The Newsletter of the IUCN/SSC Mollusc Specialist Group
Species Survival Commission • International Union for Conservation of Nature

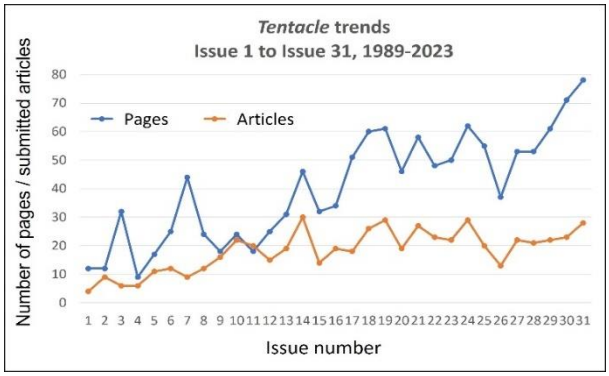
TENTACLE

UNITAS MALACOLOGICA

Editor – Robert H. Cowie

EDITORIAL

The biggest issue of *Tentacle* yet! Just for fun, I did some quick counting of submitted articles—the general (most recently with green headings), Pacific island and ex-situ breeding (orange headings) and marine (blue headings) sections, and their roughly equivalent earlier versions—from issues 1 (1989) to 31 (this one). As you see from the graph, and ignoring the anomalous page number peaks of issues 3 and 7, growth in the number of pages per issue has been fairly steady, though with some ups and downs. On the other hand, however, after a steady increase to 22 articles in issue 10 (2002), the number of articles has stuck within the 20s, with a fews dips below, and only once reached 30 (issue 14, 2006). Back then, most articles were 1-2 pages, but now I find that I am struggling to keep many articles below 3 pages. Articles are getting longer, which I'm not sure is a good thing—*Tentacle* is a newsletter! Of 566 articles concerning over 69 countries, most were from the USA (103), followed by Brasil (63), France (32, mostly French Polynesia), Canada (28) and Cuba (23). In the future I would like shorter but more articles, and from a greater spread of countries. *Tentacle* is healthy, but molluscs are threatened almost everywhere. Please encourage everyone to submit their news.



Robert H. Cowie

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IN MEMORIAM
Beata M. Pokryszko (1956–2022)

From Robert A.D. Cameron, University of Sheffield

Fig. 1. Beata Pokryszko in the field near Klodzko, Poland, in 2005. (Photo: Robert Cameron)

After several years of ill-health following a damaging fall, Beata Pokryszko died, tragically early, on 5 June 2022. Her career, from student to full Professor was spent entirely at the Museum of Natural History in the University of Wrocław. Her research on molluscs encompassed the systematics and ecology of pupilloid snails from places as far apart as Australia, Europe, Pakistan and Hawaii, the macroecology of forest snail faunas across Europe and elsewhere, the status and ecology of rare and endangered species in Poland, and variation in the polymorphic *Cepaea* species of Europe. She described, alone or with others, 30 species new to science, and one (Eocene) genus. It is a tribute to the breadth of her knowledge and co-operative spirit that her publications involve co-authors from 18 countries.

It is, though, not only for her original research that she will be remembered. A working member of the Mollusc Specialist Group of IUCN from its inception until her death, her contribution to molluscan conservation was immense. Closer to home, she was a founder member of the Association of Polish Malacologists, and an active participant in all their annual seminars, organising many herself. At the last she was able to attend, in 2019, she was awarded honorary membership in a moving ceremony. She was involved in the revival of the Polish journal *Folia Malacologica*, and was its English language editor until her death. Among the many tasks she undertook were the accounts given after each seminar, and after many UNITAS congresses or EuroMal conferences, accounts full of penetrating but never hurtful humour. There were many other written contributions in the form of reports, reviews and contributions to conservation related activities. A full account is given by Lesicki (2022). Her legacy includes several one-time PhD students now active in malacological research.

The loss is personal. Together and with others we wrote 29 papers, and our fieldwork took place in Poland, England, Romania, Ukraine, Georgia, Greece, Madeira, the Azores and Australia. The last, in Poland in 2019, was conducted mainly from a wheelchair, but with humour and authority. I came to understand the title Ataman, leader, conferred on her by her students. Nothing, even hornets or Australian ticks, could prevent the efficient execution of the task on hand. But her principal legacy is in the way she inspired and helped others.

A full obituary is given by Lesicki, A., 2022. Beata Maria Pokryszko (1956- 2022), Obituary. *Folia Malacologica* 30(4): 189-209. I am grateful to Professor Lesicki for allowing me to use it.

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NEWS

The Tony Whitten Conservation Award Programme

From the Editor

Tony Whitten (1953-2017) was an inspirational conservationist who championed biodiversity across Asia and beyond (see *Tentacle* 26). As a tribute to him, the Tony Whitten Conservation Award was established in 2019 by the Cambridge Conservation Initiative (CCI) to celebrate early career researchers from East and Southeast Asia working on any area of conservation or field biology, but especially the overlooked species and habitats that Tony was most passionate about, such as caves and karst ecosystems, and little-studied invertebrates and fishes. Winners of the 2019 awards included three working on molluscs (see *Tentacle* 28); one of the 2020 winners worked on molluscs (see *Tentacle* 29); and one of the 2021 winners also worked on molluscs (see *Tentacle* 30).

The Award programme has now finished, according to a notice on the CCI website.

Journal of Conchology to become fully open access and digital only

From the journal's website.

Published twice a year, it contains scientific papers and short communications on molluscs with emphasis on promoting conservation, biogeography and taxonomy. The contents cover, typically, descriptions of new species from anywhere in the world and reports concerning the ecology, distribution and status of molluscs. Both living and fossil molluscs are dealt with.

In addition the Journal includes the official proceedings of the Society, obituaries and book reviews. Being a scientific publication papers are published only after review by referees. The Journal is subscribed to by learned institutions world-wide, and is a flagship publication for the Society. Members and non-members may submit contributions to the Honorary Editor. Here are detailed instructions for authors on how to submit articles to the Journal.

To further the objectives of the Society from 2023 the JoC will be a fully Open Access Journal and from 2024 it will be digital only. This page of our website will be the gateway to current and past issues of the journal. We hope to make steady progress with respect to back-populating it over time (but bare [sic] with us as, given the longevity of the publication, this process may take several years!). Please feel free to browse, bookmark or download as you wish and do come back and visit this space periodically to check on the growing availability of what we trust will be a valuable resource to all those interested in molluscs.

Special issue "Advances in Freshwater Mollusk Communities" is open for submissions

From Simone Da Graça Pinto Varandas & Ioan Sîrbu

We are pleased to inform you that the Special Issue "Advances in Freshwater Mollusk Communities" of the journal *Diversity*, published by MDPI (IF 3.031, ISSN 1424-2818), is now open for submissions. The aim and reasons for launching this issue are described on its website.

Despite their importance and precarious conservation status, knowledge of freshwater mollusks is limited. Moreover, the biology and ecology of freshwater mollusk communities are underdeveloped, understudied, and a relatively small proportion of articles and experts are concerned with this topic. This special issue aims to develop and improve our knowledge of freshwater mollusk communities from all conceivable aspects. We welcome studies and articles ranging from case studies to syntheses and reviews on every aspect related to freshwater mollusk communities, such as structure, distribution, changes, dynamics, successions, productivity, relations, invasive species, energetics (patterns of energy flow), diversity, functional traits, environmental genomics, multivariate methods, multimatricial approaches, anthropogenic pressures, responses to and effects of human impact, ecological models, bioindication, monitoring methods, decision-supporting systems, long-term studies, management, conservation, and others.

We invite all interested to contribute to this special issue, disseminate the information, and encourage others to submit articles. There will be possibly ten articles published free of charge, selected based on both quality of accepted papers and the order of submissions (among the best quality articles, the editors' recommendations for the waivers will be on a first-come, first-served basis). The submission deadline is 1 November 2023, but please send contributions as soon as possible so we can assess and recommend the accepted articles for exemption from the Article Publication Charge (APC). If desired, also send a brief note informing us about your intention to write a contribution and its provisional title.

We stress that this special issue aims to assist and encourage progress in malacology, freshwater science, community biology and ecology, and others (please see the posted information and keywords).

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CONSERVATION STATUS OF FRESHWATER MUSSELS IN AUSTRALIA – NEW SPECIES, NEW LISTINGS AND WORK TO COME

By Michael W. Klunzinger

In 2014, the late Keith F. Walker led a review paper in association with the inaugural International Meeting on Biology and Conservation of Freshwater Bivalves with contributions from Dr. Hugh A. Jones and me. In our review, we highlighted issues hindering conservation assessment of freshwater mussels in Australia. A big issue is the lack of progress towards a modern taxonomic framework that tests morphology and molecular data as well as formalising undescribed species. We also highlighted data deficiency as a challenge for progressing conservation status assessments and reviewed known and potential threats from the Australian perspective (Walker *et al*., 2014).

Since our review, there has been some progress, albeit limited, in updating conservation status of declining species, recognising previously undescribed species and research investigating declines. In 2019-2020, a research team, led by Professor Fran Sheldon (Australian Rivers Institute, Griffith University) and Dr. Nicole McCasker (Charles Sturt University) conducted surveys to assess the impacts of severe drought on freshwater mussels of the Darling River, which showed that populations of *Alathyria jacksoni* have experienced 80-100 % mortality or were completely absent

Fig. 1. Mass mortality of *Alathyria jacksoni* in the Darling River during severe drought. (Photos: Nicole McCasker)

from many of the sites surveyed (Sheldon *et al*., 2020, Fig. 1). Around the same time, Associate Professor Alan J. Lymbery and Dr. Stephen J. Beatty (Murdoch University) along with current PhD student Elka Blackman (NSW Department of Primary Industries, Fisheries), led a team to assess desiccation tolerance in *A. jacksoni* and *Velesunio ambiguus*, which both occur in the Murray Darling Basin (Wright *et al*., 2022). Results indicate that *A. jacksoni* is less tolerant of drying than *V. ambiguus*, but at high temperatures (>35 °C) typical of summer drought conditions both species die within a few days. These new data clearly indicate that *A. jacksoni* is in severe decline and will be used to update the conservation status of the species. More recently (September 2022), two additional species were listed under the Victorian Flora and Fauna Guarantee Act 1988. *Hyridella depressa*, a species found in coastal catchments of southeastern Australia, was listed as endangered in Victoria. *Hyridella narracanensis*, a species patchily distributed in southeastern South Australia, southern Victoria and Tasmania, was also listed as endangered in Victoria. The only other two species currently listed under Australian legislation are *Hyridella glenelgensis*, which is critically endangered in Victoria, and *Westralunio carteri*, which is vulnerable in Western Australia. These species are also listed nationally under the Environment Protection and Biodiversity Conservation Act 1999. Several other Australian hyriids were assessed in 2014 for IUCN Red Listing in conjunction with Walker *et al*. (2014), and *Alathyria condola*, found in the Murray Darling Basin, was recently nominated as data deficient by me, Drs Hugh Jones (NSW) and Nicole McCasker and PhD student Michelle Hobbs (Australian Rivers Institute, Griffith University) (Table 1). The species of Australian hyriids that have been assessed for conservation status are depicted in Fig. 2.

In relation to taxonomy, phylogenetic studies on the threatened *Westralunio carteri* revealed three evolutionarily significant units (ESUs) from southwestern Australia (Klunzinger *et al*., 2021; Benson *et al*., 2022). Most recently, I collaborated with co-authors to combine the molecular data with morphology to formally describe one new species and two new subspecies: *Westralunio inbisi inbisi* (formerly "*W. carteri*" II) from the south coast of

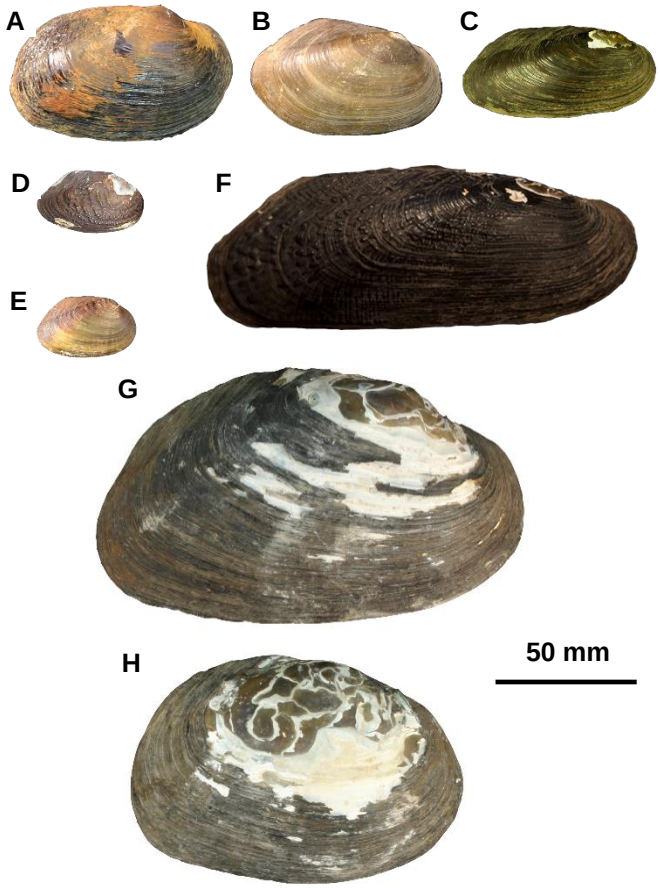

Fig. 2. Australian freshwater mussels (Hyriidae) that have been assessed for conservation status. A - *Westralunio carteri*, B - *Velesunio moretonicus*, C - *Hyridella depressa*, D - *Hyridella glenelgensis*, E - *Hyridella narracanensis*, F - *Cucumerunio novaehollandiae*, G - *Alathyria jacksoni*, H - *Alathyria condola*.

southwestern Australia and *Westralunio inbisi meridiemus* (formerly "*W. carteri*" III) from the southwest corner of southwestern Australia. As a result of describing these new taxa, the range of *W. carteri* is effectively reduced and the new taxa will require fresh conservation status assessments. Despite recent progress, there is still a lot of work to do. Table 1 clearly illustrates that most Australian freshwater mussel species have still not been assessed for conservation status. We know from the latest Australian State of the Environment Report that "In a rapidly changing climate, with unsustainable development and use of resources, the general outlook for our environment is deteriorating." This outlook does not bode well for Australia's freshwater mussels, but to effectively use current legislative instruments for their protection, we must gain a better grasp on the conservation status of species and resolve taxonomic uncertainties in order to have names of species to list.

