get older, things seem to happen faster, although in the case of Opisthobranchs, we are living in an era where a lot is happening, and quickly, so we are blessed with “interesting times”. Some of the major impacts have been, not surprisingly, the result of technology. Ten years ago we had computers, but not the high-speed easy access, which allows us to align DNA and produce huge cladograms. Many of today’s talks will utilize these techniques. The older technology of Scanning Electron Microscopy is being used more than ever, as well as new techniques in Transmission Electron Microscopy, which enable us to study minute anatomical features in detail.

The Internet has provided public access to this beautiful group of animals. Beloved by underwater photographers, aided by smaller, faster, usually digital cameras and cheaper scanners, the Internet has provided a number of venues for nudibranch photographers. This in turn has revolutionized our knowledge of ranges, spawn, feeding and behavior. We will be discussing some of the impacts of the Internet on research. Along with the Internet based photography explosion has come a proliferation of Opisthobranch books. Lately, a new trend has developed using streaming video on the Internet and underwater video CD’s, with close –up’s so well resolved, it is better than being there.

Our era is one of easy travel and access to colleagues via E-mail. Divers and photographers in far-flung places are assisting researches. Sometimes we even get to go to these places ourselves, sometimes specimens, or even researchers come to us. We are truly a global village fitting together the puzzle pieces to form a global pattern.

Preliminary Phylogeny of Aeolididina (Gastropoda: Nudibranchia) Based on Morphological Characters and the Mitochondrial 16s rRNA and COI Genes

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One of four large infraorders of nudibranchs, aeolids are speciose due in part to synonymy and polymorphism. Traditional taxonomy involving morphological characters partially caused this problem due to the subjectivity of characters interpreted by different researchers. Recently, molecular genetics has provided an added tool in taxonomy, through phylogenetic analysis. Vallès' (2002) work on *Kaloplocamus* (Doridina: Polyceridae) and *Plocamopherus* (Doridina: Polyceridae) was the first to combine the subfields for nudibranchs and is being used as the model for deriving a taxonomic treatment for aeolids. Currently, only four reviews (Rudman, 1980, 1982; Gosliner & Kuzirian, 1990; Gosliner & Willan, 1991) have been conducted on the aeolids and no family level molecular phylogeny exists. Morphological characters and the large subunit (LSU) fragment of the mitochondrial 16s ribosomal RNA, approximately 1400 bp long in nudibranchs (Vallès, 2002), are being utilized for reconstruction of the aeolid phylogeny. The cytochrome oxidase I (COI) gene is brought into play as an additional molecular marker. Morphological and molecular phylogenetic relationships are being determined through PAUP* (Swofford, 2000) using maximum parsimony, and branch support is estimated by Bremer analysis (Bremer, 1994). Molecular relationships are being established with maximum likelihood as implemented in Mr. Bayes (Heulsenbeck and Ronquist, 2001). Bootstrap (Felsenstein, 1985) is applied to determine support for nodes on the trees. Preliminary molecular findings indicate some monophyly on the genus level but largely remain unresolved until more data (morphological and molecular) are obtained.

Internet Branchology, Where have we been and where are we heading?

M. Miller
Webmaster, The Slug Site

The internet has changed our knowledge of Opisthobranchs enormously. Not only can we call up images to help in identification, a number of sites give pertinent information of key characteristics, feeding, spawn and ranges. As the Webmaster of the Slug Site, one of the earliest Opisthobranch sites, established for public access in 1995 and continuing to the present, I have been acutely aware of some of the issues raised by global internet access. A discussion will center on the impact, pros and cons, of the Internet on the study of Opisthobranchs. How has it made researchers lives easier and also what problems have arisen? Hopefully, the presentation will transcend the obvious and provoke serious thought from the audience.

Genetic subdivision in western *Anodonta*

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Three genera of freshwater mussels native to the western US: *Anodonta*, *Gonidea*, and *Margaritifera*. Of these western genera, *Anodonta* is thought to be the most speciose, although taxonomy is complicated by apparently highly plastic shell morphology and the limited survey data. Taxonomic confusion within *Anodonta* is particularly acute in the Columbia River system near the mouth of Willamette River, which is the type locality of three *Anodonta* species (*A. nuttalliana*, *A. oregonensis* and *A. wahlametensis*). We assessed the patterns of genetic diversity among *Anodonta* currently inhabiting this locality, the Columbia River basin more broadly, and several locations on other western US basins using both mitochondrial sequencing and AFLP analysis. We discovered two highly divergent lineages at the confluence of the Willamette and Columbia Rivers, apparently corresponding to the species currently recognized as *A. oregonensis* and *A. nuttalliana*. However, the depth of sequence divergence between these taxa suggests that the taxonomic confusion in western *Anodonta* may extend to the genus level. These findings, along with results from many other western drainages, will be reviewed and summarized. Our research provides an important first step towards resolving taxonomic confusion in western *Anodonta* species; a necessary step for the effective conservation, monitoring, and management of this fauna.

Advances in digital imaging and Malacology

F. Moretzsohn

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The field of digital photography and imaging keeps advancing rapidly, and new products are released continuously. This brings more options to capture images of molluscs for research or hobby. At the entry-level, the cheapest way to capture digital images of shells is probably using a flatbed scanner, but there are some caveats, such as limited depth of field and difficulty of positioning shells. Digital cameras are more flexible and range in quality from amateur to professional quality. And now that most cameras have enough resolution, pixel count is not the deciding factor in evaluating a camera, although camera makers still place much emphasis on resolution. Digital single-lens reflex cameras are the best solution for photographing most shells. However, for small shells, a microscope-dedicated camera may result in better quality, although the price is usually higher than hand-held cameras. This presentation will give an overview of digital photography and present some solutions to photograph shells at different budget levels.

Update on the biota of the Gulf of Mexico project

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The biota of the Gulf of Mexico (GOM) project, sponsored by the Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi is approaching its conclusion. This project is an update of a single volume on the hydrology, geology, and biota of the GOM published 50 years ago. The new work will consist of five volumes, with one volume (or maybe two) dedicated to the biota of the GOM. It has been an enormous task and a challenge to compile information on all of the biota of the region, and more than 100 taxonomists are part of the team. About half of the chapters have been submitted, and many of these should be completed by the time of this presentation. The chapter on molluscs was poorly treated in the original work, and now a team of expert malacologists is compiling a long list of marine molluscs, resulting in a 16-fold increase of molluscs listed. The checklist of molluscs has been rigorously revised, the taxonomy updated, and duplicates, dubious records and unidentified species removed. Currently the number of species of molluscs recorded from the GOM stands as follows: aplacophorans - 11 spp (with seven new species being described); Polyplacophora - 37 spp.; Gastropoda - 1610 species; Cephalopoda - 43 spp.; Bivalvia - 522 spp.; and Scaphopoda - 41 spp, totaling some 2253 species. The final product, in book form, is expected to be published in 2008, and should become available on the Internet thereafter.

Computer-based 3D-visualization of *Tantulum elegans* Rankin, 1979, an enigmatic Caribbean freshwater acochlidian opisthobranch

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The Caribbean freshwater opisthobranch *Tantulum elegans* Rankin, 1979, is reexamined from four fragmentary original serial sections and two recently made semithin sections of entire paratypes. A computerbased reconstruction and visualization of the major organ systems was made using AMIRA software. Severe discrepancies to the original description concern to the central nervous system showing precerebral accessory ganglia, and the presence of a two-chambered heart surrounded by the pericardium. To our surprise, *T. elegans* is a proteandric hermaphrodite showing well-developed anterior male genitalia in the male phase. Implications on acochlidian phylogeny and classification are discussed.

Impact of alien Predators on Native Snails: Distribution and Prey Choice of the Predatory Snails *Euglandina rosea* and *Oxychilus alliarius*.

