

Inducible Offenses in Marine Molluscan Grazers

Dianna K. Padilla

Department of Ecology and Evolution, Stony Brook University
Stony Brook, NY 11794-5245, USA, padilla@life.bio.sunysb.edu

Several species of gastropod grazers have been demonstrated to express morphological plasticity in their radula. The adaptive value of these inducible offenses (traits that enhance the abilities of consumers or competitors) can be limited because of long lag times between when an individual receives environmental cues and when the new morphologies can be used. Behavioral plasticity associated with dispersal potential and food preference could work to minimize this adaptive limitation if individuals disperse less from food substrates/habitats they have been exposed to most recently, and disperse readily from alternate habitats. This type of behavioral response could act to increase the amount of time an individual resides in a given habitat, minimizing the consequences of morphology-habitat mismatches because of the long lag time. Detection of and response to local predation risk could also enhance the adaptive value of such plasticities. Two sympatric species of littorinids in the genus *Lacuna* have radular morphologies that are inducible by food and environmental cues, and relatively long lag times (20–28 days) between when they sense a new environment and new teeth are ready to use. In experiments, snails disperse less frequently from food/environments in which they have been reared, and more frequently from alternate foods they have not recently experienced. Although these two species co-occur and are closely related, they show differences in dispersal behavior with one species dispersing much more readily than the other. Dispersal is also enhanced by chemical detection of predators, especially visual predators.

Contributed Session I – Marine Gastropods

**Some Nudibranchs (Mollusca: Opisthobranchia)
from Parque Nacional Morrocoy, Venezuela**

Nelsy Rivero Paredes

Universidad Simón Bolívar, Departamento de Estudios Ambientales
Apartado Postal 89000, Caracas 1080, Sartenejas Baruta, VENEZUELA nelsyrivero@cantv.net

Between January 2003 and March 2004 nudibranch gastropods were collected in different areas of Parque Nacional Morrocoy (10°52' N, 69°16' W) to determine their diversity. A total 16 nudibranchs, representing eight species and four families (Discodoridae: *Discodoris evelinae*; Scyllaeidae: *Scyllaea pelagica*; Bornellidae: *Bornella calcarata*; Chromodoridae: *Hypselodoris bayeri*, *Hypselodoris rutae*, *Chromodoris binza*, *Dendrodoris krebsii*, and *Tyrinna evelinae*) were collected from four areas: Cayo Muerto (10°55'40"–10°50'52" N, 68°15'40"–68°15'54" W), Cayo Sal (10°56'17"–10°57'20" N, 68°15'22"–68°16'03" W), Varadero (10°54'47" N, 68°14'49" W) and Punta Mayorquina (10°53'45" N, 68°13'48" W). Individuals from all these species were found living on different substrata, ranging from coral reefs and rock platforms, to algal and *Thalassia testudinum* beds.

Poster Session

***Trophon* Montfort, 1810: The History of an Old Patagonian Resident**

Guido Pastorino¹ and Miguel Griffin²

¹Museo Argentino de Ciencias Naturales
Av. Angel Gallardo 470, Lab. 57

C1405DJR Buenos Aires, ARGENTINA, pastorin@mail.retina.ar;

²Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa
Av. Uruguay 151, L6300CLB Santa Rosa, La Pampa, ARGENTINA

Species undoubtedly belonging to the genus *Trophon* have been recorded in marine rocks exposed in southern South America and dated as far back as the late Oligocene. Earlier records are doubtful and based on poorly preserved material. The origin of this genus seems to have taken place somewhere along the coast of Patagonia, where its extant members include 11 species ranging from Chile around Cape Horn as far north as Uruguay. Although a large number of nominal species have been described from other areas, mainly Antarctica, but also from as far away as New Zealand, all of these have proven to belong to different genera. Anatomic characters allow differentiating these species from true *Trophon*. Despite the fragmentary nature of the fossil record in the Cenozoic of Patagonia, it is clear that *Trophon* was well established and fairly common in the shallow shelf environments that prevailed there throughout the Cenozoic. Its absence in the richly fossiliferous Cenozoic marine rocks in Antarctica may reflect the fact that a barrier between Antarctica and South America was already in place prior to the Oligocene. This barrier was surely related to paleogeographic changes involving the opening of Drake Passage and the consequent interruption of shelf conditions connecting Antarctica and Patagonia. This probably played a more decisive role than the inception of the Circum-Antarctic Current and the establishment of cooler temperatures in the southern oceans, as the genus seems to be adapted to cold waters — and possibly was so also in the past — as indicated by the sharp interruption of its range toward the north, where it does not extend beyond the edge of the southbound, warm Brazilian Current.