I am working with a number of collaborators across Australia and, as a member of the IUCN Mollusc Specialist Group, to collect the data we need to inform taxonomy, threatening processes, species biology and ecology. Over the next few years, we will publish data that will answer long-standing questions of taxonomy and phylogeography and provide fresh assessments to update species conservation statuses. What we

Table 1. Conservation status of Australian freshwater mussels (Hyriidae). Taxonomy follows Ponder *et al*. (2022) and Klunzinger *et al*. (2022). CR – Critically Endangered, DD – Data Deficient, EN – Endangered, LC – Least Concern, na – Not Assessed, NT – Near Threatened, VU – Vulnerable. Sources: DBCA (2022), DCCEEW (2022) and DELWP (2022).

Scientific Name	IUCN Red List	State Listing	EPBC
Velsunioioninae			
Alathyria condola	DD (pending)	na	na
Alathyria jacksoni	DD	na	na
Alathyria pertexta pertexta	na	na	na
Alathyria pertexta wardi	na	na	na
Alathyia profuga	na	na	na
Lortiella froggatti	na	na	na
Lortiella opertanea	na	na	na
Lortiella rugata	na	na	na
Velesunio ambiguus	na	na	na
Velesunio angasi	na	na	na
Velesunio moretonicus	NT	na	na
Velesunio wilsonii	na	na	na
Westralunio carteri	VU	VU[1]	VU[3]
Westralunio inbisi inbisi	na	na	na
Westralunio inbisi merdiemus	na	na	na
Hyriinae: Hyridellini			
Cucumerunio novaehollandiae	LC	na	na
Hyridella australis	na	na	na
Hyridella depressa	na	EN[2]	na
Hyridella drapeta	na	na	na
Hyridella glenelgensis	CR	CR[2]	CR[3]
Hyridella narracanensis	NT	EN[2]	na

Legislation for listed species:[1] *Biodiversity Conservation Act 2016* (Western Australia), [2] *Flora and Fauna Guarantee Act 1988* (Victoria), [3] EPBC – *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia).

need to achieve this is 1) funding to conduct field surveys and 2) collaboration from stakeholders to disseminate information and fill knowledge gaps.

Benson, J., Stewart, B.A., Close, P.G. & Lymbery, A.J. 2022. Evidence for multiple refugia and hotspots of genetic diversity for *Westralunio carteri*, a threatened freshwater mussel in south-western Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* 32: 559-575.

DBCA (Department of Biodiversity, Conservation and Attractions), Parks and Wildlife Service. 2022. *Threatened and Priority Fauna List*. Government of Western Australia.

DCCEEW (Department of Climate Change, Energy, the Environment and Water). 2022. *EPBC Act List of Threatened Fauna*. Australian Government.

DELWP (Department of Environment, Land, Water and Planning). 2022. *Flora and Fauna Guarantee Act 1988 – Threatened List, September 2022*. Victoria State Government.

Klunzinger, M.W., Lopes-Lima, M., Gomes-dos-Santos, A., Foufe, E., Lymbery, A.J. & Kirkendale, L. 2021. Phylogeographic study of the West Australian freshwater mussel, *Westralunio carteri*, uncovers evolutionarily significant units that raise new conservation concerns. *Hydrobiologia* 848: 2951-2964.

Klunzinger, M.W., Whisson, C., Zieritz, A., Benson, J.A., Stewart, B.A. & Kirkendale, L. 2022. Integrated taxonomy reveals new threatened freshwater mussels (Bilvalvia: Hyriidae: *Westralunio*) from southwestern Australia. *Scientific Reports* 12: 20385.

Ponder, W.F., Hallan, A., Shea, M.E., Clark, S.A., Richards, K., Klunzinger, M.W. & Kessner, V. 2022. *Australian Freshwater Molluscs: the Snails and Bivalves of Australian Inland Waters*.

Sheldon, F., McCasker, N., Hobbs, M., Humphries, P., Jones, H., Klunzinger, M. & Kennard, M. 2020. *Habitat and Fow Requirements of Freshwater Mussels in the Northern Murray-Darling Basin*. Report to the Commonwealth Environmental Water Office. Australian Rivers Institute, Griffith University and Institute of Land, Water and Society, Charles Sturt University. 59 p.

Walker, K.F., Jones, H.A. & Klunzinger, M.W. 2014. Bivalves in a bottleneck: taxonomy, phylogeography and conservation of freshwater mussels (Bivalvia: Unionoida) in Australasia. *Hydrobiologia* 735: 61-79.

Wright, D., Thiem, J., Blackman, E., Beatty, S., Lymbery, A. & Davis, S. 2022. *Desiccation Tolerance of River and Floodplain Mussels in the Murray-Darling Basin*. Technical Report to the Commonwealth Environmental Water Office. NSW Government Department of Primary Industries. 46 p.

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ENVIRONMENT AND MORPHOLOGY OF A POPULATION OF THE ENDEMIC TERRESTRIAL SNAIL *SYNAPTERPES* AFF. *HANLEYI* (PFEIFFER, 1846) FROM A PROTECTED AREA OF ATLANTIC FOREST IN THE STATE OF RIO DE JANEIRO, BRASIL

By Flavia C. dos Santos Rangel, Silvana C. Thiengo, Jucicleide Ramos-de-Souza, Guilherme M. da Silva, Alexandre B. Pinheiro da Silva, Carolina R. Marchi, Anna C. de Almeida Salles & Suzete R. Gomes

The genus *Synapterpes* Pilsbry, 1896 has been reported from Brasil, Colombia and Ecuador (Zilch, 1959; Salgado & Coelho, 1999). It was originally proposed by Pilsbry (1896) for *S. hanleyi* (Pfeiffer, 1846) and *S. coronatus* (Pfeiffer, 1846). Both species were described from Brasil, without specification of locality, but 1846 was also the year when Ida Pfeiffer (no relation) undertook collections in Rio de Janeiro State. According to Pilsbry (1896), *Synapterpes* species share the following characteristics: oblong-turrited, thin, glossy, more or less vitreous shell with crenulated sutures; apex of the shell with a comma-shaped apical dimple; shell aperture long-ovate with thin, sharp outer lip and a simple columella, not truncated below and with edge narrowly reflexed.

Pilsbry (1896) mentioned that the shell characters placed *Synapterpes* in the Achatinidae near *Neobeliscus*. But he argued that *Neobeliscus* has a bulbous, more or less costulate apex, without an apical dimple, distinguishing it from *Synapterpes*. He also mentioned that, if the identifications of Binney (1874) were correct, the jaw and dentition of *Synapterpes* are like those of species of *Strophocheilus*, which at the time was placed in Helicidae. More recently, Simone (2018), after describing a new species of subulinid from Brasil, compared it with *S. hanleyi*, arguing that some features such as the shell, lung, penis, gonad and jaw, and the absence of brood embryos or young specimens in the uterus, demonstrated that this species could be a bulimulid.

Synapterpes hanleyi is the type species of the genus. It was redescribed by Salgado & Coelho (1999) who provided descriptions of living specimens, shells and anatomy. They based their study on four specimens from the State of Rio de Janeiro, collected in the Tijuca Forest (Rio de Janeiro) and Serra dos Órgãos Forest (Teresópolis), both characterised by the Atlantic Forest biome. The material was from the Museu Nacional Malacology Collection, as well as a shell from the Senckenberg Museum (without collector and other data, SMF 157248). There has been no subsequent study of the species and it is currently on the list of endangered species of Brasil, classified as Data Deficient (DD). This means that there is no adequate information to assess its distribution and/or population situation and that it may be endangered (ICMBio, 2018).

The Atlantic Forest is known for its biodiversity hotspots and, in Brasil, only 11.6 % of the natural vegetation cover remains, in an intensely fragmented state (Scarano & Ceotto, 2015). Despite their known ecological and biological importance, non-marine gastropods of this highly threatened biome are still poorly known in Brasil. They are still scarcely collected in preserved areas, where, in general, they are not abundant and commonly have restricted distributions.

Here we provide information about the environment and morphology, with images, of living specimens and the shell of *Synapterpes* aff. *hanleyi*, based on material from the Fiocruz Atlantic Forest Biological Station (EFMA), a protected area in Rio de Janeiro. This study is part of a wider ecological study of terrestrial molluscs in this park and it was developed based on material collected by the authors in 2021 and 2022, at EFMA. EFMA is part of the Fiocruz Mata Atlântica Campus (CFMA), in Jacarepaguá, Rio de Janeiro, RJ, which partially overlaps the Pedra Branca State Park - PEPB (Gentile *et al*., 2018).

Collections were made in two areas, a forest area close to the Fincão Community, identified as a transition area in Fig. 1, and a recovered forest area (Fig. 1C). Collections were obtained via active search with a study area subdivided into plots adapted from Silva *et al*. (2020), with a sampling effort of three collectors for 30 minutes. A pilot collection was undertaken to define the plots, with two fixed replicates measuring 10 m x 20 m in each area.

Data on physical-chemical parameters of the soil were obtained, based on analysis of a collection of 200 g of soil. Relative humidity, precipitation and temperature were obtained from the National Institute of Meteorology (INMET), which records daily means for these variables. Based on these values we calculated the mean for the collection month in each season.

The specimens collected were taken to the Laboratory of Malacology of the Instituto Oswaldo Cruz (LABMAL), where they were photographed, fixed, identified and deposited in the Mollusc Collection of the Instituto Oswaldo Cruz (CMIOC 12979, 12986, 12988, 12992, 13220, 13229, 13250).
Three shells and six live specimens of *Synapterpes* aff. *hanleyi* were collected in three seasons: winter, spring and summer. All were collected in leaf litter on the woodland floor. In

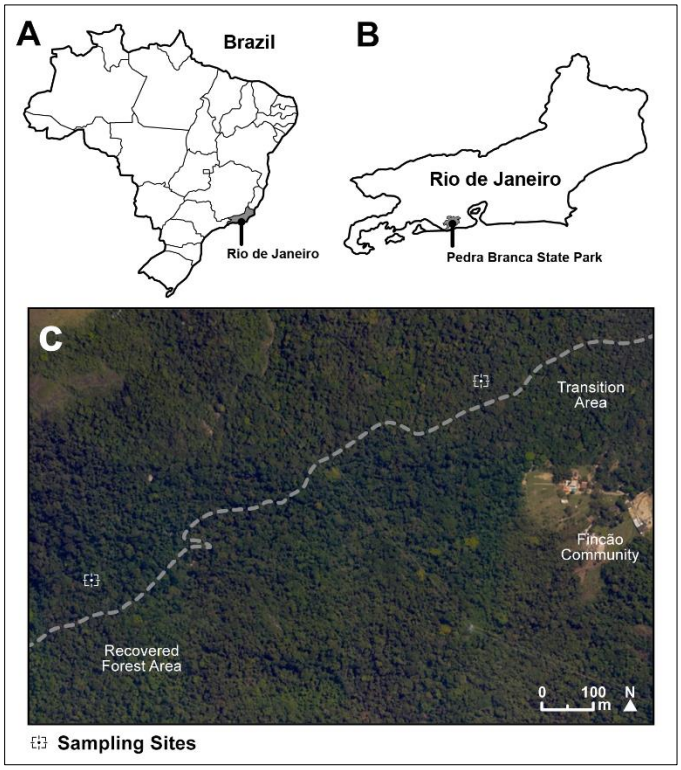

Fig. 1. A - Brasil, showing the State of Rio de Janeiro; B - The State of Rio de Janeiro showing the area of the Fiocruz Mata Atlântica Biological Station - EFMA; C - Google Earth image showing the sites where the specimens were collected (transition and recovered forest areas). The dashed line represents the main trail. The Fincão community that is located close to EFMA is also indicated.

winter (August 2021) we found an adult and a young specimen close to each other (Fig. 2).