Habitat variation predicts intraspecific shell shape variation in Galapagos bulimulid land snails

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Bulimulid land snails of Galapagos form the most species-rich radiation on this archipelago, and they exhibit striking inter- and intra-specific variation in morphological and ecological traits. Previous work suggests that shell shape variation among species in this group is consistent with adaptation to ecological variation throughout their range. In this study I aim to understand the role of ecology in driving morphological variation within species in this group of land snails. Although most bulimulid species on Galapagos have distribution ranges restricted to one vegetation zone, *Bulimulus reibischi* is a species whose distribution overlaps the arid and transition vegetation zones. I specifically test for a relationship between habitat differences and morphological differences among populations distributed across the whole range of this species, controlling for historical contingency. I use geometric morphometrics methods to quantify shell shape differences among populations of *B. reibischi*, and I find that this single species of *Bulimulus* has populations varying in morphological traits. Further, I find that this morphological variation is predicted by the habitat characteristics where they are found, rather than the geographical distance between populations. This finding is consistent with the idea that selection for different ecological niches was involved in causing speciation in bulimulid snails in the past.

Natural feeding regimes of slugs in central Maryland_

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Although it is known that slugs may feed on live plants, detritus, and many other food types, few studies attempt to document localized variation in feeding preferences or record the feeding habits of native Philomycid slugs. I investigated the major food types consumed by natural populations of slugs in several sites in central Maryland. In the lab, feces were collected from these gastropods as a representation of their natural diets. Basic food types (fungus, dead plant, live plant, animal matter, and soil) were identified in feces through microscopic examination and their proportions in the diet were quantified. Food preferences of individuals in populations of different species were compared. I also surveyed food availability at each site and the microhabitat preferences of each species. I discuss how food availability causes variation in diet among populations and how microhabitat preferences may contribute to interspecific divergences in diet. By allowing slug species to be categorized by feeding regime, this preliminary study will enable a future analysis of the costs and benefits of slug feeding regimes.

Updating knowledge of land snail distributions in New York State

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Literature reports 121 species of land snails from New York State but knowledge of their geographic distributions remains poor. Of the 60 counties in New York, 2/3 report <20 land snail species, while well-collected counties report >60 species. Better distribution information would address where scarce species live.

This project, funded by New York State Biodiversity Research Institute, updates distribution knowledge of New York land snails by two methods: examining existing specimens in 8 regional museums, and new field surveys. Field surveys targeted 12 sites (3-4 localities each) across New York State having high quality talus communities. Talus might be refuges for uncommon or unusual snail species.

143 species of New York land snail species are recognized from literature, 3800 museum records, and 1540 new field survey records. We found 22 species from museums and fieldwork not previously reported in literature, and literature reported 13 species we did not find. 22 species (15%) are non-native species while the remaining 121 species are native. Snail diversity at the 46 localities (800 m² each) ranged from 5-26 species and abundance (in 1/8 m² litter samples) from zero to 7,152 snails per m².

Most species show statewide distributions, although many show scattered and patchy distributions, suggesting habitat restriction or under-collecting. A few species have regional affinities, such as *Anguispira fergusonii* on the Atlantic coast, and *Vitrina angelicae* inland, but distributions of other infrequently reported species remain poorly known. The Ilion Gorge in Herkimer County showed astonishingly high land snail diversity, with some species reported from zero or few other places in the state.

Additional species are likely to occur in New York State. For example, literature-reported *Webbhelix multilineata* and *Zoogenetes harpa* were not present in museum specimens or field collections, and resolving taxonomic issues will likely result in recognizing more species.

Echinochiton dufoei (Polyplacophora): New Reconstruction

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When first described (Pojeta, et al., 2003) the anterior end of *Echinochiton dufoei* was poorly known; the one complete specimen was poorly preserved. Two new specimens fill in this gap. *E. dufoei* is from the Grand Detour Formation (Middle Ordovician) of southern Wisconsin.

One specimen preserves all eight valves. On the right and anterior sides the hollow spines of five valves are preserved. This specimen shows that the head valve was rounded anteriorly and that it had four spines, two pointing laterally and two pointing anteriorly.

The second specimen preserves most of the anterior four valves parallel to bedding. Hollow spines are preserved anteriorly and on both lateral sides. Although the spines of the anteriorly rounded head valve are skewed counterclockwise, they show the same arrangement as the specimen noted above.

Neither of the specimens shows the presence of the dorsally projecting scutes lateral to the head valve such as occur between the valves and spines of the other seven valves.

E. dufoei differs from the presumed primitive Silurian mollusk *Acaenoplax* (Sutton, et al., 2001). *Acaenoplax* is vermiform, has seven dorsal valves, one ventral valve, and tufts of lateral and dorsal spines.

Echinochiton dufoei was allied to multiplacophoran mollusks such as *Polysacos* (Vendrasco, et al., 2004) which has a head and tail valve connected by three rows of intermediate valves, all are surrounded by hollow spines. The central valves and lateral scutes of *Echinochiton dufoei* are homologized with the three rows of intermediate plates of *Polysacos*.

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Corbicula fluminea: Relevant in New Jersey?

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Montclair State University

The Asian clam *Corbicula fluminea* has been seriously underreported from New Jersey. Quantitative sampling of primarily lotic New Jersey waters revealed a heterogeneous distribution of this non-indigenous bivalve. Population and sediment analyses indicated a slight “preference” for medium-grained sands but minimal relationships to other “standard” parameters. High numbers of smaller clams were more typical of slow moving waters and sandy sediments, probably reflecting stochastic drift events and settlements. Similarly, the largest specimens were found in waters with the lowest flow rate, again reflecting a lack of drift-inducing water dynamics. Can widely dispersed but seemingly randomly located populations of *Corbicula* still pose a threat to industry and indigenous fauna? Has spread of this bivalve in the U.S. northeast peaked? Are there simple ways to determine the limiting factors for dispersal? We suggest that the answers can’t be clear until other highly variable anthropogenic environmental factors are better understood.

Sampling bias and the perceived quality of the fossil record of chitons (Mollusca, Polyplacophora): Changing a paradigm

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Modern chitons occur worldwide in all oceans and represent critical components of modern ecosystems. Were chitons similarly important in past environments? The answer is unknown. The paradigm that chitons (Polyplacophora, Mollusca) are a 'minor' molluscan class has caused chitons to be excluded from taphonomic and evolutionary studies, despite a record that spans the Lower Cambrian to the present. Paleontologists tend to collect and study readily-available, well-preserved and abundant fossil material. Chiton fossils typically are rare, poorly preserved, and limited in numbers. The man-made sampling bias has negatively affected the perceived quality of the entire chiton fossil record. As part of an ongoing effort to understand the true representation of chitons in the fossil record, a database of fossil chitons has been compiled and analyzed. Preliminary results indicate that the chiton fossil record had not been fully documented in previous investigations, and fossil chitons are more common through their geologic history than previously recorded. The prior record reportedly consisted of about 358 species. The current database contains a total of over 1890 Phanerozoic occurrences in a fossil record comprised of 95 recent species, over 480 fossil species and 75 indeterminate taxa reported in the literature. Further analysis of the database will address taphonomic and evolutionary questions, such as whether the chiton fossil record is an accurate representation of the natural history, environment(s) inhabited, and evolution of the group.

Systematics of the Australasian Lymnaeidae

L. Puslednik

The Lymnaeidae Rafinesque, 1815 are one of the most widespread groups of freshwater snails, however, they are characterised by a long and confused systematic history largely due to problems associated with shell plasticity. Recent molecular studies that have utilised DNA sequences have failed to adequately represent the Australasian lymnaeids. The aim of this study was to understand the systematics of the Australasian Lymnaeidae, using 16S and ITS-2 sequences. The native Australian and New Zealand lymnaeids are currently attributed to *Austropeplea* Cotton, 1942 and *Kutikina* Ponder and Waterhouse 1997, which are thought to be represented by three and one species, respectively. Results of this study indicate there are 5 distinct species across three genera. Phylogenies based on molecular sequences suggest that the *Austropeplea lessoni* complex is more closely related to lymnaeids from South East Asia than to other Australian lymnaeids. Furthermore, based on molecular and anatomical phylogenies, *A. viridis* is suggested as sister to the *A. tomentosa* complex. Therefore it is highly likely the *A. lessoni* complex and *A. tomentosa* complex have separate derivations. Two theories of biogeography of the Australasian Lymnaeidae have been recently proposed and were examined in light of the new phylogeny. While it seems certain that the *Austropeplea lessoni* complex had a South East Asian origin, the origin of the *A. tomentosa* complex is still unclear. The close relationship of the *A. tomentosa* complex with Asian *A. viridis* plus the derived position of the group in the family, suggest a second invasion of Australia by lymnaeids from South East Asia. However, the basal position of the New Zealand *A. tomentosa* would suggest the group occurred here first and moved into Australia, thus suggesting a Gondwanan radiation of the *A. tomentosa* complex. The discovery of a lymnaeid fossil in Antarctica lends further weight to this theory.