Symposium – Relationships of the Neogastropoda

Tempo and Mode of Diversification in the Indo-West Pacific

Gustav Paulay¹, Christopher P. Meyer¹, and Jonathan B. Geller²

¹Florida Museum of Natural History, University of Florida
Gainesville, FL 32611-7800, USA, paulay@flmnh.ufl.edu;

²Moss Landing Marine Laboratories, 8272 Moss Landing Road
Moss Landing, CA 95039, USA

Although the statement that the Indo-West Pacific harbors the greatest marine diversity has become a cliché, not all taxa show high diversity in the region. While some families include hundreds of regional species, others are monospecific. Some groups are diverse both at the local and regional levels, while others have modest local, but high regional diversity. What conditions facilitate or impede the development of megadiversity? Intensive biodiversity surveys at several Pacific locations combined with molecular phylogenetic studies reveal varied patterns of diversity and modes of diversification. Speciation can occur at a variety of locations, across a wide range of spatial and temporal scales, driven by varied mechanisms. Although allopatric speciation can occur almost anywhere in the region, speciation events strongly cluster in some areas that serve as diversity pumps. The geographic scale of allopatric speciation varies over orders of magnitude from inter-island to inter-regional scales, and this is substantially correlated with dispersal ability. Nevertheless, even taxa with exceptional dispersal ability can speciate allopatrically within the region. The temporal dynamics of speciation are also highly variable. While sufficient isolation to allow secondary sympatry takes >10 million years in many groups, others diversify much more rapidly. Evidence supports the importance of founder speciation in addition to vicariance, and selection is a powerful force in generating diversity. We will review numerous examples to illustrate these points and explore what combinations of these factors are most conducive for the development of megadiversity.

**Land Snails from St. Elzear Cave, Gaspé Peninsula, Quebec:
Antiquity of *Cepaea hortensis* in North America**

Timothy A. Pearce¹ and Jennifer C. Olori²

¹Section of Mollusks, Carnegie Museum of Natural History
4400 Forbes Ave, Pittsburgh, PA 15213, USA, PearceT@CarnegieMuseums.org;

²Cornell University, Ithaca, NY 14853, USA

The land snail *Cepaea hortensis*, common in Europe, was once considered introduced into North America. However, archaeological evidence indicates that *C. hortensis* was in North America before the arrival of Columbus. Could Vikings have brought the species to North America, or was it present in North America before the Vikings explored 1000 years ago? The St. Elzear Cave on the Gaspé Peninsula, Quebec, has a 13 m vertical drop at the entrance, which was effective at trapping organisms. The cave entrance opened to the surface after the most recent glaciation, about 12000 years ago. The 168-cm-deep cave sediments were excavated from 1977–1979. We identified ten species of land snails from the sedimentary deposits in the cave. Five species were abundant enough to allow for evaluation of their presence through the layers. Four native species (*Discus catskillensis*, *Zonitoides arboreus*, *Anguispira alternata*, and *Neohelix albolabris*) were present throughout the excavation. *Cepaea hortensis* was present in only the upper 84 cm of the cave sediments. Two lines of evidence from St. Elzear Cave suggest that *C. hortensis* has been in North America for at least 6000 years. The first appearance of *C. hortensis* halfway up the 168-cm sediment column suggests it appeared halfway through the 12000 years that the cave has been open, or 6000 BP. Second, extrapolation from a radiocarbon date on wood higher in the section provides a similar estimate of 6460 BP. Both of these estimates indicate that *C. hortensis* was present in North America longer before the Vikings.