We found most specimens of *Synapterpes* aff. *hanleyi* in the winter: three live specimens and two shells. Calcium concentration in winter was higher (36.4 mg/L) than in the other seasons; the pH did not differ among seasons and the overall average was pH 5. In winter mean precipitation was 1.8 mm, mean temperature was 20.5 °C and mean relative

Fig. 2. A – Collection site in the transition area where an adult specimen of *Synapterpes* aff. *hanleyi* was found near a young specimen in August 2021; B – The adult specimen just after being found.

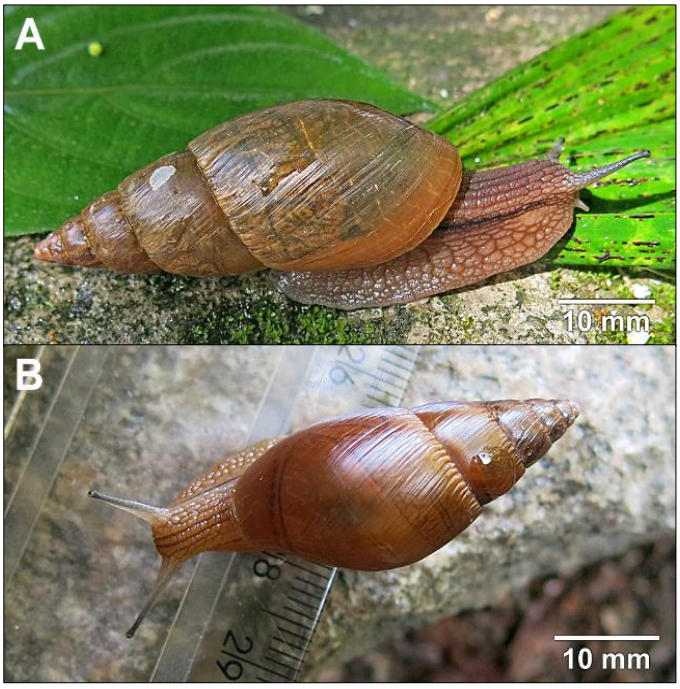

Fig. 3. Live specimens *Synapterpes* aff. *hanleyi*. A – adult (CMIOC 13250); B – young specimen (CMIOC 13220).

humidity of the air was 75.5 %. The highest mean temperature was in summer (25.07 °C) and the lowest in spring (18.5 °C).

The largest specimen collected was 49.8 mm long and 19.3 mm wide (CMIOC 13250); the smallest was 10.9 mm long and 5.9 mm wide (CMIOC 13229). Specimens were found in both the transition and recovered forest areas (Fig. 1). According to Gentile *et al*. (2018) the preserved forest area supports a canopy ranging from 10 to 40 m and an irregular slope ranging from flat to steep. Disturbed forest areas are in the process of regeneration, with vegetation in different stages of ecological succession.

The body of *Synapterpes* aff. *hanleyi* is light brown. Anteriorly, there are two horizontal dark brown stripes on the sides of the body, reaching the head as far as near the upper tentacle base (Fig. 3A). The shell is uniformly reddish-brown, thin and peculiarly bright (Fig. 4). It is very fragile and the frontal margin of the peristome is easily damaged.

We noticed that protoconch sculpture in *Synapterpes* aff. *hanleyi* is rarely preserved in adult specimens, in which it seems to be smooth (Fig. 5 A, D). After comparison of the adults and young specimens, we could verify that the protoconch exhibits the crenulated suture and thin spiral lines, which can be seem more clearly in young specimens. Based on the shells, our specimens are very similar to *Synapterpes hanleyi*, based on Salgado & Coelho (1999) and Simone (2006). However, they seen to be slightly narrower and have a spire with less demarcated sutures than *S. hanleyi*. Salgado & Coelho (1999) mentioned that the shell of *S. hanleyi* is 48 mm high and 20 mm wide and that its protoconch is smooth.

In order better to understand possible variation and discuss the classification of this species we intend to study specimens of *Synapterpes* from Tijuca Forest, Serra dos Órgãos and other populations from Rio de Janeiro available in the collections of

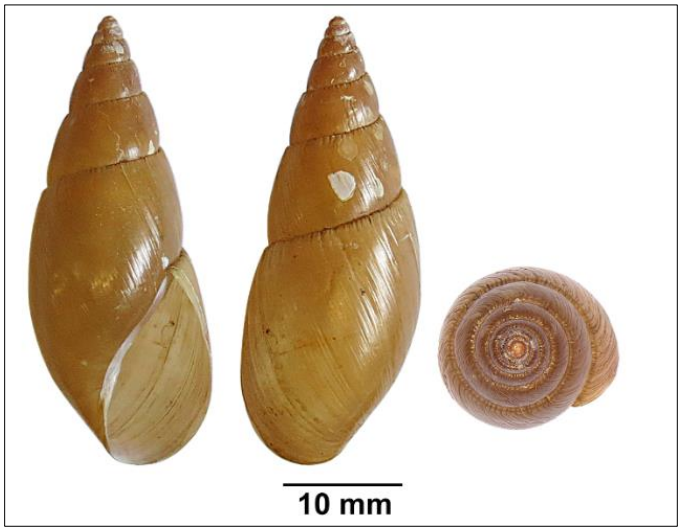

Fig. 4. Shell of *Synapterpes* aff. *hanleyi* in apertural, abapertural and apical views (CMIOC 13250).

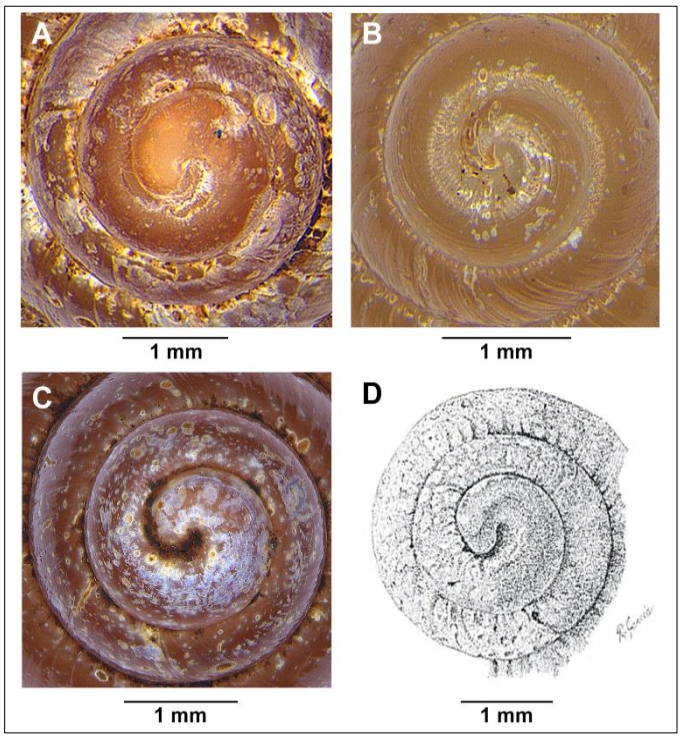

Fig. 5. Protoconchs of three specimens of *Synapterpes* aff. *hanleyi*. A – protoconch from adult (CMIOC 13250), B – preserved protoconch from a young specimen (CMIOC 12986), C – eroded protoconch from an adult specimen (CMIOC 13220), D – protoconch of *S. hanleyi* from Salgado *et al*. (1999).

the Museu Nacional (MNRJ) and in the collection of the Laboratory of Malacologia of the Universidade Federal do Rio de Janeiro (UFRJ), investigating shell, anatomy and molecular data from different populations, in comparison with the specimens from EFMA.

Our preliminary results demonstrate the importance of faunal surveys focused on the diversity of native molluscs, as they provide information on endemic and rare species. This knowledge is essential for the implementation of actions aimed at the protection and conservation of these species,

which are often threatened because they inhabit fragments of the Atlantic Forest, a biome seriously threatened by urbanisation and the consequent degradation in Brasil.

We are indebted to Dr. Ricardo Moratelli, Jailton Paes, Samuel Pereira and staff for facilitating access to study sites and for support during the field trips. To the graphic designer Eduardo Cinilha for the photos and map. To Nilson Azevedo Pires and staff (SMS-RJ) for their fundamental collaboration with the fieldwork. And to Dr. José Augusto Albuquerque dos Santos for his contribution in carrying out the soil analyses.

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TERRESTRIAL MOLLUSC CONSERVATION IN SOUTH AFRICA

By Mary Cole

I became a member of the *IUCN Mollusc Specialist Group* in 2021. Having worked on South African land snails since about 2000, I realised the need for updating the status of the few South African species on the Red List and for assessing many more species. The Threatened Species Programme of the South African National Biodiversity Institute (SANBI) is headed by Dr. Domitilla Raimondo, who is on the Steering Committee of the IUCN Species Survival Commission. She and Dewidine van der Colff, the SANBI Red Listing officer, have been supportive, since the vast majority of South African invertebrates have not yet been assessed, as is the case world-wide. Global assessments were done for 14 endemic land snail species by Dai Herbert in the early 2000s; five were Critically Endangered, four Endangered, four Vulnerable and one Least Concern (Table 1, Fig. 1). These assessments need to be updated applying the latest IUCN Red List Categories and Criteria and some of the statuses may change. I completed the Red List training course on how to conduct assessments and it was decided to initially target the above 14 species, four others that had been assessed previously and the 19 South African species of Cyclophoridae (all endemic). Many other species occupy the same ranges and are subject to the same threats, so they will follow. I had discussions with Mary Seddon at the World Congress of Malacology in August 2022 and she set up a South African working set on the Species Information Service for van der Colff and me to enter data. So far only one species has been completed and is in draft, namely *Gulella aprosdoketa* (Fig. 2). It is on the Red List as Endangered, but now meets the criteria for Vulnerable.

Fig. 1. *Natalina beyrichi* was listed as Critically Endangered on the Red List in 2000.

Table 1. South African land snails on the IUCN Red List of Threatened Species.

Species	Threat category
Natalina beyrichi	CR
Natalina wesseliana	VU
Chlamydephorus dimidius	VU
Chlamydephorus burnupi	VU
Chlamydephorus purcelli	EN
Gulella aprosdoketa	EN
Gulella claustralis	EN
Gulella puzeyi	CR
Gulella salpinx	CR
Sheldonia puzeyi	VU
Trachycystis clifdeni	CR
Trachycystis haygarthi	EN
Trachycystis placenta	CR
Gulella plantii	LC

Note: *Trachycystis clifdeni* placed in *Chilocystis* on MolluscaBase

In the following I provide background information on terrestrial mollusc conservation in South Africa.

Fig. 2. *Gulella aprosdoketa* Connolly 1939 was listed as Endangered on the Red List in 2004, but now meets the criteria for Vulnerable, according the latest IUCN Red List Categories and Criteria.

A recent checklist of the terrestrial molluscs of South Africa produced by the SANBI Checklist Co-ordinator, Thembile Khoza, and me, has 558 species, 444 (80 %) being endemic. The checklist should be available via the SANBI website, but currently has some

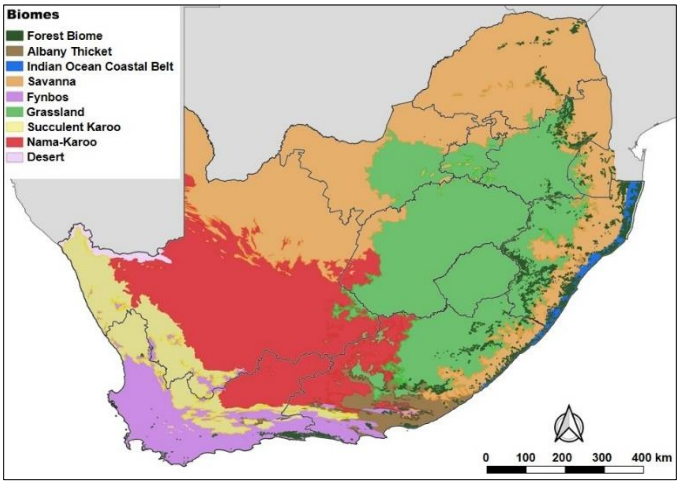

Fig. 3. Vegetation biomes of South Africa.