SEM observations of the siphons of wood boring clams of *Xylophaga* (Myoidea:
Pholadidae)

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Larval deep-sea wood-boring clams settle on seafloor substrate, usually wood, undergo metamorphosis and begin to bore into the substrate. The clams spend their lives inside their burrow, sometimes with their siphons extending freely. SEM observations of siphons of three new species of *Xylophaga*, two collected from artificial deployments of wood from 1550 and 3232 m depth, and one from museum collections, reveal diverse structures that are apparently sensory in nature.

The excurrent siphon of *Xylophaga* sp. F has 5 to 8 large (up to 430 μm) cirri with terminal pits from which cilia emerge. The incurrent siphon of this species has both an inner and outer ring of cirri. The inner cirri have a scaly surface with cilia emerging from between these scales. In contrast, the smooth outer cirri lack cilia. The siphonal openings of *X. sp. S* and *X. sp. B* lack cirri. In *X. sp. S*, minute papillae are scattered on the distal incurrent siphon and form a line flanking the groove just distal to the excurrent opening. The papillae have concentric folds that suggest they may expand and contract and terminal openings from which cilia project. The skin of distal incurrent siphon of *X. sp. B* has small (10-14 μm diameter) round structures that barely project above the epidermis. From the terminal openings of these structures emerge a tuft of cilia. Central flagella, possibly indicative of choanocytes, are absent from all cilia-bearing structures.

Each of the three species of clams considered here has an incomplete siphon that is a comparatively short excurrent siphon. Although their function is unclear, the presence of these morphologically diverse structures, that likely have a sensory function, suggests that life inside bored wood is more stimulating than often assumed.

Who says it's not easy to get around in LA: Palos Verdes Peninsula is an ineffective genetic barrier for chitons and limpets.

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Point Conception has long been recognized as a major biogeographic break that demarcates the boundary between the Oregonian and Californian faunal provinces. The observed changes in community structure are believed to be a result of changes in environmental factors such as water temperature, salinity, and directional current flow. An abundance of species range termini occur near Point Conception however, many species have wide ranges that span across it. Furthermore, intraspecific phylogeographic breaks for these ubiquitous species have not been found to be concordant with Point Conception. Recent authors have found patterns of genetic separation further south near Los Angeles, California, suggesting that the area around the Palos Verdes Peninsula might represent a more significant dispersal barrier. We have tested this specific hypothesis by looking for congruent patterns of phylogeographic breaks for multiple chiton and limpet species common to southern California. All species have similar ecology and produce lecithotrophic larvae with a relatively brief pelagic dispersal period. Specimens have been collected from populations on either side of the Palos Verdes peninsula, and DNA from the mitochondrial gene regions 16S and *cox-I* have been sequenced. Phylogenetic analysis of the sequence data has revealed no genetic structure throughout the entire range sampled for all species. Population genetic analysis revealed that most species exhibit population structure however, the observed structure does not correspond cleanly with this putative genetic barrier. Thus, the Palos Verdes peninsula does not appear to be an effective barrier to gene flow for chitons and limpets.

Physiological tolerance and range limits of the congeneric sacoglossans *Alderia modesta*
and *A. willowi*

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Establishing pre- and post-settlement mechanisms that set range limits should permit prediction of how species will respond to climate change. The cosmopolitan sea slug *Alderia modesta* has a southern range limit of San Francisco Bay, which lies just inside the northern limit of its sibling species *A. willowi*. Over three years San Francisco Bay was seasonally dominated by the southern species *A. willowi* from July to January, whereas only the northern species *A. modesta* occurred from February to June. These transitions coincided with seasonal change in salinity, suggesting that abiotic factors may favour each species at a different time of year, and potentially set their range limits. We tested the effects of salinity and temperature on larvae and adults of both species, to assess (a) how *Alderia* spp. differ in physiological tolerance, (b) if reproduction is suppressed at low salinities, and (c) if pre- or post-settlement mortality explains demographic shifts in San Francisco Bay. Adult *A. modesta* were efficient osmoregulators, surviving 1 week at 2 ppt, whereas adult *A. willowi* suffered 20% mortality at 8 ppt and 80% mortality at 2 ppt. Reproduction was completely suppressed at 2 ppt in *A. willowi*, but not in *A. modesta*. Larvae of *A. willowi* survived >12 hr at 10 ppt, but experienced complete mortality below 6 ppt. Comparative data for larvae of the northern species, and effects of temperature on larval growth and survival, will be presented. Understanding how *Alderia* spp. respond to changing environmental conditions may indicate how global warming will shift ranges for these and other estuarine taxa. Historical records suggest *A. modesta* may already have experienced a northward shift over the past 50 years.

Taxonomic revision of endemic Nicaraguan freshwater mussels (Bivalvia Unionidae) Part II

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Lake Nicaragua and Lake Managua are two of the largest lakes in the Western Hemisphere and were formed due to tectonic and volcanic activity < 3million years ago. The lakes are home to a number of species of freshwater mussels, found nowhere else in the world, that were described in the middle part of the 19th century. These descriptions were based on shell characters, that do not allow for clear identification of species and that make their taxonomic placement relative to other unionids difficult to assess. A revisionary analysis of the freshwater unionid mussels of the Nicaraguan “Great Lakes” is in its second year. Following a literature review and examination of many of the existing museum holdings a collecting trip to Lake Nicaragua (Cocibolca) and the surrounding area was undertaken this year. The purpose of this trip was to collect materials for a re-description of these taxa. Newly collected material will be compared to type material and descriptions. The new descriptions will be prepared in a monographic format and include descriptions of soft anatomy, conchology, and glochidia, observations on natural history and reproductive period. In addition, tissue samples were taken for future molecular phylogenetic analyses to develop hypotheses for relationships between these taxa and the phylogenetic affinities to North American unionids.

The Pacific Northwest Nursery IPM website: An extension resource for gastropod information.

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The Pacific Northwest Nursery IPM website has been established to provide educational materials and links for the identification and management of pests in commercial nursery production in the Pacific Northwest. The ornamental production industry is at risk from the establishment of exotic gastropods, many of which are quarantine pests. This industry may also be a potential means of dispersal of these organisms. One endeavor of the website is to increase the awareness of exotic and established slugs and snails as it relates to commercial nurseries. The PNW Nursery IPM website has received over a million hits since its inception in the fall of 2001 with nearly half of those hits received in 2005. The website has found a unique niche amongst those curious about slugs and snails with over 30 percent of the hits directed to the gastropod section.

Paleontological evidence for the origin of valves in polyplacophoran molluscs

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A recent infusion of new paleontological data has stimulated studies of the early diversification of the Mollusca and has re-focused attention on relationships among the non-conchiferan molluscan classes. These new data come from the discovery of complete animals (*Halkieria*¹, *Kimberella*², *Acaenoplax*³, *Echinochiton*⁴, *Polysacos*⁵, *Odontogriphus*⁶), rather than disarticulated calcareous valves or sclerites, in deposits of Ediacaran, Cambrian, Ordovician, and Devonian age. They illustrate the fact that the morphological disparity of Paleozoic polyplacophoran mollusks was significantly greater than is found in the crown group, and they raise new questions about relationship among the extant crown groups “Aplacophora”, Polyplacophora, and Conchifera.

We know from *Odontogriphus*, and its probable Ediacaran forerunner, *Kimberella*, that the basic molluscan architecture was established prior to the production of a mineralized dorsal exoskeleton. There is good evidence from Cambrian fossils for the derivation of the outer layer of polyplacophoran valves (tegmentum) from the fusion of tissue-filled aragonitic sclerites like those found in *Halkieria*. Thus the sensory esthetes of modern chitons, which penetrate the tegmentum by bypassing the inner shell layers, are homologous to the tissues that secreted the sclerites before they fused to form valves. A similar function is envisaged for the spines of *Acaenoplax*, which must have been extruded as the animals grew. In contrast, the shells of conchiferans were a separate evolutionary innovation, as concluded by a number of previous authors. If Bengtson’s “coeloscleritophora” is indeed a monophyletic group, then cancelloriids illustrate how individual sclerites may be amalgamated into larger skeletal units.