Contributed Session II – Terrestrial Gastropods

Studies on Volutids in Argentina (Caenogastropoda: Volutidae)

P. E. Penchaszadeh, F. Arrighetti, G. Bigatti, M. Cledón, J. Giménez, D. Luzzatto, and C. Sanchez Antelo

Laboratorio de Invertebrados, Facultad de Ciencias Exactas y Naturales (UBA) and MACN-CONICET, Av. A. Gallardo 470
1405 Buenos Aires, ARGENTINA, penchas@bg.fcen.uba.ar

Adelomelon brasiliiana (Lamarck, 1811) specimens were captured monthly in the Mar del Plata area (15m depth) during three consecutive years. The reproductive season extends from September to April. The mature oocytes reach 200 µm in diameter before spawning. In autumn, a resting phase begins, and non-spawned oocytes undergo reabsorption. Among the Volutidae, *Adelomelon brasiliiana* is the only species known to lay free egg capsules. The distribution of egg capsules is aggregated due to bottom currents. Egg capsules are often stranded on the beach after strong storms; there they die or suffer predation by shore birds. Gonad development of *Zidona dufresnei* (Donovan, 1823) (Caenogastropoda: Volutidae) was studied over a period of two consecutive years. The reproductive season in this species in the sampled locality off Mar del Plata extended from October to March. Size at first gonadic maturity in females was 12.8 cm shell length and in males 12.0 cm shell length, but size at which 50% of the population was mature was 15.7 cm in females and 15.0 cm in males. The record of stable isotopes ratio ^{18}O deposited in the shell calcium carbonate of *Z. dufresnei* that reflects seasonal oscillations in water temperature was used to infer size-at-age. Three years of sampling of *Odontocymbiola magellanica* (Gmelin, 1791) and *Adelomelon ancilla* (Lightfoot, 1786) by scuba diving in depths of 6–10 m were performed in Golfo Nuevo, Patagonia, in order to study the spawning seasons, the diet and imposex occurrence. Imposex was registered in individuals of *Adelomelon beckii* (Broderip, 1836) off Mar del Plata (50–60 m depth); thus *A. beckii* is the deepest-occurring species where imposex was observed in the southwestern Atlantic.

Contributed Session III – Marine Mollusks

Systematics and Biogeography of the Squid Genus *Alloteuthis* (Loliginidae) Based on Morphological and Molecular Sequence Data

Carolyn Porter

Department of Zoology, Southern Illinois University
Carbondale, IL 62901, USA, carolynp@siu.edu

Alloteuthis comprises three nominal species of small (~10–15 cm dorsal mantle length) slender squids found in the eastern Atlantic Ocean and Mediterranean Sea. These squids are objects of minor fisheries, and they are abundant members of the neritic cephalopod fauna in European and West African waters. Recent morphometric analyses have suggested that two *Alloteuthis* species — *A. media* and *A. subulata* — actually represent arbitrary divisions of a gradual range of variation in body shape, and hence should be synonymized under the name *Alloteuthis media*. To address this question, and to investigate phylogeographic patterns within this group, we have sequenced a region of the mitochondrial cytochrome c oxidase subunit I (COI) gene from several specimens from each of the three nominal *Alloteuthis* species (*A. media*, *A. subulata*, and *A. africana*) from throughout their ranges, as well as several specimens of *Afrololigo mercatoris*, the sister taxon of *Alloteuthis*. Preliminary analyses suggest that (1) specimens assigned to *A. subulata* and *A. media* based on morphometric comparisons are very similar genetically and (2) there is very little haplotype variation across the ranges of these species. Our findings thus appear to support the suggestion that *A. media* and *A. subulata* should be synonymized.

Poster Session

In-Utero Responses in Bellamya Brood to a Potential Predator

Robert S. Prezant and Eric J. Chapman

Department of Earth and Environmental Studies, Montclair State University Montclair, NJ 07043,
USA, prezantr@mail.montclair.edu

The live-bearing gastropod *Bellamya (Cipangopalidina) chinensis* is an excellent test organism to address questions of environmental influence on reproductive potential. A member of the Viviparidae, *B. (C.) chinensis* gives birth to fully developed juveniles. In brooding adults, all stages of development are found simultaneously *in utero*, from newly fertilized ova to large juveniles. Thus a single brooding female contains all ontogenetic stages, each essentially exposed simultaneously to the same environment as the parent. This could mean that changes in parental environment could be reflected in biochemical, physiological, and/or morphological changes in the developing young. A previous author's results in finding changes in adult snail shell in the presence of predators led us to ask if brooded juveniles might also modify shell form or if total reproductive output might change in viviparid snails under similar "threat." We tested this with *B. (C.) chinensis*. When brooding adults of this snail were placed in the presence of a crayfish, we found that juveniles released were 91% the size of control offspring and total release of offspring essentially doubled. Thus, more and smaller juveniles were released in this brooding gastropod in the presence of a predator. It is possible that these changes reflect an adaptation for "protection in numbers" and/or an increased ability of the juveniles to hide in smaller crevices.