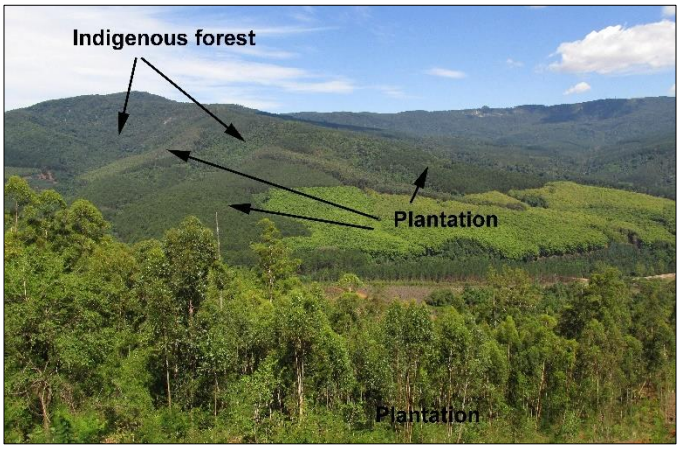

Fig. 4. Example of clearing of indigenous forest for commercial forestry plantations.

teething problems. Narrow-range endemism is typical. Although the majority of species belong to families of tropical origin, the species are endemic to the country; for example there are 115 species of Charopidae with 92 % endemism and 148 streptaxids with 87 % endemism.

South Africa is quite arid, with a mean annual rainfall of ~460 mm and much of the vegetation is arid-adapted (Mucina & Rutherford, 2006). Snail diversity is greatest in the mesic biomes, namely Forest, Indian Ocean Coastal Belt (IOCB) and Albany Thicket, which together form a relatively small part of the land surface area (Fig. 3). Rain forest is patchy naturally and large blocks have been cleared for commercial forestry in most areas (Fig. 4). The IOCB is a continuation of the coastal vegetation of tropical east Africa and occurs on dunes and low-lying areas near the coast and is rich in snails. Fynbos has high levels of endemism in all taxa including snails.

Few if any land snail species are deliberately targeted for sale to collectors, none for food, and there are a few isolated incidences of sale in medicine markets. Threats to snails are common to all biodiversity in South Africa; the major ones are land transformation for agriculture or housing, and habitat degradation due to over-population, poverty and unsustainable use of natural resources, leading to indirect effects on molluscs such as trampling and disturbance. There is lack of compliance at all levels of society and enforcement agencies are under-staffed and under-budgeted, with a lack of will among some staff. On the positive side, despite these challenges, there are many very hard-working and passionate individuals doing their best to uphold conservation. Although there are no published studies on snails, climate change could be a major threat since the forest biome is already highly fragmented.

South Africa has a history of conservation going back to 1900 and a well-developed protected area network (see Protected Areas Register Interactive Map of the Department of Forestry, Fisheries and the Environment) with plans to expand it (SA DEA, 2016). The most effective way to ensure the conservation of our snails is by conservation of their habitats. Of the total land surface area, 9.2 % is protected by law and managed specifically for biodiversity conservation compared to 5.4 % in 1980 (Statistics South Africa, 2021). In practice, management of provincial, local and forest nature reserves is often very poor and some exist on paper only. Biodiversity stewardship programmes in which private or communal landowners voluntarily enter into legal agreements or other formal partnerships with conservation authorities have led to a considerable increase in the conservation estate since about 2015. In addition, certain commercial activities benefit mollusc conservation, e.g. ranching and game-farming for hunting because the habitat is more or less preserved.

Table 2. Relevant legislation for biodiversity conservation, management and sustainable use in South Africa.

National Environmental Management Act (Act 107 of 1998)
National Environmental Management Act: Biodiversity Act (Act 10 of 2004)
National Environmental Management Act: Protected Areas Act (Act 57 of 2003)
National Forest Act (Act 84 of 1998)
National Environmental Management Act: Environmental Impact Assessment Regulations (December 2014)
Terrestrial Plant and Animal Species protocols (Government Notice number 1150 October 2020)

South Africa has an excellent national policy and legislative framework for biodiversity conservation, management and sustainable use (Table 2) and is a signatory to the Convention on Biological Diversity, the Nagoya Protocol and the Convention on International Trade in Endangered Species. The South African National Biodiversity Institute was created in 2004 as a product of the National Environmental Management: Biodiversity Act (Act 10 of 2004). One of its mandates is to monitor and report on the state of biodiversity in the country and to provide science-based advice to the Department of Environmental Affairs (DEA) and other organs of the state. This is dependent on the data and information available, and there is reasonable data on species diversity and distribution for many molluscs. Work on this is ongoing, and mollusc databases are constantly being improved, although there are only two people employed to work on terrestrial snails at South African institutions. There are national initiatives by SANBI to co-ordinate and publish biodiversity data. The East London Museum's malacology database was published on GBIF in 2018, so this needs to be updated, particularly with regard to terrestrial molluscs. Work is also ongoing on revisions and species descriptions of South

Fig. 5. *Trachycystis clifdeni* (placed in *Chilocystis* by MolluscaBase eds., 2023) was listed as Critically Endangered in 2004, but occurs in a protected area so is not at immediate risk of extinction. It qualifies as Critically Rare in the South African system of Species of Conservation Concern. (Photo: Dai Herbert)

African taxa; in the past 20 years four revisions (Cole, 2019; Herbert, 2020; Herbert & Moussalli, 2010; 2016) and 67 species descriptions have been published.

The term Species of Conservation Concern (SCC) is used in legislation for species that have high conservation importance in terms of preserving South Africa's biodiversity but do not meet the criteria for threatened status according to the IUCN Red List because of its emphasis on assessing the risk of extinction (Fig. 5). SCC include threatened species in the IUCN categories, but also those classified as Near Threatened (NT), and in the South African categories of Critically Rare, Rare, Declining and Data Deficient (insufficient information to make an assessment, but the species is well defined) (SANBI, 2010). A species is Critically Rare when it is known to occur at a single site, but is not exposed to any direct or plausible potential threat and does not otherwise qualify for a category of threat according to one of the five IUCN criteria. A species is Rare when it meets at least one of four South African criteria for rarity, but is not exposed to any direct or plausible potential threat. The four criteria hinge on restricted range, habitat specialisation, low densities of individuals, or small global population.

A fairly new initiative that has positive implications for mollusc conservation is the Species Environmental Impact Assessment (EIA) Guidelines (SANBI, 2020) in support of the Terrestrial Plant and Animal Species protocols, which were gazetted on 30 October 2020 (Government Notice number 1150).

Invertebrates that are currently included on South Africa's list of SCC or the IUCN Red Lists should be searched for as part of the EIA process. Appropriate, taxon-specific survey methods are also stipulated and I gave input on land snails. An online screening tool has been developed, which contains spatial data for invertebrate species and habitats of conservation concern, particularly forests. Thus if a development footprint loaded into the screening tool intersects with places where invertebrates of conservation concern or forests occur then it requires that an invertebrate specialist undertakes fieldwork to look for these species in those taxonomic groups for which expertise is available to assist and molluscs have been specifically included. The screening tool currently includes 333 terrestrial invertebrate SCC, but there is an urgent need to assess more species according to the IUCN Red List and the South African system of SCC so that the screening tool can be updated to give a more accurate reflection of the numbers of snails of conservation importance that should not be overlooked. As with all legislation, there may be problems with compliance, but this is an important step.

Another new development was the recent request to provide a list of land snails to add to the Eastern Cape province's provincial list of protected species. In addition to national lists, the nine provinces have their own lists. These lists contain well-known taxa such as cycads and large mammals and very few invertebrates. It is the first time snails have been considered.

In summary, South Africa has a good protected area network (and plans to expand this) in which molluscs are reasonably safe. We have well thought-out legislation, considering there is a balancing act between biodiversity targets and needs of an expanding population. An important step is that invertebrates including molluscs are being specifically catered for in legislation.

There are opportunities to include molluscs in national conservation initiatives. There is an urgent need to assess molluscs and list them on the IUCN Red List, South Africa's list of Species of Conservation Concern and provincial conservation plans. It is also important to keep on improving knowledge of taxonomy with revisions and species descriptions, and to update mollusc databases regularly.

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FRESHWATER SNAILS IN PUBLIC PARKS OF RIO DE JANEIRO CITY, BRASIL

By Lucas Lima, Elizângela F. Silva, Aline C. Mattos, Alexandre B. Silva, Suzete R. Gomes, Marta C. Pinto, Arielly P. Sousa & Silvana C. Thiengo

The delimitation of conservation units and municipal parks certainly constitutes an important action to preserve and conserve environments that have not yet been altered and/or to return degraded areas to green areas (Brito, 2000; Dalapicolla *et al*., 2021). The existence of public parks in the city of Rio de Janeiro, such as Bosque da Barra, Jardim Botânico, Quinta da Boa Vista, Parque Recanto do Trovador, Parque da Prainha and Parque Henrique Lage, has contributed to the formation of a total green surface of about 2,444 km² in the Metropolitan Region. All are open to visitors, and some are located close to protected areas, as in the case of the Jardim Botânico and Quinta da Boa Vista near the Tijuca National Park and Parque da Prainha, which is part of Pedra Branca State Park (PEPB).

Surveys of freshwater gastropods in the state of Rio de Janeiro have been undertaken throughout the 2000s by Thiengo *et al.* (2001, 2002a, b, 2004a, b, 2006). However, there are few studies of freshwater gastropods in the public parks of the State of Rio de Janeiro and in Rio de Janeiro city itself. Some few examples are the studies of Ximenes *et al.* (2022) in the Jardim Botânico and de Oliveira *et al.* (2020) in Quinta da Boa Vista Park. There have also been studies in protected areas, for example those of Rangel *et al.* (2021) and Santos & Mello (2016) in the PEPB. Considering the importance of freshwater molluscs and the lack of studies in these public parks, since 2018 we have carried out surveys of freshwater gastropods in parks in the city of Rio de Janeiro to evaluate the diversity of native species in these areas as well as the presence of introduced species that may be impacting native species.

Sampling took place between June 2021 and March 2022 in two federal public parks (Jardim Botânico, and Parque Henrique Lage) and four municipal public parks (Bosque da Barra, Parque Natural Municipal da Prainha, Recanto do Trovador Park and Quinta da Boa Vista). We chose 19 sites in these parks, considering the different types of water bodies in each of them. These sites were sampled in each season of the year, with three collectors collecting for 10 minutes, for a sampling effort

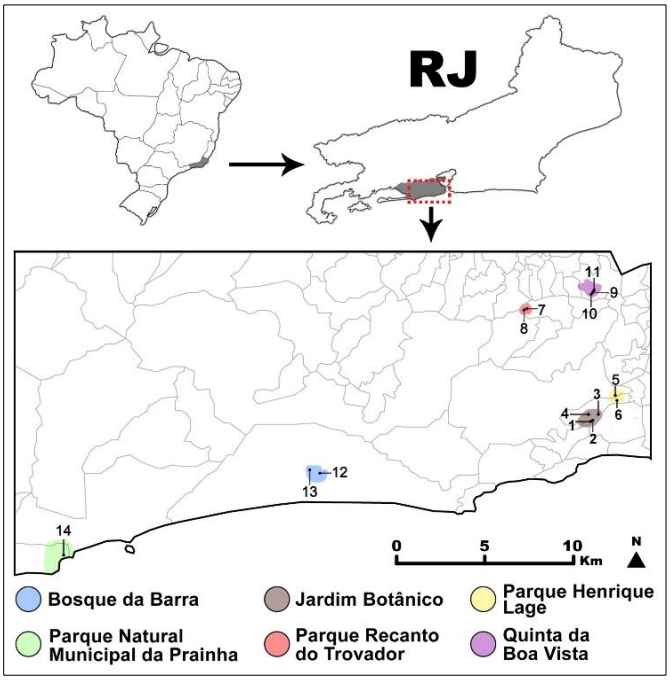

Fig. 1. Top – Brasil, with the location of Rio de Janeiro State and the location of Rio de Janeiro city within the State. Below – location of each park in Rio de Janeiro city and the species recorded at the numbered sites in each park: *Biomphalaria tenagophila* – 1, 2, 9, 12, 13; *Melanoides tuberculata* – 7, 8, 10, 11, 14; *Physella acuta* – 1, 2, 3, 4, 8, 11; *Pseudosuccinea columella* – 1, 2, 3, 4, 5, 6, 8, 10, 11, 13. We did not find molluscs in the other five sites.

of 30 minutes per site (Fig. 1), according to a modified method of Olivier & Schneiderman (1956).

In total, 1,525 snails were collected, of four species in four families (Lymnaeidae, Physidae, Planorbidae, Thiaridae): 815 specimens of *Melanoides tuberculata* (Müller, 1774), from Recanto do Trovador Park (516), Prainha Municipal Natural Park (291) and Quinta da Boa Vista (8); 223 specimens of *Physella acuta* Draparnaud, 1805 from Jardim Botânico (195), Quinta da Boa Vista (25) and Parque Recanto do Trovador (3); 362 specimens of *Biomphalaria tenagophila* (d'Orbigny, 1835) from Jardim Botânico (208), Quinta da Boa Vista (142) and Bosque da Barra (12); 125 specimens of *Pseudosuccinea columella* (Say, 1817) from Jardim Botânico (98), Quinta da Boa Vista (9), Henrique Lage Park (8), Recanto do Trovador Park (8) and Bosque da Barra (2) (Fig. 2).