1. Conway Morris & Peel, *Nature* 345: 802-805 (1990).
2. Fedonkin and Waggoner, *Nature* 388: 868-871 (1997).
3. Sutton et al., *Nature* 410: 461-463 (2001).
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5. Vendrasco et al., *Nature* 429: 288-291 (2004).
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Isolating factors affecting crenobiontic springsnail (Prosobranchia: Family Hydrobiidae)
colonization of unoccupied habitats in arid lands of the western U.S.

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Recent taxonomic studies have described more than 100 species of springsnails from approximately 2000 springs in arid lands of western North America. Their diversity and abundance is particularly notable in the Great Basin where the distribution of extant species is believed to be a result of active dispersal of ancestral forms through periodic aquatic connections during pluvial periods, or prior to development of the Basin and Range landscape. Recent genetic studies have located some populations outside of home basins and the distribution of some species are not congruent with drainage basin history, suggesting that springsnails may be passively dispersed.

Their propensity for passive dispersal was examined during replicated experiments in Petri dishes to quantify mortality rates of three species from the Owens basin of eastern California (*Pyrgulopsis wongi*, *P. perturbata*, and *P. owensensis*) by exposure to air and moist conditions, and to water from foreign springs. All snails died within 15 minutes in treatments where they were exposed to air. Complete mortality in moist conditions was not documented over the 180 minutes of exposure, suggesting that these species may survive passive transport if held in conditions similar to those simulating moist feathers of waterfowl. When maintained in water from their home spring, mortality over 35 hours was low. When placed in water from springs occupied by other species in these trials, all snails died within 35 hours. These findings suggest that springsnails may survive for long periods during passive transport under moist conditions. Successful colonization of new habitats may be unlikely due to mortality from rapid emersion into foreign waters. Additional studies are needed to determine if mortality is due to temperature or chemical elements in the water.

Chitons (Mollusca: Polyplacophora) associated with hot vents/cold seeps around Japan

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From chemosynthetic environments, only two chiton species have been known in the world to date. The present paper reports three new chiton species from chemosynthetic environments around Japan: *Deshayesiella* sp. from the hydrothermal vent sites of the seamounts in the northern Mariana Islands area, *Placiphorella* sp. a from cold seep sites of the Kuroshima Knoll off Yaeyama Islands, and *Placiphorella* sp. b from Hachijo Depression in the Izu-Ogasawara (Bonin) Islands area, which is not an active vent/seep site but a possibility of hydrothermal activity has been suggested. *Deshayesiella* sp. can be a vent-associated species, whereas the two *Placiphorella* may be guest species. Additional distributional records of the two ever-known species, *Leptochiton tenuidentus* and *Thermochiton undocostatus* are given.

Nature of the dwellings of *Rocellaria stimpsoni* Tryon, 1861, a common endolithic to semi-endolithic bivalve of southwest Florida

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From the high frequency of their dwellings in shells and corals on the beaches of southwest Florida, it is apparent that representatives of the gastrochaenid bivalve *Rocellaria stimpsoni* are a numerically significant component of the molluscan assemblages offshore. It is therefore surprising that simply the presence of the species in the region has received little attention and especially that its prevalence there has gone unrecorded. Not only does the morphology of the shells of *R. stimpsoni* distinguish this species from others of its family, the nature of its dwellings, which has not been previously reported, is very distinctive. In general, the dwellings do resemble those of some confamilial species in being either wholly endolithic or partially enclosed by secreted or agglutinated walls and in possessing a shape resembling a “round”-bottomed flask. The bulbous portion of the flask corresponds to the cavity that houses the shell, the neck of the flask to the cavity enclosing the siphons. Proximal to the shell cavity, the siphonal cavity is circular or oval in cross section, but near its distal end it becomes modified into two adjacent, partially separated, short tubes by the insertion of two opposing, longitudinal carinae that do not completely converge. What sets the dwellings of *R. stimpsoni* apart from other gastrochaenids is the presence of spinose rings that extend from the carinae around the periphery of each of the two tubes. The rings are situated near but somewhat below the opening into the dwelling forming a baffle that could inhibit entry by predators. Almost invariably, the rings bear four spines, thereby imparting to the opening through the baffle the appearance of somewhat crude, conjoined quadrifoils. Dwellings of different gastrochaenid species that possess predator-detering baffles have been mentioned previously by others. However, these baffles differ significantly from those of *R. stimpsoni* in lying at the junction between the siphonal and shell cavities or near the base of the siphons instead of close to the siphon tips. The location of the baffle in *R. stimpsoni*'s dwellings could impart a distinct advantage—affording protection while allowing the siphons to be at least partially if not fully extended, whereas the baffles of previously described dwellings require greater withdrawal of the siphons of an individual under threat and a consequential interruption of feeding and respiration.

Habitat selection and movements of *Enteroctopus dofleini* in Prince William Sound,
Alaska: pilot studies with tagging and relocation

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This study examined the movements of several tagged individuals of Giant Pacific octopus (*Enteroctopus dofleini*) in Prince William Sound (PWS), Alaska, at several sites over the past decade (1996-2006). Octopuses were collected from varying depths from the intertidal to 100 m, outfitted with Vemco sonic transmitters using varying attachment schemes, and released either where captured (control for artifacts), in novel habitat at a similar depth to their capture location (control for depth), or in novel habitat at a different depth than their capture location (treatment).

Three animals in 1996, four in 2003, and one in 2005 were captured in shallow water, tagged, released and tracked. Data from up to eight additional animals captured from both deep (>30 m) and shallow water in 2006 will also be included. Tag retention varied from 1-51 days, according to different methods used in tag attachment in 1996-2005. A habitat quality index developed from measures of physical and biological habitat characteristics (depth, substrate, dens, kelp cover and prey availability) was used in a study of habitat selection (N=4 tagged and relocated octopuses plus N=3 tagged and released where captured). Relocated octopuses moved to better habitat (3 of 4 increased in index scores vs. 0 of 3 controls) when forced to reselect habitat. For relocated (2003) octopuses, mean post release change in habitat quality index was 0.64. This study indicates that octopuses are sensitive to habitat variation and are likely active selectors of habitat based on several physical and biological characteristics, many of which (substrate, kelp cover, depth) may be related to both food availability and shelter from predators.

Discovery of the South African polyplacophoran *Stenosemus simplicissimus* (Thiele, 1906)
(Mollusca, Polyplacophora, Ischnochitonidae) in the Southern Ocean

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Recent expeditions to the Atlantic sector of the Southern Ocean have yielded valuable collections of shelf and deep water polyplacophorans. These comprised several specimens of *Stenosemus simplicissimus* (Thiele, 1906), a species previously only known by its holotype and from its type locality at the Cape of Good Hope. The new material enabled a thorough morphological redescription of the species by studying valve, perinotum, and radula characters with SEM. The new records from Shag Rocks and the eastern Weddell Sea enlarge the species' biogeographic distribution from the temperate South African region to the polar South Georgia and Weddell Sea regions. Its bathymetric range from formerly 318 m is extended to 285-1064 m. Reasons for the limited occurrence of deep water Antarctic polyplacophorans are discussed.

Building a comprehensive phylogeny of the scallops (Bivalvia: Pectinidae): what molecules say about taxonomy

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The scallops (family Pectinidae) are a cosmopolitan group of marine bivalves comprising over 250 extant species. Members of the family exhibit diverse morphologies as well as life histories. Despite their interesting biology and economic importance, scallop diversity and evolutionary relationships are poorly understood. Historically, this was due to an unstable classification system largely based on convergent shell characteristics; while modern taxonomic treatments of the Pectinidae either lack rigorous phylogenetic methods or have low taxon representation of the family. One of the few comprehensive taxonomic treatments of the family is the work of T. R. Waller, who has greatly contributed to the stabilization of pectinid systematics by developing hypotheses of pectinid relationships based on uniquely derived characters of shell microsculpture. Under his classification, Waller recognizes four subfamilies and 10 tribes in the Pectinidae.