Contributed Session IV – Freshwater Mollusks

Mitochondrial Gene Rearrangements at a Snail's Pace

Timothy A. Rawlings¹, Timothy M. Collins¹, and Rüdiger Bieler²

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

²Department of Zoology (Invertebrates), Field Museum of Natural History
1400 S. Lake Shore Drive, Chicago, IL 60605-2496, USA

Given that animal mitochondrial (mt) gene order tends to be extremely conserved even at high taxonomic levels, the arrangement of mt genes within the phylum Mollusca appears exceptionally variable. Representatives of three classes of mollusks share remarkably few gene boundaries, with gene order varying extensively even within the class Gastropoda. Here we present further evidence of an unusually labile gastropod mitochondrial genome: numerous gene order changes have occurred within the Vermetidae, a family of sessile, uncoiled, suspension-feeding gastropods that radiated from a basal caenogastropod stock in the early Cenozoic. Demonstration of major gene order changes within such a young taxonomic group is exciting for a number of reasons. First, vermetid mt genomes may help to understand more fully the mechanics of gene order changes, since the telltale vestiges of gene duplications and translocations, typically erased or overwritten with time, may still be present within these genomes. Second, vermetid mt genomes offer the opportunity to study putative mechanisms accounting for gene order homoplasy and tRNA gene remodeling at a fine taxonomic level. Finally, gene order changes can provide compelling phylogenetic markers that can supplement or contradict primary sequence data, and provide resolution for deeper nodes that are often weakly supported in sequence-based phylogenies. We have found four mitochondrial gene order changes that are phylogenetically informative within the Vermetidae. These markers should allow us to improve our phylogenetic hypothesis for the enigmatic Vermetidae and to investigate the conditions under which sequence-based phylogenies lack resolution or prove misleading.

Contributed Session I – Marine Gastropods

**The Cuban Land Snail *Zachrysia*: The Emerging Awareness
of an Important Snail Pest in the Caribbean Basin**

David G. Robinson¹ and Angela Fields²

¹USDA-APHIS-PPQ / Academy of Natural Sciences
Philadelphia, PA 19103, USA, robinson@ansp.org;

²Department of Biological and Chemical Sciences, University of the West Indies
Cave Hill, BARBADOS

Three species of the terrestrial snail genus *Zachrysia* are confirmed as established outside of Cuba. Their shells are often difficult to differentiate from one another, although anatomically they are quite distinct. *Zachrysia trinitaria* (Pfeiffer, 1858) appears so far to be restricted to the Miami-Dade area of Florida. Although shells matching those of this species in institutional collections date back more than fifty years, this is the first report of this taxon outside of Cuba. *Zachrysia auricoma havanensis* (Pilsbry, 1894) is reported in Panama and the Yucatán Peninsula of Mexico and is a widespread pest throughout synanthropic environments in Puerto Rico, but seems not to have spread further into the Caribbean. *Zachrysia provisoria* (Pfeiffer, 1858) is an aggressive, polyphagous plant pest in southern Florida, and is spreading with horticultural exports: molluscan pest surveys over the last five years have detected its presence in Barbados, Saint Croix, Jamaica, and most recently, Mustique and Nevis. It has also been found in horticultural shipments from the Bahamas and Costa Rica. Immature *Zachrysia* sp. has also been detected in horticultural exports from Haiti, the Dominican Republic, and Guatemala, although the genus has not been reported as established or even introduced in those countries. Most nations seem unaware of the potential consequences to their agricultural and horticultural industries should *Zachrysia* be inadvertently introduced with horticultural imports, or be allowed to spread. Rather than being a pest of emerging importance, *Zachrysia* is actually an important and widespread pest but there is only a slowly emerging awareness of its potential significance.