Biomphalaria tenagophila (Fig. 3) is considered native to Brasil. Its current distribution in Brasil ranges from the south of the state of Bahia to the extreme south of the country.

Pseudosuccinea columella (Fig. 3) was initially described from the USA, but it is now found throughout the Americas and considered an invasive species in Europe and Africa (Ngcamphalala *et al*., 2022).

Melanoides tuberculata (Fig. 3), of Afro-Asian origin, was introduced to Brasil in the 1960s (Vaz *et al*., 1986) and is currently recorded from 351 municipalities of 20 Brasilian states, with the southeast region having the second highest number of occurrences (Coelho *et al*., 2018).

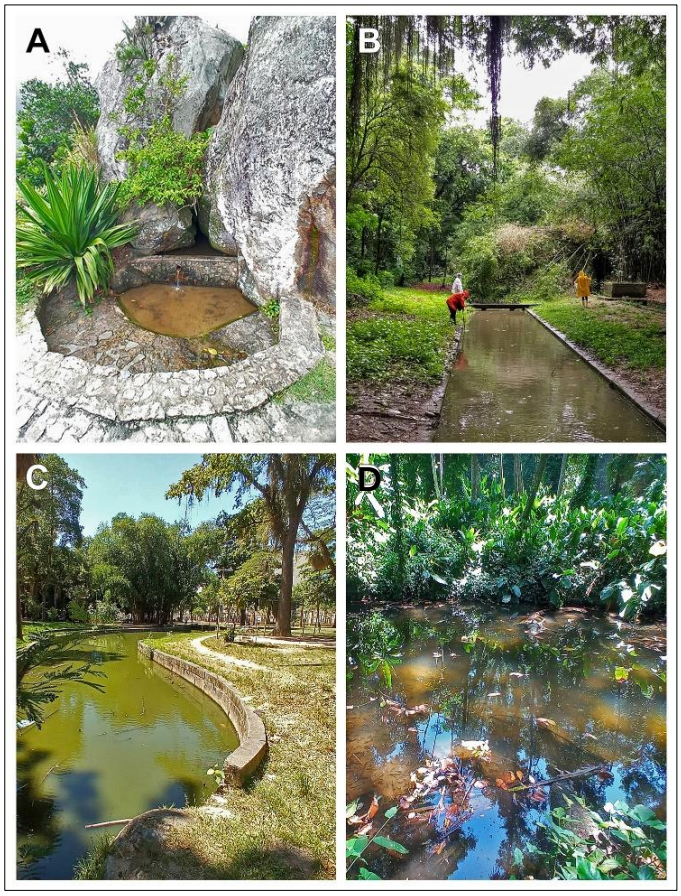

Fig. 2. Examples of sites in the parks where we collected molluscs. A – Prainha Natural Municipal Park; B – Botanical Garden ditch in the Quinta da Boa Vista; C – Larger lake in Recanto do Trovador Park; D – Lake in the Henrique Lage Park.

Physella acuta (Fig. 3) is considered to have originated in North America but is now a cosmopolitan species, as it has been introduced to many areas around the world. Possibly, it was introduced to Europe and from there it spread to Africa, Asia and Australia (Burch, 1982; Oscoz *et al*., 2010). In Rio de Janeiro, it has already been recorded in 57 municipalities (Thiengo *et al*., 2001, 2002a, 2002b, 2004a, 2004b, 2006).

Thiengo *et al*. (2001) carried out a survey of the freshwater molluscs of the Metropolitan mesoregion of the State of Rio de Janeiro and reported the following species: *Heleobia davisi* Silva & Thomé, 1985, *M. tuberculata*, *Antillorbis nordestensis* (Lucena, 1954), *Biomphalaria glabrata* (Say, 1818), *Biomphalaria straminea* (Dunker, 1848), *B. tenagophila*, *Drepanotrema anatinum* (d'Orbigny, 1835), *Drepanotrema cimex* (Moricand, 1838), *Drepanotrema lucidum* (Pfeiffer, 1839), *Physa cubensis* Pfeiffer, 1839 (currently *Physella acuta*), *Stenophysa marmorata* (Guilding, 1828) and *P. columella*, in addition to *Pomacea* sp.

Ximenes *et al*. (2022) in a survey in the Botanical Garden, found native species of Ancylinae and *S. marmorata*, but they also found introduced species. These authors noted that the competition between native and invasive species could be disadvantageous, and that the presence of invasive species may be related to the decline of populations of native species, as in the case of *S. marmorata*, which is included in the list of

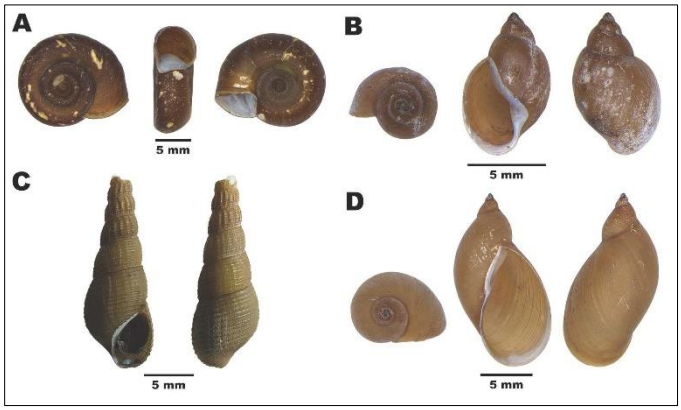

Fig. 3. A – *Biomphalaria tenagophila*; B – *Physella acuta*; C – *Melanoides tuberculata*; D – *Pseudosuccinea columella*.

Brasilian species threatened with extinction, suffering from competition with invasive *P. acuta*. *Pseudosuccinea columella* is categorised as Vulnerable (VU) in the Brasilian List of endangered species, meaning that the species is at risk of extinction in the country (ICMBio, 2018). According to Cuezzo (2020), life cycle characteristics, such as high proliferation rates, high passive dispersal capacity and high tolerance to polluted water, greatly favoured the invasive capacity of *P. acuta*. In the present study *P. acuta* was found in sympatry with *P. columella*, but no specimens of *S. marmorata* were obtained.

Our results demonstrate the value of public parks and urban green areas in maintaining populations of freshwater molluscs. They also call attention to introduced species that may be competing with native species, since some of these parks are near conservation units that have an important role in preservation of local biodiversity in Rio de Janeiro. We also note that we still have native species of Ampullariidae and Ancilynae that were collected in these parks and that still need to be identified. The distribution and abundance of these species also need to be better evaluated in these parks to understand possible impacts caused or suffered by these populations.

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REDISCOVERY OF THE GLUTINOUS SNAIL, *MYXAS GLUTINOSA* (MÜLLER, 1774) (LYMNAEIDAE) IN THE RIVER AUBE, NORTH-EASTERN FRANCE

By Jean-Michel Bichain and Julien Ryelandt

This article is an extended abstract of a paper recently published in French (Bichain & Ryelandt, 2023).

The Glutinous snail, *Myxas glutinosa* (Müller, 1774), is currently considered to be the rarest of European freshwater pulmonate gastropods while being regarded as threatened over most of its global range (Whitfield *et al*., 1998; Carlsson, 2001; Byrne *et al*., 2009; Vinarski *et al*., 2013; Willing *et al*., 2014). However, the biology and ecology of *M. glutinosa* remain poorly understood, with contradictory assertions about its tolerance to various environmental factors such as water pollution, eutrophication and calcium concentration (Vinarski *et al*., 2013). In France, the species has been reported as declining since the second half of the 20th century (Mouthon & Vimpère, 2014). Consequently, it is classified as Endangered (EN) and Critically Endangered (CR) in the Red Lists of France (UICN comité français, OFB & MNHN, 2021) and more specifically of the Grand Est region (north-eastern France) (ODONAT Grand Est, 2023), respectively.

Surveys conducted in the river Aube at the end of August 2022, found the species alive in a stretch of about 700 m near the town of Bayel (Fig. 1), 40 years after the first observation in this area (Mouthon, 1979; CEMAGREF 1987). The sampling consisted of two-hour visual searches using hand nets to locate individuals sequestered in the floating vegetation and in the submerged hydrophyte meadows. Sampling was conducted from downstream to upstream, over the entire width of the river and to a depth of approximately 1.5 m. About 50 individuals were collected and then released back into the water. Some were observed crawling on the immersed undersides of the leaves of the yellow water-lily, *Nuphar lutea*, in shallow and slow-moving parts of the river. Other

Fig. 1. River Aube between Bayel and Lignol-le-Château at a place called "les Varennes" (48°12'26.2"N, 4°46'37.2"E).

Fig. 2. A specimen of *Myxas glutinosa* (Müller, 1774) collected in *Potamogeton perfoliatus* beds (shell height about 9 mm).

individuals were collected in *Potamogeton perfoliatus* beds located in shallower or deeper parts of the river or in the backwater areas downstream of the sloping banks (Fig. 2). The species was found in low numbers in *Glyceria fluitans* grass beds located in the riffles. Without attempting to make a precise quantification, we estimate that the vast majority of collected individuals had a shell of less than 10 mm in length; only a few had shells of more than 15 mm. Some water parameters were also measured, including temperature (18.95 °C), pH (pH 8.11), conductivity (499 µS/cm), dissolved oxygen concentration (7.81 mg/L) and Redox potential (87.6 mV). Two other areas upstream and one downstream of this part of the Aube River were surveyed using the same sampling method but did not reveal the presence of *Myxas glutinosa*. Our preliminary data confirm the presence of *Myxas glutinosa* precisely at one of the previously recorded areas in north-eastern France, almost 40 years after the first observations.

In conjunction with the discoveries in the Eure River (western France) (Cucherat & Philippe, 2015) and in a swampy area in northern France (Cucherat, 2023), this find constitutes the third recently confirmed occurrence in France. However, our data do not allow us to conclude anything about the size or density of populations, nor about the age classes encountered, although it seems that the sampled individuals consisted largely of juveniles. The rediscovery of *M. glutinosa* in the Aube is nonetheless good news. There is little mystery as to how this species could go unnoticed for almost half a century. Indeed, non-marine molluscs are subject to most of the biases that can be applied to knowledge of biodiversity, particularly those concerning their geographical distribution, biology, ecology or population size for example. Regarding conservation issues, locating and protecting the *Myxas glutinosa* populations is a priority that should be integrated into regional strategies for conserving river ecosystems.

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A BIRD'S EYE VIEW OF THE AMPULLARIIDS OF MACAPÁ, AMAPÁ, BRASILIAN EASTERN AMAZON

By Liliane F. Costa, Kevin P. Barbosa, Suzete R. Gomes, Lucas Lima, Tatiane A. Barbosa, Monica A. Fernandez & Silvana C. Thiengo

Although the Amazonian biome contains a rich diversity of non-marine molluscs, there are few studies, and most of these are simply geographic records of species. The State of Amapá, in the northwest of the Amazonian region (Fig. 1) is no exception, with just a few works focused on these molluscs, among them, for example, Simone (2006), Oliveira *et al*. (2012), Coscarelli *et al*. (2018) and Barbosa *et al*. (2021).

The ampullariids are freshwater gastropods distributed throughout tropical and subtropical regions of Africa, Asia and the Americas, often in dense populations. In Brasil, ampullariids, particularly species of the genus *Pomacea*, occur in most parts of the country, although the greatest endemic diversity of species surely occurs in the Amazonian

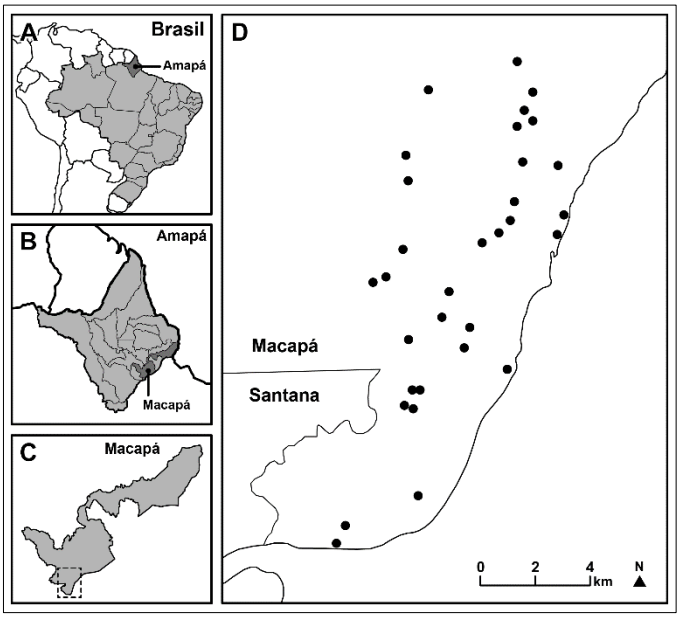

Fig. 1. A - Location of the State of Amapá in Brazil, B – the State of Amapá showing the location of Macapá, C – Macapá, showing the studied area of Amapá municipality, D – collection sites.

region (Thiengo *et al.*, 2011). In addition to their undeniable ecological importance, they are significant agricultural pests and disease vectors, which has led to an increase in research on them during recent decades (Hollingsworth & Cowie, 2006; Hayes *et al.*, 2012, 2015; Thiengo *et al*., 2017; Barbosa *et al.*, 2022). South American species of *Pomacea* such as *Pomacea maculata* Perry, 1810 and *Pomacea canaliculata* (Lamarck, 1822) were intentionally introduced to some Asian countries to be used as human food and became pests in rice fields causing serious economic damage (Lv *et al.*, 2009; Cowie *et al.*, 2017). These species are also intermediate hosts of a nematode, *Angiostrongylus cantonensis* (Chen, 1935), that causes eosinophilic meningitis (EM), a zoonosis endemic to Southeast Asia and the Pacific islands, although in recent years several cases have been reported outside the endemic area, including in the Caribbean islands and South America (Cowie *et al.*, 2022). In Brasil, at least 35 human cases of EM have been reported, and *Pomacea lineata* (Spix in Wagner, 1827) was found infected with *A. cantonensis* in a patient's peridomicile, in Pernambuco in northeast Brasil (Thiengo *et al.*, 2010; Morassutti *et al.*, 2014).