This study examines Waller's classification system with a phylogenetic analysis of two mitochondrial genes (12S and 16S rRNAs). Based on phylogenetic analyses of over 40 species representing all subfamilies and tribes of the Pectinidae, I found support for a monophyletic Decatopectinini, Pectinini, and Amusiini, and Waller's (1991) hypothesis that *Delectopecten* as the most basal extant lineage of the Pectinidae. However, this analysis did not support the monophyly of three subfamilies (Palliolinae, Chlamydinae, Pectininae) and three out of ten tribes (Chlamydini, Mimachlamydini, Aequiptectini). Implications of these findings for understanding the evolution of complex traits in the Pectinidae will be discussed.

The culture of iron-limited chitons (Mollusca: Polyplacophora) as a method for observing the processes of radula mineralization.

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The chiton radula represents an excellent example of matrix-mediated biomineralization, with the incorporation of both iron and calcium minerals onto the organic matrix of the major lateral tooth cusps. In addition, it is an ideal tissue for the study of biomineralisation *in situ* since the different minerals are deposited at precise stages of radula development. These biominerals are thought to be delivered to the teeth by the overlying superior epithelial tissue, which surrounds the cusps during all stages of development. However, the mechanisms involved in transporting the mineralizing ions to the tooth cusps are poorly understood and as such, a fundamental step in the initial phase of biomineralization remains a mystery.

The very presence of these minerals in chiton teeth places a physical limitation on the use of conventional preparation techniques, which has hampered detailed studies of the epithelial cells in the past. We have recently developed a method of limiting iron availability and suspending iron mineralization, thus facilitating the examination of epithelial cells via a range of techniques including light microscopy, transmission and scanning electron microscopy, X-ray microanalysis (EDS) and *in situ* Raman spectroscopy.

An ability to now obtain structural and chemical information from radula teeth of chitons at advanced stages of maturation, will improve our understanding of the role played by the organic matrix and the superior epithelium in mineral formation and growth. Preliminary data on differences between control and iron-limited animals will be discussed, along with the implications of this study to the general field of biomineralization.

The stylus canal: A conduit for the delivery of ions to the mineralizing tooth cusps of chitons (Mollusca: Polyplacophora)?

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The major lateral teeth of the chiton radula are heavily mineralized with iron and calcium biominerals, with the delivery of ions thought to be effected by the overlying superior epithelial tissue, which surrounds the tooth cusps at all stages of development. Centrally located within the bases of the mineralized teeth is a cell filled cavity, referred to as the stylus canal. The cells within the canal are continuous with the superior epithelial tissue and appear to terminate at the junction of the tooth base and cusp. This junction zone has previously been reported to be the initial site of ion deposition in chiton teeth. As such, the cells within the stylus canal are in an ideal location for the delivery of ions to this region. However, past histological examinations have focused on the cells abutting the cusp surface, while the cells of the canal have been virtually ignored.

In order to elucidate the structure and function of the cells within the stylus canal a histological investigation has been undertaken, using light microscopy, and transmission and scanning electron microscopy. In addition, the radula teeth have been analyzed using X-ray microanalysis (EDS).

The mechanisms of ion delivery to the mineralization fronts within the tooth cusps is currently poorly understood, and the reasons for the initial deposition of ions into the junction zone has been confounding, both in regard to how the ions get there and why they are deposited there first. Proof of the existence of a subsidiary ion delivery mechanism has the potential to significantly enhance our understanding of the biomineralization pathways in these animals. The overall morphology of the stylus canal and ultrastructure of the canal cells will be presented and the role of the cells as a significant pathway for the delivery of ions to the developing major lateral teeth will be discussed.

Population structure and life history of the West Indian Topsnail, *Cittarium pica*
Insights into the relationships within “basal” chitons (Polyplacophora: Lepidopleurida)

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This study represents the first phylogenetic investigation into the internal relationships of a clade within the Polyplacophora. The putative most basal suborder of Recent chitons, Lepidopleurina, contains around 150 extant species in nine genera, and a further 17 fossil genera. Despite this diversity, ninety percent of recent taxa are classified in the single genus *Leptochiton*. The study of this group has been historically slow to develop; most species live in inaccessible deep-sea habitats, and are fundamentally difficult to identify because of their small, plain appearance. Traditional shell characters are insufficient to differentiate lepidopleuran taxa. Additional morphological character sets from soft anatomy (e.g. gametocyte morphology, gill arrangement, and locations of gonadopores and nephidiopores) have previously been described only from a small number of taxa. This work expands taxon sampling in a combined approach, with new morphological descriptions as well as molecular sequence data to illuminate phylogenetic relationships within Lepidopleurina. Morphological descriptions draw from historical museum collections (including name-bearing types) as well as recent collecting expeditions in the Indo-Pacific. Molecular analysis includes two nuclear ribosomal genes, 18S rRNA (ca. 1780 bp) and 28S rRNA (ca. 2200 bp), and one mitochondrial protein-coding gene (cytochrome oxidase subunit I) for more than 20 species covering eight ingroup genera. Preliminary phylogenetic analysis of molecular sequence data does not recover currently accepted genera and indicates a probable paraphyletic structure within the Lepidopleurina. The order Lepidopleurida occupies a critical position with respect to understanding larger-scale patterns in polyplacophoran (and molluscan) evolution.

Agricultural Internet Monitoring System (AIMS) launch and results of mollusk hits

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Many examples of USDA-regulated organisms may be found being sold on the internet, and mollusks are included among them. The agricultural internet monitoring system (AIMS) is a cooperative effort between the Plant Epidemiology and Risk Analysis Laboratory of the Animal and Plant Health Inspection Service and the Center for Integrated Pest Management of North Carolina State University. AIMS is a secure semi-automatic intranet-based application that has been designed to webcrawl the world wide web and search for items of agricultural interest entering the United States. It evaluates sites for their risk and indexes the information contained there, automatically generates information letters to potential violators of USDA regulations, and archives all activities associated with the search of that URL. AIMS was launched in January 2006 and has returned nearly 12,000 URLs of interest. More than 3,000 of these were mollusk-related sites, of which 49 were found to be potentially in violation of USDA regulations. The majority of potential violators offered *Achatina fulica*, *Pomacea canaliculata* and other *Pomacea* spp., escargot snails, or snails for classroom use. The first two are prohibited and the latter two have restraints placed upon which species are permitted to enter the U. S. alive. Based on the data returned in its first six months of use, AIMS appears to be a valuable tool to help protect U. S. agriculture and the environment.

Two New Species of *Marionia* (Mollusca: Nudibranchia) from the Indo Pacific Region

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Collections in the Philippines during 1992, 1994, and 1995, along with specimens from Indonesia collected during 1998, provide the basis for the description of two new species of tritoniid nudibranchs. When the photographs of the animals were first examined, it was thought they might represent color variations of the same species, but subtle differences prompted close examination of internal anatomy. The results showed two distinct species. *Marionia* sp. "a" and *Marionia* sp. "b" are shown to be different from all other described tritoniid nudibranchs, and are described herein. *Marionia* sp."a" is shown to feed on octocorals in the family Ellisellidae. Both taxa exhibit a bi-lobed bursa copulatrix, which may provide a new character for future phylogenetic analysis. A preliminary phylogenetic analysis of the family Tritoniidae is presented, and the relationships within the family are discussed.