Special Session – Snails and Slugs as Agricultural and Horticultural Pests

**No Reproductive Isolation Between the Freshwater
Pulmonate Snails *Physa virgata* and *P. acuta***

John D. Robinson¹, Robert T. Dillon, Jr.¹, Thomas P. Smith¹,
and Amy R. Wethington²

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

²Department of Biological Sciences, University of Alabama
Current Address: Department of Biological Sciences, Purdue University
West Lafayette, IN 47907, USA

Mate choice tests uncovered no evidence of prezygotic reproductive isolation between a population of *Physa virgata* (Gould, 1855) collected from its type locality in the Gila River of Arizona and *Physa acuta* (Draparnaud, 1805) from a control site in Charleston, South Carolina. Ten outcross *virgata* × *acuta* pairs initiated reproduction at approximately the same age as *virgata* × *virgata* and *acuta* × *acuta* controls. The mean 10-week fecundity of the outcross pairs was slightly but not significantly less than either pure-line controls, and the viability of F₁ hybrids was slightly but not significantly greater. We detected no evidence of reduction in F₁ fertility. Thus *P. virgata* should be considered a junior synonym of *P. acuta*.

Photoperiod Effect in the Embryonic Development of the Queen Conch *Strombus gigas* (Linnaeus)

Luis A. Rodríguez-Gil¹, Joji Ogawa², and Richard S. Appeldoorn³

¹Instituto Tecnológico de Mérida, Km. 5, Carretera Mérida a Progreso
Mérida, Yucatán, MÉXICO, luisrdzgil@aol.com;

²Japan International Corporation Agency, JAPAN;

³Departamento de Ciencias Marinas, Universidad de Puerto Rico
Recinto Universitario de Mayagüez, PUERTO RICO

This scientific investigation aims to describe basic biological mechanisms involved in the culture of *Strombus gigas* and the main objective was to determine the direct effect of photoperiods during embryonic development until hatching. Seven egg masses of the queen conch, *Strombus gigas*, still in their first cell divisions, were subjected to six different photoperiod treatments in two phases. The first phase involved three egg masses and had a 5-hour advanced photoperiod and the second involved four egg masses with a 7-hour advanced photoperiod. The photoperiods were advanced with respect to 18:00 hours (the normal time of sunset at the collection areas in Mexico). The experimental apparatus consisted of six wooden boxes, each containing five receptacles in which portions of each egg masses were placed. Seawater flow was 200 ml/min at a controlled temperature of $27.8 \pm 0.2^\circ\text{C}$. The number of larvae that hatched was counted in all treatments in intervals of one hour, from the beginning of eclosion in whichever treatment took the longest to complete hatching, with the objective of observing if embryos responded to the different photoperiods. The results indicated that eclosion depended on the alternation of light/dark, such that light could be programmed to advance up to seven hours and that three cycles of artificial light/dark were enough to show enough endogenous control suggesting that this sequence can be compared to a biological clock regulated by photoperiod.

Contributed Session III – Marine Mollusks

Species Discovery Curves for Marine Mollusks: No Sign of an Asymptote

Gary Rosenberg

Academy of Natural Sciences, Philadelphia, PA 19103, USA, rosenberg@ansp.org

Species discovery curves were plotted for Western Atlantic marine gastropods and Indo-Pacific marine species based on the data in Malacolog 3.3. <<http://data.acnatsci.org/wasp/>> and the Biotic Database of Indo-Pacific Marine Mollusks <<http://data.acnatsci.org/obis/>>. Year of naming was used as a proxy for year of discovery, with each species currently considered valid assigned the year that the oldest available name for it was introduced, thereby correcting for artifacts introduced by homonymy. For both faunas, the curves are almost linear since the 1840s, meaning that species have been discovered at a relatively constant rate since that time. The 1840s marked a shift from works that attempted to document all known mollusks, to monographic works at the genus and family level, with a concomitant increase in rate of discovery. The lack of clear asymptotes means that it is impossible to estimate how many species these faunas contain, but the true number is likely more than twice the number currently known. The curves suggest accelerating discovery since World War II, but whether this is a true increase in rate or merely lag time to synonymy is unknown. Global databases of known mollusk species, online interactive identification keys, and DNA technology will further increase rates of discovery for mollusks.

Special Session – Biodiversity of Marine Mollusks