On the other hand, conservation of freshwater biodiversity is directly affected by the negative impacts of human activities, such as building of dams, pollution, invasive species impacts, and over-exploitation, which is also the case in the Amazonian region (Gatti *et al.*, 2016; Azevedo-Santos *et al.*, 2019; Tickner *et al.*, 2020). Knowledge of the species in a region and their distribution can help the relevant government agencies in the application of strategies aimed at their preservation.

Aiming to contribute to the knowledge of this important group of molluscs in the Amazon Basin we undertook collections of specimens of *Pomacea* spp. in the municipality of Macapá, the capital of the state of Amapá, in northwest Brasil, between 2019 and 2021.

Fig. 2. Some enviroments where specimens of *Pomacea* were collected in Macapá.

The speciems collected were identified based on conchological features, analysis of the male reproductive system, and sequencing of the barcode region of subunit I of cytochrome *c* oxidase (MT-COI). The results will be incorporated into the Master's thesis of the first author.

The municipality of Macapá is in the southeastern part of the state of Amapá, on the left bank of the Amazon River (Fig. 1). The municipality is crossed by the Equator and its elevation is around 16 m, with a hot/humid equatorial climate. Its estimated human population in 2021 was 522,357 (IBGE, 2017). In addition to large rivers such as the Amazon, Macapá also has several natural breeding sites for freshwater molluscs, such as bathing areas and wetlands known as "ressaca areas". These are humid environments comprising clogged physical river systems drained by fresh water and connected to a main watercourse, strongly influenced by rainfall and having herbaceous vegetation (Takiyama *et al.*, 2012). The municipality is divided into seven Territorial Areas, each having several neighborhoods. Collections were undertaken from 2019 to 2021, every two months in 30 neighborhoods representing all these Territorial Areas. Two collections were undertaken in each neighborhood, always by three to four collectors, with an average time of 30 minutes at each collection point (Fig. 2). The specimens were numbered and fixed in 70 % ethyl alcohol according to Fukuda *et al.* (2008). Samples were deposited in the Mollusc Collection of the Instituto Oswaldo Cruz (CMIOC) and will also be in part donated to the Collection of the Institute of Scientific and Technological Research of the State of Amapá (IEPA).

The specimens were collected in areas that represented natural water reservoirs but also in other diverse ecosystems that are influenced by the effects of the tides through channels and streams and by the rainy periods that are characteristic in this region. Some of these areas are illegally occupied by residents

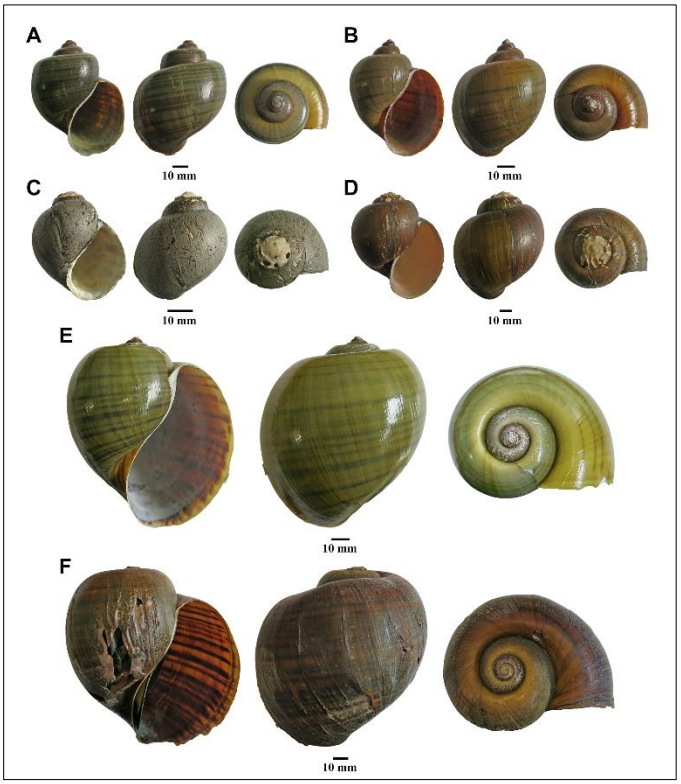

Fig. 3. Shells of *Pomacea* species collected at Macapá, state of Amapá, Brazil. A – *P diffusa*, B – *P. dolioides*, C – *P. interrupta*, D – *P. urceus*, E – *P. maculata*, F – *Pomacea* sp. 1.

without water, sewage, energy and paving infrastructure and located in areas at risk of flooding (Fig. 2).

We found the following *Pomacea* species: *P. diffusa* (Blume, 1957), *P. interrupta* (Sowerby, 1909), *P. dolioides* (Reeve, 1856), *P. urceus* (Müller, 1774), *P. maculata* Perry, 1810, and *Pomacea* sp. 1 (Fig. 3).

Pomacea diffusa, *P. dolioides* and *P. maculata* were the most widespread species in Macapá. *Pomacea urceus* and *P. interrupta* had more restricted distributions, being found only in Fazendinha and Alvorada neighborhoods. The wide distribution of *P. diffusa* in Brasil may in part be the result of introductions from locations within the country (Thiengo *et al.*, 2011). *Pomacea maculata* and *P. urceus* are considered endemic to Amazonia and the Guianas (Thiengo *et al*., 2011). Considering the Brasilian Amazon, *P. diffusa*, *P. dolioides* and *P. urceus* have previous records for the states of Amazonas and Pará (Pain, 1950; Cowie & Thiengo, 2003; Simone 2006; Rawlings *et al*., 2007; Hayes *et al*., 2008; Thiengo *et al*., 2011). Thus, our preliminary results expand the known distributions of *P. urceus*, *P. diffusa*, *P. interrupta* and *P. dolioides* to Amapá.

Important impacts on water resources and the loss of aquatic biodiversity in the Brasilian Amazon region have been caused by deforestation and pollution. It is likely that some of these ampullariid species are experiencing localised declines because of urbanisation, habitat degradation and changes in hydrological regimes, although no studies have noted any major threats. Also, the region has been occupied irregularly by residents, often causing irreversible damage to the kinds of enviroments where most specimens were found. Thus, more studies considering aspects related to the diversity, ecology and biology of these populations are needed to shed light on possible threats in Amapá and the Amazon region as a whole.

We are grateful to the professionals at LACEN-Macapá—Miguel Filho, Jorge Duarte, Marlucia Façanha, Natalia Castelo—for supporting our field work, and to the graphic designer Eduardo Cinilha for the photos and map.

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HOW NETWORK ANALYSIS COULD HELP IN THE STUDY OF INVASIONS OF NON-NATIVE MOLLUSC SPECIES

By F. Agustin Victorero, Evangelos Vlachos, Cristina Damborenea & Gustavo Darrigran

Since the first publication that drew attention to the importance of biological invasions (Elton, 1958), our knowledge and awareness of their role as important factors influencing ecosystems and the decline of biodiversity has increased. However, the prevention and control of biological invasions continue to represent a great challenge for biodiversity conservation management because of this impact on ecosystems (Simberloff *et al*., 2012) and negative socioeconomic effects (Pejchar & Mooney, 2009). At the global level, these challenges reach high levels of international politics, as exemplified in particular by Article 8(h) of the Convention on Biological Diversity (United Nations, 1992) and subsequent decisions of the CBD conferences of parties, e.g. the Aichi Biodiversity Target 9 (see United Nations, 2013).

In this context, non-native mollusc species (NNMS) are huge threats to entire terrestrial, freshwater and marine ecosystems. Usually as a result of human commercial activities, NNMS are introduced into novel areas and rapidly expand by using a variety of dispersal vectors and pathways, including river systems, sea-routes and land-routes. In South America, NNMS represent a constant concern for conservation and a number of studies are being developed to tackle their invasions (e.g. Darrigran *et al*., 2020, 2022). These studies show that the diverse ecosystems of the South American continent suffer particularly from this problem. Darrigran *et al*. (2020) identified four hotspots in South America that serve as entry points and distribution foci for NNMS in the continent: Subtropical-Atlantic, Northern Andes, Central Andes and Southern Andes. Now we present a new approach, modelling the dispersal potential of NNMS in the continent by adapting methods originally developed for the study of social networks. We conceptualise the South American continent as composed of a set of nodes that are connected to each other by a series of edges that represent the main dispersal vectors: geographical proximity, rivers, roads, railways etc. The result is a model of the connectivity pattern of the continent (Fig. 1).

Conceptualized as a network, we are now able to calculate metrics for the entire system as well as the individual nodes, thereby allowing an understanding of which places deserve special attention and conservation resources. Just as in social networks there are established hierarchies and people that control the flow of information, the same is true in the dispersal of NNMS. There are geographical points that form 'crossroads' between different types of vectors. Just as in a large social group in which the social relationships create smaller and interconnected communities of people, a geographical network is also composed of several communities that might agree or disagree with our currently defined borders.

Network methodology allows modelling and comparing, both statistically and visually, different types of networks that cannot be compared otherwise. Our first network model of South America (Fig. 1A) is composed of 259 nodes that each represent a different state or province, thus modelling the connectivity pattern of the political boundaries. Our second network model (Fig. 1B) is composed of 85 nodes that represent 5° x 5° squares covering all possible ecoregions of South America. This second model does not take into account political boundaries. When we compare these two networks are we going to find that the same areas are the most important for NNMS dispersal? How do modern political boundaries and divisions affect conservation?

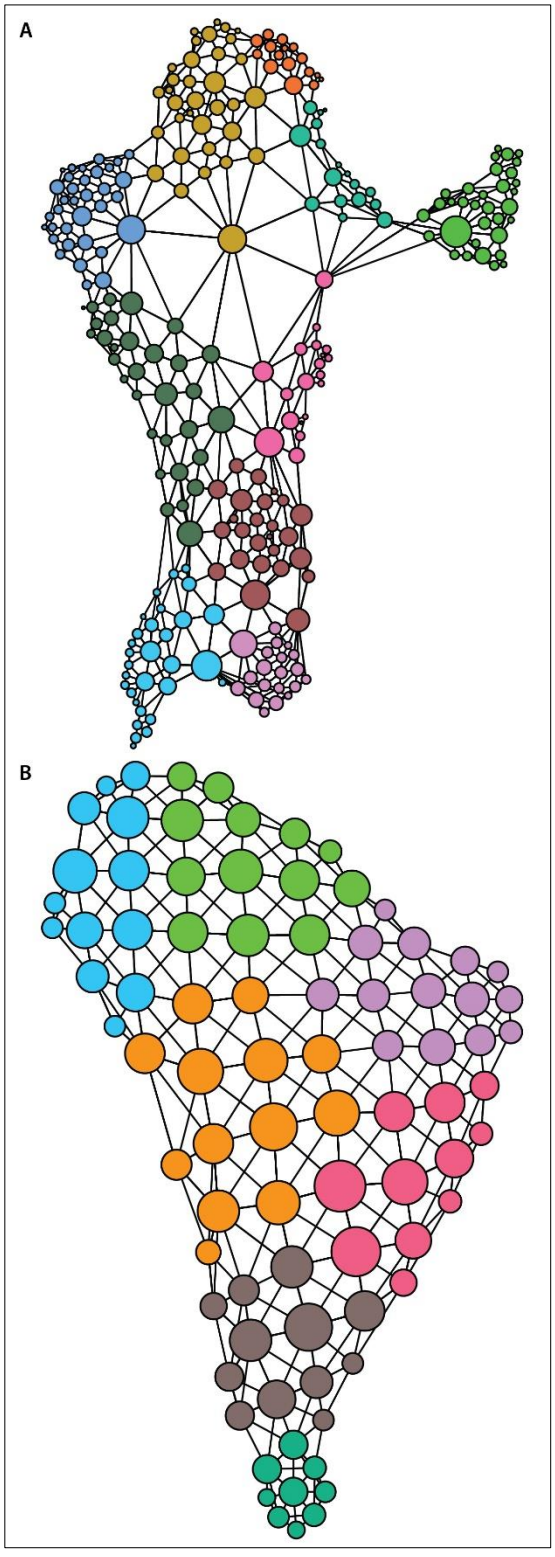

Fig. 1. Connectivity pattern of dispersal vectors used by non-native mollusc species in South America. A – network model in which the nodes represent states or provinces; B – network model in which the nodes represent 5° x 5° squares covering all possible ecoregions. Relative sizes of nodes indicate the number of vectors connecting them. Colours of nodes represent the communities or modules recovered in the network. The layout is based on the Force Atlas 2 algorithm and the networks have been constructed in the Gephi 0.9 software (Bastian *et al*., 2009).