Detection of underwater stimuli by *Nautilus pompilius*

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The marine environment is dominated by mechanical and acoustical energies such as water currents and vibrations. To respond to a given stimulus, marine organisms must collect information from their environment and subsequently process it. Two behavioral experiments were designed to test the sensory capabilities of *N. pompilius*. The first experiment exposed the animals to a series of angular accelerations and rotations to test the hypothesis that these animals are able to internalize environmental cues, such as hydrodynamic flow, with the potential aid of a canal that connects their statocyst to the exterior environment through an epidermal pore (an anatomical configuration that is unique within the Class Cephalopoda only to *Nautilus spp.*). The positions of the animals' hyponomes (siphons) were recorded throughout the experimental trials and their natural responses to angular acceleration were established using baseline data from the control condition. Analysis of the animals suggested that when the animals were exposed to treatment conditions (unilateral and bilateral applications of petroleum jelly to the area containing the epidermal pore), they responded by significantly repositioning the hyponome either in the complete opposite direction (phase-shift) or by maintaining the same direction but reducing the amplitude of the response. The second experiment tested the hypothesis that Chambered *Nautilus* are capable of responding to waterborne vibration — a sensory mechanism that had yet to be investigated. Animals were exposed to a vibrating bead that produced a range of displacements and intensities with ventilation rate as a behavioral measure. Nautiluses did indeed respond to a suite of vibratory stimuli, demonstrating for the first time that they have this ability. Specifically, a decrease in respiration rate was significantly correlated to an increase in source-displacement and source-intensity. Animals responded to stimuli in closer range by decreasing their ventilation rates even further.

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Deep water chitons known from benthic monitoring programs in the southern California Bight

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More than 30 species of chitons may occur in deep waters (>30 m) of the Southern California Bight (SCB), although little is known about their distribution or ecology. A total of 15 described species representing 8 genera and 4 families is reported here for the region, plus 2 possible new species. These chitons were collected by long-term benthic monitoring programs operated by the City of San Diego, City of Los Angeles, and Los Angeles County Sanitation Districts, or as part of larger multi-agency regional monitoring projects of the entire SCB. Most samples are from depths between 30-305 m, although records are included for a few species from shallower water (9-27 m). The Lepidopleurida is represented by the Leptochitonidae (3 species, 2 genera), while the Chitonida is represented by 3 families, including Ischnochitonidae (5 species, 1 genus), Mopaliidae (6 species, 4 genera), and Callistoplacidae (1 species). The lepidopleurids *Leptochiton rugatus* and *Hanleyella oldroydi* are 2 of the most common chitons, accounting for ~40% of all SCB specimens. A second species of *Leptochiton*, *L. nexus*, is also reported, while a third possibly new species is known from a single specimen. *Lepidozona* (Ischnochitonidae) is the most diverse genus, represented here by 5 species: *L. interstincta*, *L. mertensii*, *L. retiporosa*, *L. scabricostata* and *L. scrobiculata*. Of these, *L. retiporosa* and *L. scrobiculata* are most common, accounting for ~31% of chitons examined. A sixth possibly new species of *Lepidozona* is known from a single animal. The Mopaliidae is represented by the following genera and species: *Dendrochiton gothicus*, *D. thamnopus*, *Mopalia lowei*, *M. phorminx*, *Placiphorella mirabilis*, and *Tonicella venusta*. The Callistoplacidae is represented by *Callistochiton palmulatus*. Information is presented on the distribution, abundance, size, and co-occurrence of the above SCB chitons. Finally, dubious records for another 2 previously reported species are discussed.

Phylogenetic reconstruction of the genus *Dendronotus* (Gastropoda: Nudibranchia) with insight into world-wide distribution patterns

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Nudibranchs are marine invertebrates commonly referred to as sea slugs. They are classified in the phylum Mollusca, class Gastropods, subclass Opisthobranchia, order Nudibranchia. Species of the genus *Dendronotus* in the family Dendronotidae are found in northern temperate waters. Two species are found in the Atlantic Ocean (one on hydrothermal vents), eight are found along the Pacific coast of North America, and one is found in both the Atlantic and Pacific Oceans. Nudibranchs in the genus *Dendronotus* have traditionally been grouped together based mostly on their external morphology. No studies have been conducted to establish whether they are truly monophyletic group. The aim of this study is to reconstruct the evolutionary history of species of the group *Dendronotus* and their position within the family Dendronotidae based not only on external features but also on the morphology of their radula and jaws, the thorough examination of their reproductive structures, and DNA sequence data. The expected phylogenetic hypothesis will allow us to better understand the evolution of the group and test additional hypotheses on the origin and causes of the high diversity of species of *Dendronotus*.

The hypothesis that will be addressed is that all or many Pacific species of *Dendronotus* species are monophyletic and represent a species radiation. Demonstrating monophyly of a large Pacific clade is a prerequisite for support of a Pacific radiation hypothesis. Statistical analysis of the phylogenetic trees will then be conducted to examine the tree stability and attempt to find signatures of mass extinction events that would explain the absence of *Dendronotus* from large geographic areas.

Hemocyanin genes: How did they evolve?

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Hemocyanins are the extracellular copper-containing respiratory proteins of many mollusks. They circulate freely within the hemolymph and cause the bluish color of the oxygenated molluscan blood. Depending on the species, they possess a molecular mass of 3,500 - 4,000 kda but also can form higher aggregates of >8,000 kda. Their early origin probably dates back to the Precambrian when they evolved by repeated exon duplications of a tyrosinase-related copper-containing protein leading to the recent, repetitively arranged subunits of 350 - 400 kda. The different domains of these subunits are called functional units and are termed FU-a, -b, -c, -d, -e, -f, -g and -h. These evolutionary exon duplications probably were facilitated by very old introns which bordered one ancient, continuous exon. These introns separating each recent functional unit exon are still present and called linker introns. Such principal structure probably gave rise to the known barrel-like quaternary structure of molluscan hemocyanins and, mostly by causing low osmotic pressures due to the protein's enormous size, provided the basis for an extracellular respiratory protein. However, some 'unusual' hemocyanins can also be observed: some have internal FU-rearrangements (*S. officinalis*), in others 'essential' glycosylation sites were deleted (*N. nucleus*), or in some even their ability to form higher aggregates was lost (Polyplacophora). We assume that this was also facilitated by a few (ÿ) more recent intron insertions which can be observed in different hemocyanin-genes. However, evolution never stops and the yet most impressive intron gain can be observed within the *Aplysia californica* hemocyanin gene: a total number of 53 introns could be detected which probably derived by internal gene conversion and also might give rise to 'new' types of hemocyanin.

The Mollusks: A guide to their study, collection, and preservation—A new publication of the American Malacological Society

C. Sturm, T. Pearce, and A. Valdés²

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The proceedings of the 1941 meeting of the American Malacological Society, held in Rockland and Thomaston, Maine, was a series of articles on how to collect, clean, and preserve mollusks. This work was reissued in 1955, 1966, and 1974. The 1974 edition, *How to Study and Collect Shells*, contained 108 pages and two illustrations.

A workshop on issues of interest to collectors of mollusks was held during the 1999 AMS meeting in Pittsburgh, Pennsylvania. While the session was directed to the non-professional malacologist, many professionals attended this workshop. Some of the topics discussed included archival and curatorial methods, computer databases, collecting unionoids, amateur-professional cooperation, and the molluscan literature. Publication of these proceedings as an update of *How to Study and Collect Shells* was approved at the AMS meeting in San Francisco (2000). This volume, *The Mollusks: A Guide to Their Study, Collection, and Preservation*, edited by C. F. Sturm, T. A. Pearce, and A. Valdés, is the result.

This volume differs from its predecessors. It is more substantive with 445 pages, 101 illustrations, and 31 chapters written by 29 contributors. This volume includes topics not found in earlier editions, such as chapters on the Aplousobranchia, Monoplacophora, Cephalopoda, and Scaphopoda. Chapters cover all groups of freshwater, terrestrial, and marine mollusks. The biology and ecology of these organisms is discussed. Film and digital photography, cladistics, how to write a taxonomic paper, a review of the zoological code and issues in molluscan conservation are covered for the first time. There is an extensive listing of taxonomic literature (over 700 references) keyed to biogeographic zones and taxonomic groups. Other topics include chapters covering fossil mollusks and organisms that may be mistaken for marine mollusks. Information on how to obtain this book will be provided. Questions regarding this book can be directed to <doc.fossil@gmail.com>.