Which places deserve special and coordinated attention among states/provinces or even countries? Network analysis can provide numerical and visual answers to these questions.

One thing is certain and visible with the naked eye (compare Fig. 1A and Fig. 1B): the two networks are different and describe different connectivity patterns. This is expressed both graphically and numerically. Thus, we try to find points of agreement and conflict between the two. Still, both show that modern political boundaries are not always the correct divisors on which to base decisions. The colours of the nodes in both networks of Fig. 1 represent the connected communities or modules recovered by the model. In the political model (Fig. 1A) 10 modules are recovered. These modules do not always correspond to one country or a group of countries. Brasil, for example, is divided into several modules. The modules recovered in the geographical module (Fig. 1B) correspond more closely to the previously defined NNMS hotspot regions.

Establishing protocols and surveillance systems in hotspots of species introductions would prevent the introduction of non-native species, and be one of the most effective actions to address this environmental threat of biological invasions.

The metrics produced from this study, for the individual nodes of the networks, can be compared with external quantitative data (e.g. precipitation, species richness, human population, socioeconomic factors) to find statistical correlations among them. Our preliminary analyses show strong statistical correlations between most network metrics and factors like precipitation, number of airports and cities, species richness and socioeconomic factors like GDP (Gross Domestic Product) per capita. These initial results are promising as they point out that climatic, ecological and socio-political factors might affect and control the dispersal of NNMS in South America, as well as allowing detection of hotspots of species introductions where surveillance systems can be applied.

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SMALL AND VULNERABLE – WHAT CAN BE DONE TO PROTECT FRESHWATER HYDROBIIDAE IN MOROCCO?

By Khadija Boulaassafer, Mary Seddon & Mohamed Ghamizi

The family Hydrobiidae is one of the largest mollusc families, with a wide distribution, especially in the western Palaearctic. These snails can go unnoticed because of their minute size which can vary from 0.5 to 6 mm (e.g. Fig. 1). They also occupy highly diverse habitats, from high altitude springs to lowland streams, lakes, ponds and estuaries. In Morocco, the family is mostly distributed in the northern region of the country, with the majority of described species located in the high altitudes of the Middle Atlas and the Rif. Although Morocco is considered a hotspot for freshwater fauna, the Hydrobiidae have received little attention from taxonomists and the occasional descriptions of its species have been based on morphological and anatomical traits, which have been proven to be insufficient to correctly delimit species in the family. Recent molecular data generated by Boulaassafer *et al*. (2018, 2020, 2021) helped in describing new hydrobiid species and assigning previously described taxa to other genera. Thirteen of them were the subject of an assessment by the first author, with help from the IUCN Mollusc Specialist Group, to determine their conservation status (Table 1).

Knowing that the freshwater habitats in Morocco play a crucial role in the country's ecology and economy as they provide important ecosystem services, such as drinking water supply, irrigation and a refuge for biodiversity, protecting these targeted taxa is crucial not only for the preservation of the ecosystem but also for the well-being of the local communities.

Several localities of freshwater habitats in Morocco, including springs, streams and rivers, were visited. Measurements of the water quality were done on-site, and locals and officials were interviewed to gather the most information possible about the history and current status of the habitats, their importance to the populations, their fluctuations over time and the possible causes of those fluctuations. The data collected were compared to previous investigation results gathered between 2015 and 2018.

Fig. 1. *Pseudamnicola ouarzazatensis*, a Critically Endangered species, from Zaouit N'wassif, 70 km from the city of Ouarzazate, Morocco.

The results of these field surveys were alarming; four of the type localities were dry, i.e. those of *Corrosella marocana* (Pallary, 1922) (Fig. 2), *C. wakrimi* Boulaassafer *et al*., 2021, *Mercuria tensiftensis* Boulaassafer, Ghamizi & Delicado, 2018, and *M. tingitana* Glöer, Boeters & Walther, 2015. This is mainly due to lack of adequate precipitation in the last few years, coupled with over-pumping of the groundwater either for irrigation or by utility companies. Although most of these stressors are direct results of global climate change,

Table 1. The species of Hydrobiidae assessed, according to the IUCN criteria. Red – Critically Endangered; orange – Endangered; yellow – Vulnerable.

Species	Assessment results
Corrosella pallaryi	CR B1b(i,ii,iii,iv)c(i,ii)+2b(i,ii,iii,iv)c(i,ii)
C. marocana	CR B1ab(ii,iii)c(ii,iii)+2ab(ii,iii)c(ii,iii)
C. atlasensis	CR B1ab(iii)c(ii)+2ab(iii)c(ii)
C. mahouchii	CR B1ab(ii,iii)c(ii,iv)+2ab(ii,iii)c(ii,iv)
C. nechadae	CR B1b(iii)c(ii)
C. wakrimi	CR B1ab(i,ii,iii,iv)c(i,ii,iii)+2ab(i,ii,iii,iv)c(i,ii,iii)
Mercuria bakeri	CR B1ab(ii,iii)c(i,ii)+2ab(ii,iii)c(i,ii)
M. midarensis	VU B1ab(iii)+2ab(iii)
M. targouasensis	EN B2ab(iii)
M. tensiftensis	EN B1ab(ii,iii,iv)+2ab(ii,iii,iv)
M. tingitana	CR B1ab(iii)+2ab(iii)
Pseudamnicola ramosae	CR B1ab(iii,iv)c(i,ii,iii)
P. ouarzazatensis	CR B1ab(iii)+2ab(iii)

Fig. 2. The decline of Lahjar Spring, the type locality of the endemic species *Corrosella marocana*. A – November 2015; B – May 2022.

anthropogenic activity can very much affect the quality and sustainability of these fragile habitats. For instance, the expansion and development of the city of Nador in the northeast of Morocco, without proper plans for managing construction waste and sewage, has led to the pollution of nearby rivers, which are a habitat of the endemic species *Mercuria midarensis* (Boulaassafer, Ghamizi & Delicado, 2018).

These results indicate the importance of urgently addressing the threats facing freshwater habitats in Morocco, not only to directly influence preservation of the endemic biodiversity but also to benefit (directly or indirectly) the isolated communities economically. Therefore, to protect species of Hydrobiidae in Morocco, a multifaceted approach is needed. First, it is important to educate and raise awareness amongst students, NGOs and other stakeholders of the importance of freshwater ecosystems and their unique biodiversity, as well as the importance of the endemic fauna, especially for a scarcely studied country. It is crucial to involve the local communities in preserving these freshwater ecosystems, as they have a vested interest in these habitats for their economic and cultural significance.

Finally, it will need a colossal effort to protect and preserve the freshwater ecosystems in Morocco. It is crucial to 1) implement strict regulations for farmers, including regulating the types of crops grown, promoting drought-resistant varieties to address water scarcity issues and implementing efficient irrigation systems, 2) promote more rationalised and sustainable water usage both in cities and rural areas, 3) protect these freshwater habitats by creating protected areas or through land-use planning, and 4) reduce the impact of anthropogenic stressors, including treating wastewater, implementing agricultural best practices and enforcing industrial regulations. It is indeed challenging to fulfil the above recommendations; nevertheless, the scientific community can and will continue to educate and raise awareness about our endemic fauna.

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FRESHWATER MUSSELS IN MEXICO (2017-2022)

By Kevin S. Cummings & Jeremy S. Tiemann

Historically, the freshwater mussels (Unionoida: Unionoidea and Etherioidea) of Central America have been associated with Nearctic lineages (Ortmann, 1921; Frierson, 1927). Graf (2000) noted that Central America was one of a few territories of overlap between the Unionoidea on the northern continents and the Etherioidea from the South. However, the Central American assemblage is distinct from that of North America and endemic to the American tropics. Little current information is available on the mussel fauna of Central America, and we have relied largely on the outdated papers by Frierson (1927) and Haas (1969) for estimates of freshwater mussel diversity. Additional research on the distribution, status and systematic relationships of the mussels of Central America is thus badly needed. Documenting changes to species ranges and identifying their potential causes is critical

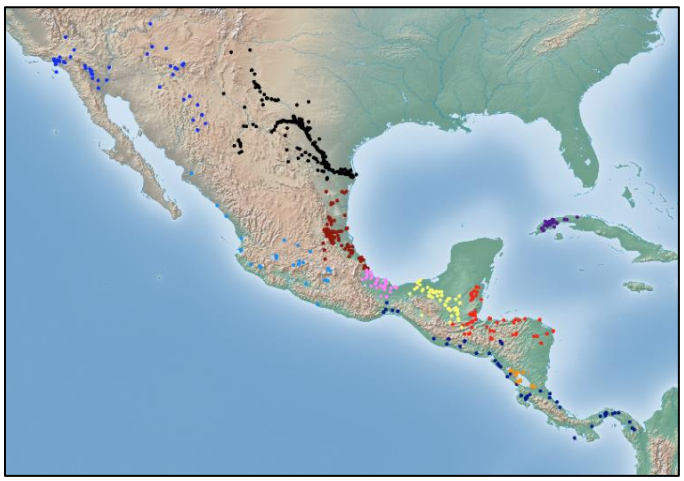

Fig. 1. The Malacological Provinces of Central America north to south. Gulf of Mexico Provinces: Río Grande del Norte (black), Pánuco (dark red), Papaloapan (pink), Usumacinta (yellow). Pacific Drainage (including endorheic basins) Provinces: Colorado (blue), Mesa Central and Balsas (light blue), Oaxaca, Mexico to Panama (navy blue). Caribbean Provinces: Belize to Nicaragua (bright red), Lake Nicaragua (orange). Cuba (purple).

for the conservation of freshwater mussels (Haag & Williams, 2014). To do this requires understanding of taxonomy and knowledge of status and trends of remaining populations. This is particularly true in Central America, where only 10 of the 82 species have been assessed for the IUCN Red List, of which one, *Sinanodonta woodiana* (Lea, 1834), is non-native; three, *Anodonta nuttaliana* Lea,1838, *Fusconaia mitchelli* (Simpson in Dall, 1895) and *Anodontites trigona* (Spix in Wagner, 1827), do not even occur in Central America; and five, *Pyganodon grandis* (Say, 1829), *Megalonaias nervosa* (Rafinesque, 1820), *Uniomerus tetralasmus* (Say, 1831), *Truncilla donaciformis* (Lea, 1828) and *Lampsilis teres* (Rafinesque, 1820) are strictly North American, thus leaving only one endemic Central American species, *Anodonta impura* Say, 1829, that has been assessed and it is classified as Data Deficient. Much work needs to be done to provide a clear picture of the conservation status of freshwater mussels in Central America.

Cummings *et al*. (in preparation) are preparing a monograph on the freshwater mussels of Central America to be published later in 2023 or in early 2024. Freshwater mussel distribution maps have been prepared based on data from thousands of museum specimens and field surveys in selected rivers in México. Some distribution patterns became evident, largely associated with major drainage basins (Kiser *et al*., 2022). The entire freshwater mussel fauna was grouped into ten provinces based on natural drainage hydrology, shared taxa and endemic species (Fig. 1). The provinces generally followed those of Miller *et al*. (2005: 26-47) for the fishes of México and roughly corresponded to those of Abell *et al*. (2008: 408-409), also based largely on fishes. Field surveys over the past five years were conducted in four major basins that drain to the Gulf of Mexico—from north to south: the Conchos, a Río Grande tributary in Chihuahua (2018); the Pánuco in San Luis Potosi (2017, 2018); the Papaloapan in Veracruz (2022); and

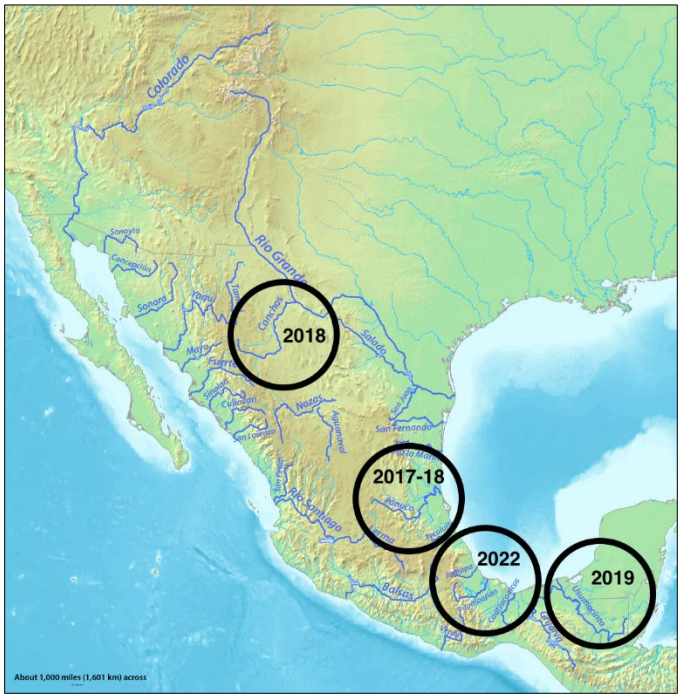

Fig. 2. River basins draining to the Gulf of México sampled in 2017-2019 and 2022.

the Usumacinta in Chiapas and Tabasco along the Guatemalan border (2019) (Fig. 2).