Sacoglossan opisthobranchs on NW Pacific shores: *Stiliger berghi* Baba 1937 and *Elysia* sp. on filamentous red algae

C. D. Trowbridge, Y.J. Hirano, Y. M. Hirano
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Delicately branching red algae are increasingly appearing on foreign shores as unintentional introductions yet the role of marine herbivores that feed selectively on members of Order Ceramiales are insufficiently studied around the world. We are studying two sacoglossan opisthobranchs that feed on filamentous red algae: (1) the temperate to boreal *Stiliger berghi* Baba, 1937 on wave-sheltered shores of Honshu and Hokkaido, Japan and (2) the subtropical to tropical *Elysia* sp. on shores of Okinawajima. Preference experiments demonstrated that *S. berghi* strongly preferred to associate with the alga *Dasya* when given pairwise algal choices but readily consumed several algal genera and exhibited no preferences between algal life-history phases (diploid tetrasporophytes vs. haploid female gametophytes). *Elysia* sp. is a small sacoglossan that consumed uniseriate and polysiphonous red algae on west-coast shores of Okinawajima. Given the small size and seasonally abundant populations of red-algal feeders, we predict that these sacoglossans and their ecological analogs on other shores may have an unexpectedly important role in consuming and/or fragmenting native or introduced Ceramialeen red algae. Furthermore, when such sacoglossans occur in sheltered harbors in close proximity to vectors of introduction, there may be unintentional introductions to domestic or foreign shores.

Morphometrics of *Callitochiton elenensis* (Mollusca: Polyplacophora) from the Bahia de la Paz, B. C. S, México

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Chitons are exclusively marine and are characterized by eight overlapping shell plates called valves, which articulate to form an oval to elongate body outline. Some members of *Callitochiton*, including *C. elenensis*, vary dramatically in the shape and extent of rib sculpturing, which we suspect might have adaptive consequences. In particular, larger specimens especially seemed to vary, suggesting that the chitons might first elongate approximately isometrically and then change to grow up and out while more heavily fortifying their valves, or perhaps grow differently from the start depending on their microhabitat. In order to test our observations, we performed landmark-based morphometric analysis of the entire body in dorsal view, and then disarticulated valves, focusing on valve VIII (the tail valve). We collected 76 chitons of a range of sizes between March 2004 and October 2005 from the intertidal to the shallow subtidal at the La Concha Resort in La Paz, B.C.S., México. The largest specimens found were relatively high in the intertidal. Most were photographed and analyzed for potential overall body allometry in dorsal view. Then these and some other specimens were disarticulated in a dilute warmed KOH solution, with valves separated by valve number. Images of each valve VIII were then obtained in calibrated ventral, dorsal, and lateral orientation. We report here the preliminary landmark-based results of a morphometric analysis of this valve's allometry, and suggest some hypotheses that might account for this change in shape. For example, *C. elenensis* is unusual in rapidly dropping off an overturned rock, rolling into a tight ball. The inflation of terminal valves might protect the otherwise vulnerable junction of the head and tail valves from predators, when it is rolled up. Alternatively, the higher internal volume might allow the chiton to increase space available for gonads and other soft tissues.

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Aesthete canal morphology in nine chitons revealed by epoxy casts and a discussion of similar shell pore systems in Cambrian molluscs.

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University of California

Epoxy casts of the aesthete canal system in valves of nine chiton species (from three families) are highly variable. This variation shows a much stronger correlation with phylogeny than ecology, as members of each family share similar canal systems in spite of differences in life habit and environment. The casts also reveal a greater connectivity in the total aesthete canal system than is widely realized. For example, canals in the apical area connect to those in the slit rays, the ventral area below the jugum, and the dorsal surface of the valve.

Such epoxy casts can also be used to help interpret natural sediment casts of fossil molluscs and mollusc-like organisms. This allows a better comparison of the shell canal system of chitons with that of previous and current *Problematica* such as multiplacophorans and hyoliths, so that analogous and homologous features can be identified. In addition, phosphatic internal molds of molluscs from the Early to Middle Cambrian (~540-510 million years ago) are commonly covered with small, bumpy projections which can be interpreted as partly filled pore channels. A survey of these structures in internal molds of the oldest known molluscs suggests that molluscan shells may have been primitively porous, although they lacked the complexity of the canal system of modern chitons. The fossil data seemingly contrast with published observations that modern pore-bearing molluscs differ in their pore systems and in the tissues that fill the pores. This method of making epoxy casts of modern mollusc shells is also being used to assess cases of possible shell microstructure preservation in the Early to Middle Cambrian phosphatic internal molds of molluscs. Many equivocal cases exist, and this epoxy casting method—which mimics the detailed phosphate molding process that occurred to produce the fossils—can be used to help arbitrate in such cases.

Observations of deep-sea octopodid behavior from undersea vehicles

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Three of the four octopodid subfamilies recognized by Voss in 1988 occur below the photic zone, the depth to which sunlight penetrates. Despite high octopodid diversity in the deep sea, the logistics of working in the habitat have limited opportunities to both sample and observe these octopuses in situ. Over the last decade, my field program has used NSF, NOAA, NSERC-funded ship and submersible time to observe octopuses opportunistically. Most often observed were octopuses near hydrothermal vents at depths in excess of 2000 m because most submersible time is dedicated to studies of these geologically active habitats. Although the lights and the noise created by submersible operations inarguably result in unique seafloor conditions that may alter the animals' behavior, without them, seafloor observations would be impossible.

Regardless of these potential artifacts, the behavior of octopuses of the genera *Benthoctopus*, *Graneledone* and *Vulcanoctopus* appeared to be within the range of what could be expected. Observations indicate that members of these genera differ in activity levels, wariness and, between the first two, egg-brooding behavior. Octopuses of *Graneledone* are typically larger, more massive, slower-moving and were more often seen foraging during ambulation than were those of the other genera. Often, they could be readily captured with the manipulator arm after a brief period of observation. The higher activity level and propensity to jet shown by individuals of *Benthoctopus*, which cannot be identified to species from images, meant that they better avoided capture and could be only briefly observed. Octopuses of *Vulcanoctopus* remain little known, despite the considerable submersible time spent in their habitat. Chemoreception and tactile input are likely key ways in which deep-sea octopodids locate prey. As predicted by Voss, the prey of these deep-sea octopuses may be small and require minimal preparation by the octopus prior to ingestion.

The case of the mystery limpet – is *Ferrissia fragilis* a cryptic invader of European freshwater ecosystems?

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An enigmatic freshwater limpet (Ancyliidae: Basommatophora) was first detected in Europe six decades ago, and it has since been recorded across much of the continent. In the recent European literature, it has been identified as either *Ferrissia wautieri* (Mirolli, 1960) or as *F. clessiniana* (Jickeli, 1882), and each name is charged with distinct biogeography associations. *F. wautieri* is assumed to be endemic, and its absence from earlier European faunal surveys is attributed to its small size, formerly undescribed status, and misidentification as *Acroloxus lacustris*. In contrast, *F. clessiniana* is assumed to have recently spread across Western central/Eastern Europe from presumed endemic foci in either Southern Europe and/or North Africa. Based collectively on the phylogenetic placement of a voucher-less GenBank sequence, an early (but overlooked conchological identification by J. Morrison and a number of striking ecological, morphological and physiological similarities, I proposed an alternate hypothesis. It states that the rapid expansion of this mystery limpet across European watersheds represents a cryptic invasion of New World *F. fragilis*. My trans-Atlantic invasion hypothesis makes the explicit phylogenetic prediction that genotypes of verified European specimens will nest within a clade of North American *F. fragilis* and will be phylogenetically distinct from *F. clessiniana* genotypes sampled from its endemic range. Testing this hypothesis is the subject of my oral presentation.

One Down, Thousands to Go: Virginia Completes the First Successful Eradication of a Zebra Mussel Population

B. T. Watson, R. T. Fernald
Virginia Department of Game & Inland Fisheries

In September 2002, the Virginia Department of Game and Inland Fisheries (VDGIF) confirmed that a zebra mussel infestation was present in Millbrook Quarry, western Prince William County, documenting the first known population within the Commonwealth. Given the potential impacts if zebra mussels were to escape from the quarry, VDGIF worked with federal, state, and local agencies; industry and conservation organizations; and individuals to pursue eradication. The 3 ½ year effort involved establishing an interagency workgroup to assess the feasibility of eradicating the population; investigating the hydrologic, geochemical, and biological characteristics of the quarry and infestation; evaluating potential avenues for eradicating the zebra mussels; surveying nearby Broad Run, Lake Manassas, and other popular dive sites and reservoirs to ensure that zebra mussels had not escaped into other waters; issuing a Request for Proposals to eradicate the infestation; selecting a process and contractor to conduct the eradication; and surveying Broad Run for occurrence of native mussels or other species that might be impacted by potassium seepage from the quarry. Eradication began on January 27, 2006 and comprised of elevating potassium concentrations in the quarry through the introduction of potash – a commercial grade fertilizer. The quarry was injected with 174,000 gallons of potash solution (12% potassium) over a 3-week period, with a target concentration of 100 ppm. Eradication was confirmed via visual confirmation by VDGIF scuba divers, video documentation of the dead zebra mussels through use of a robotic camera, and achievement of 100% mortality of eighty bioassays of 100 live zebra mussels each placed at various locations and depths throughout the quarry. In dramatic contrast, other aquatic wildlife including turtles, fishes, aquatic insects, and snails continue to thrive in the quarry. This is the first successful eradication of an open water zebra mussel population from a large, open water body.

The intraspecific polymorphism in host attracting structures *Toxolasma parvus* (Barnes, 1823) (Unionidae)

G.T. Watters, K.F.Kuehni, R.J. Trdan, J.M.Walker, W.R.Hoeh
Ohio State University, Saginaw Valley State University, Kent State University

Unionid bivalves are typically dioecious with some taxa exhibiting shell and anatomical sexual dimorphism. Morphological adaptations such as mantle lures, which facilitate the transfer of parasitic larvae from brooding parent to host, are striking in some taxa (eg. Lampsilini). *Toxolasma parvus* (Lampsilini) has been alternatively referred to as hermaphroditic and without shell sexual dimorphism or dioecious and exhibiting shell sexual dimorphism. This confusion and the recent discovery that some populations of *T. parvus* lack the diagnostic characteristic of the genus (a caruncle-type lure) elicited this study into mantle lure morphologies, mating systems, and genetic divergences within *T. parvus*. This study examined the shell and mantle morphologies of living and preserved museum specimens of *T. parvus* and carried out gonad-based mating system determinations and *cox1* sequence analyses on freshly collected specimens. No shell sexual dimorphism was observed in the *T. parvus* specimens examined. Ethanol-preserved *T. parvus* individuals displayed one of these distinct mantle luring morphologies: caruncles only, mantle flaps only, or caruncles and mantle flaps. Individuals with mantle flaps were genetically identical to caruncled individuals. The distribution of the observed variation in mantle lure morphology and lack of correlated DNA sequence differentiation suggest that this variation represents an intraspecific polymorphism. The variation in mantle lure morphology and the typically hermaphroditic mating system of *T. parvus* may facilitate the colonization of new habitats.

Interplay between hosts genetic diversity and disease transmission in a host-parasite association

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Enhanced genetic variability through outcrossing is believed to be evolutionary favorable because it potentially provides a greater suite of responses in the face of environmental change and can suppress the negative fitness effects of deleterious recessive allele accumulation. Parasites can act as a strong selective force in host populations and the magnitude of this force is predicted to increase for this idea is both limiting and conflicting. In this study, we experimentally investigated the life history responses of inbred and outcrossed hosts (*Biomphalaria glabrata*) in the presence or absence of the human parasite, *Schistosoma mansoni*. Surprisingly, exposure to *S. mansoni* resulted in high infection levels regardless of host genetic background suggesting no outcrossing advantage. However, further examination of both host and parasite life-history traits uncovered significant differences based on crossing status. In general, outcrossed progeny survived longer and exhibited greater reproduction success compared to inbred progeny. In addition, *S. mansoni* larvae tended to be released in lower numbers from outcrossed snails relative to their inbred counterparts. As an extension of this work, we combined estimates of parasite reproduction and host size to generate a novel 'exploitation index' and found that the indices strongly predicted host survivorship. These experiments demonstrate that progeny resulting from parental outcrossing have a fitness advantage in the face of parasitism, which may have consequences for disease transmission dynamics in the field.

Finding the needles among the haystacks: Uncovering consistent morphological differences among the phenotypically hyper-variable *Isognomon* (Bivalvia: Pterioidea)

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Geometric morphometric shape analysis is a powerful, recently developed tool for the quantitative analysis of morphological differences. Using this system, I constructed and analyzed a dataset consisting of 4 isognomonid taxa from two subgenera, *Isognomon (Melina) ephippium*, *I. (Melina) alatus*, *I. (Parviperna) bicolor*, and *I. (Parviperna) recognatus*. To uncover taxon-specific morphological differences we examined the sampled taxa for differing ontogenies using multivariate regression. After examining these developmental patterns, the samples were normalized using the regression data to produce a centroid-size standardized dataset for interspecific comparisons. These taxa were then compared using both traditional landmark analysis and thin-plate-spline analysis followed by principle component analysis and canonical variate analysis. These types of analysis allow for the partitioning of variance into intraspecific and interspecific variation exposing meaningful variation for the comparison of these species.

Chemical defense in hatchlings of the blue ringed octopus *Hapalochlaena lunulata*

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Some blue-ringed octopuses (*Hapalochlaena spp.*) contain tetrodotoxin (TTX), which is a potent neurotoxin that inhibits action potentials in nerve and muscle tissue. *Hapalochlaena spp.* are presumed to use TTX to subdue prey; however, TTX may also serve as a defense. Highly camouflaged at rest, *Hapalochlaena spp.* can rapidly change their body coloration to display bright blue aposematic rings or lines. Whether TTX is a defense for octopus hatchlings that have not yet developed this coloration is unknown. Hatchlings of *H. lunulata* are pelagic and would benefit greatly from such a chemical defense. We found that *H. lunulata* immediately post-hatching contained 114 ng TTX per hatchling via high performance liquid chromatography—an amount that could intoxicate or kill a guppy-size fish (< 0.5 g). To determine if hatchlings were chemically defended by TTX, one hatchling each was offered to several predators, 12 species of fish, and 6 species of stomatopods. Predators were offered brine shrimp as a control. Of 25 predators that consumed brine shrimp, only 6 consumed *H. lunulata* hatchlings. Rejected hatchlings were spit out within 3 seconds. However, TTX is tasteless and odorless and no fish showed signs of TTX intoxication whether they had eaten an octopus hatchling or not. Thus, hatchlings may be defended by another distasteful compound. Regardless, this is the first empirical confirmation of chemical defense in hatchlings of the genus *Hapalochlaena*.

Systematics, evolutionary history and biogeography of the vetigastropod genus *Turbo* and subfamily Turbininae

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We assess the consequences of tectonic events and temperature regime on the diversification of Indo-West Pacific (IWP) turban shells. As a first step, monophyly of both the family Turbinidae and the nomenclotypic genus *Turbo* were tested using molecular markers. Samples were obtained from more than 40 species of *Turbo* (out of approximately 70) and representatives from genera belonging to eight of the nine sub-families in Turbinidae. Bayesian and parsimony phylogenetic analyses of two nuclear genes and two mitochondrial genes suggest that neither the molluscan family Turbinidae, nor the genus *Turbo* are monophyletic. Changes to the systematics are suggested.

Phylogenetic analyses also indicate that IWP *Turbo* species form a single clade, which molecular-clock estimates suggest is Paleocene in age – pre-dating the closure of the Tethys Sea and therefore pre-dating the physical separation of the IWP from other biogeographic regions. Fossil evidence for the largest subgenus, *Marmarostoma*, confirms that at least some *Turbo* lineages currently restricted to the IWP, were previously more widespread. The combination of the phylogeny with the fossil evidence suggests that diversity in modern IWP *Turbo* is the result of the evolutionary persistence within the IWP of several lineages, some of which were more widespread in the Eocene. These lineages diversified within the IWP in the Miocene – late Oligocene, as a result of the increased availability of shallow-water habitats and carbonate platforms in the central IWP. The presence of a single IWP clade is also consistent with the idea that there has been no successful migration of lineages into the IWP from other biogeographic realms once the IWP became isolated. Superimposing the temperature regime (tropical or temperate) of each species onto the molecular tree, in combination with data from the fossil record, suggests that speciation rates in temperate Turbininae are slower than in their tropical sister taxa.