One of our initial objectives was to evaluate the status of the endangered Texas hornshell, *Popenaias popeii* (Lea, 1857), a freshwater mussel thought to have a historical range from the Rio Grande drainage in the United States and Mexico south along the Mexican Gulf coast to northern Veracruz (Johnson, 1999). *Popenaias popeii* is currently ranked as Critically Endangered by IUCN (Bogan, 1996), NatureServe (2017) and the US Fish & Wildlife Service (USFWS, 2018). Of the historical information available for it, the majority of recent live occurrences were in the Rio Pánuco basin in the states of San Luis Potosi and Tamaulipas, Mexico. The streams in the Rio Pánuco drainage were first sampled for molluscs in 1909 by Hinkley (Pilsbry, 1910; Pilsbry & Hinkley, 1910). Fred Thompson collected at various sites in Gulf of Mexico drainages (ríos Actopan, Cazones, Nautla, Pantapec and Pánuco) in Tamaulipas, San Luis Potosi and Veracruz on various dates from 1965 to 2001 (unpublished). A third, and also unpublished survey of the freshwater mussels of Mexico was conducted by Daniel Bereza (1950-2007)—formerly of the Academy of Natural Sciences of Philadelphia—and colleagues collected freshwater mussels in 1978 and 1982 in the states of Coahuila (23 sites), Queretaro (2), San Luis Potosi (37) and Tamaulipas (12) (also unpublished).

The *Popenaias* populations in the Pánuco basin were genetically distinct from those in the Río Grande and we described a new species, *Popenaias berezai* Inoue *et al*., 2020, from the Río Valles. No *Popenaias* were found alive or dead in the Conchos basin (Tiemann *et al*., 2020).

Our work in the Usumacinta (2019) was to further investigate freshwater mussels along the Gulf Coast, building on the work

Fig. 3. Río Valles (Gulf of Mexico–Pánuco drainage), Aldea Huasteca, 4 km ESE of Micos, San Luis Potosí, México. 6 December 2017. 22.0989, -99.1390.

Fig. 4. Río Xanil (Gulf of Mexico–Grijalva–Usumacinta drainage), Cascades de Agua Azul, Chiapas, México. 5 December 2019. 17.2564, -92.1149.

of Hinkley (1920) and Goodrich & van der Schalie (1937). In December 2022 we investigated streams in the Papaloapan basin in Veracruz, following up on work by Baker in the 1920s (Baker, 1922). The results of these surveys will be published in the new monograph. Photographs of specimens collected and additional information can be found on the MUSSELp website (Graf & Cummings, 2023).

In general, the streams we investigated in the Pánuco and Usumacinta were of high quality with a largely intact and abundant mussel fauna (Figs. 3-5). Streams in the Conchos were devoid of native bivalves and invasive Asian clams (*Corbicula*) were widespread and abundant (Fig. 6). Sampling conditions in the Papaloapan were not ideal because of recent rains but it was clear that the rivers there have been degraded to a large extent. Some, like the Río San Juan, still harbour mussels (Fig. 7). As with the Conchos, non-native molluscs

Fig. 5. *Delphinonaias largillierti* (Philippi, 1847). Laguna de Catazaja (Gulf of Mexico–Grijalva–Usumacinta drainage), Catazajá, Chiapas, Mexico. 2 December 2019. 17.7297, -92.0183.

Fig. 6. Río Conchos (Gulf of Mexico–Río Grande drainage), Peguis Canyon, Ojinaga, Chihuahua, México. 7 May 2018. 29.5058, -104.7644.

were widespread and abundant in the Papaloapan. *Melanoides tuberculata* (Müller, 1774) and *Corbicula fluminea* (Müller, 1774) were present at nearly all sites.

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Fig. 7. Río San Juan (Gulf of Mexico–Papaloapan drainage), Nopalapan, Veracruz, México. 4 December 2022. 18.1134, -95.3264.

Rosenberg and Paul Callomon (ANSP), Dawn Roberts (CHAS), Tim Pearce (CM), Liz Shea (DMNH), John Slapcinsky and the late Fred Thompson (FLMNH), Rüdiger Bieler, Jochen Gerber and Marty Pryzdia (FMNH), Rachel Vinsel and Alison Stodola (INHS), Adam Baldinger and the late Richard Johnson (MCZ), Philippe Bouchet and Virginie Héros (MNHN), Art Bogan and Jamie Smith (NCSM), Kathie Way and Jon Ablett (NHMUK), the late Tom Watters (OSUM), Ronald Janssen and Karl Otto-Nagel (SMF), Diarmaid Ó Foighil and Taehwan Lee (UMMZ), Robert Hershler, Ellen Strong, Tim Coffer, Kathryn Ahlfeld, and Paul Greenhall (USNM) and Thomas von Rintelen, Mathias Glaubrecht and Frank Köhler (ZMB).

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THREE MOLLUSC SPECIES REASSESSED BY COSEWIC IN 2022

By Dwayne A.W. Lepitzki & Joseph P. Carney

As travel and gathering restrictions due to the COVID-19 global pandemic eased in the latter part of 2022, the fall meeting of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) returned to being in person, although mask wearing was still encouraged. The spring 2022 meeting, however, was online. COSEWIC is an independent body of experts that assigns conservation status to species using IUCN criteria and recommends listing and legal protection under the Canadian Species at Risk Act (SARA; see Lepitzki & Mackie, 2013, in *Tentacle* 21 for details). Although fewer species were once again assessed at both the spring and fall meetings in 2022 because of the backlog and disruptions caused by COVID, three mollusc species were reassessed: one terrestrial snail and one slug, and a freshwater mussel. All were reassessments because SARA requires at-risk species to be reassessed every 10 years or sooner, if warranted. (Note that although COSEWIC adopted the IUCN criteria, it adjusted the names of the categories. IUCN Critically Endangered and Endangered is COSEWIC Endangered; IUCN Vulnerable is COSEWIC Threatened.)

In Canada, *Vertigo rowellii* (Threaded Vertigo) and *Magnipelta mycophaga* (Magnum Mantleslug) are confined to the province of British Columbia with the ranges of both extending south into the USA. Both were assessed in 2012 as Special Concern, a status that was retained in 2022 (SARA Public Registry, 2022a,b). On the Atlantic side of Canada, Brook Floater (*Alasmidonta varicosa*) also retained its earlier 2009 status of Special Concern (SARA Public Registry, 2022c). While increased search effort since the original assessments has increased the known ranges and/or numbers of occupied sites of all three species, they all still have restricted ranges and are facing a variety of threats that are contributing to a continuing decline in habitat quality.

Fig. 1. *Vertigo rowellii* (Threaded Vertigo) in a groove of furrowed bark of a large Bigleaf Maple (*Acer macrophyllum*) near Sooke River, Vancouver Island, British Columbia, Canada. (Photo: K. Ovaska)

Vertigo rowellii (Threaded Vertigo), a snail with an average height of 2.7 mm in Canada (Fig. 1), is typically found living on the bark of Bigleaf Maple (*Acer macrophyllum*) trees along both sides of the Strait of Georgia, between the city of Vancouver and southern Vancouver Island, and on southern Vancouver Island. Its presumed poor dispersal abilities and habitat requirements mean its index of area of occupancy (IAO) and extent of occurrence in Canada are below IUCN thresholds for Endangered and Threatened, respectively; however, the number of locations is above thresholds for Endangered or Threatened. Habitat loss and degradation due to housing and urban development, logging and roads are the primary threats.

Fig. 2. *Magnipelta mycophaga* (Magnum Mantleslug) near Fernie, British Columbia, Canada. (Photo: K. Ovaska)

Magnipelta mycophaga (Magnum Mantleslug), a large slug up to 80 mm in length when extended (Fig. 2), is endemic to the northern Columbia Basin in western North America with half of the global range extending into Canada. Its IAO is below the threshold for Endangered but the number of locations is above thresholds for Endangered or Threatened, similar to *Vertigo rowellii*. Habitat fragmentation continues to be a threat, as are logging and habitat shifts, droughts, storms and flooding due to climate change.

Fig. 3. *Alasmidonta varicosa* (Brook Floater). Specimen from Canadian Museum of Nature, Ottawa, Canada. (Photo: Fisheries and Oceans Canada)

Alasmidonta varicosa (Brook Floater), a medium-sized freshwater mussel (Fig. 3), is confined to scattered watersheds in two Canadian provinces on the Atlantic side of Canada. While the number of locations for this species is also above thresholds for Endangered or Threatened, its IAO remains below the threshold for Threatened. Pollution from domestic, urban, agriculture and forestry sources continues to be the greatest threat to the species.

More information on COSEWIC, including definitions of the criteria and status, can be found at the COSEWIC website.

Status reports for all species assessed by COSEWIC eventually will be posted online; follow the links at the website. The 2022 reassessments are not yet posted.

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POTENTIAL THREATS TO THE UNIQUE GASTROPODS OF LAKE BAIKAL

By Tatiana Y. Sitnikova, Konstantin M. Kucher, Sergei I. Kiyashko, Natalia V. Maximova & Igor V. Khanaev

Lake Baikal (Siberia, Russia) is the deepest (1,640 m) lake in the world, distinguished from other ancient lakes by the presence of oxygen at maximum depths and therefore by a deep-water fauna (Vereshchagin, 1949). Shallow-water species (Fig. 1), comprising 80 % of ~110 endemic species (Sitnikova & Shirokaya, 2013), are the most vulnerable to the adverse effects of the recent ecological crisis (eutrophication) in Lake Baikal, with algal blooms of *Spirogyra* covering some regions of the littoral (Fig. 2), the spreading of *Elodea* (Kravtsova *et al*., 2010), as well as diseases and the extinction of green sponges (Khanaev *et al*., 2018; Belikov *et al*., 2019).

Fig. 1. Endemic gastropods on healthy sponges: *Benedictia baicalensis* (foreground) and *Megalovalvata baicalensis*.

The exact causes of Lake Baikal eutrophication are unknown, but two possible causes have been discussed: human impact (dumping of household waste, including phosphorous-containing detergents) (Timoshkin *et al*., 2018), and increasing littoral water temperature associated with global climate warming (Kravtsova *et al*., 2021).

The effects of natural gas emissions accompanying thermal and mineral (including nitrogen-containing) fluids in local eutrophic areas have not been investigated at all. Numerous underwater hydrotherms are known in different regions of Lake Baikal, one of them is located in the littoral of Solontsovaya Bay (northwestern part of Lake Baikal) (Golubev, 2007). Here, decaying algal mats and mollusc graveyards were discovered in the littoral before the ecological crisis (Takhteev *et al*., 2000) and by us in June 2022 (Fig. 3). The dead molluscs were dominated by the bivalves (Sphaeriidae) and the Palaearctic gastropod *Radix auricularia* (Lymnaeidae), which prevail in numbers on sandy substrates in some Baikal localities (Fig. 4).

Radix auricularia is a recent invader of the open littoral of the lake, having emerged from shallow, summer-warming bays about 50-60 years ago (Stift *et al*., 2004; Schniebs *et al*., 2022). It is possible that eutrophication was one of the reasons for the expansion of *R. auricularia* along the perimeter of the lake.

We speculate that eutrophication may have been affected by earthquakes, which intensify gas emissions (Bezrukov *et al*., 2019) in regions of tectonic faults and contribute to a short-term rise of the water temperature (Tronin *et al*., 2004). From 37 to 132 earthquakes per year with magnitudes ranging from 2 to ~7 were recorded in Lake Baikal during 2000-2022 (http://seis-bykl.ru/).

Fig. 2. Baikal stony littoral covered by *Spirogyra*.

Fig. 3. Decaying algal mats and snail graveyards in Solontsovaya Bay.

In the open littoral of the lake, *R. auricularia* lives together with 15-20 endemic gastropods, one of which, *Benedictia baicalensis*, has a similar shell size. Analysis of stable isotopes of carbon and nitrogen in tissues of these grazer species showed that their isotope niches overlapped significantly. Snails of *R. auricularia* attach egg masses to the same substrates as *B. baicalensis*. Thus, the Palaearctic snails may compete with endemic species for food resources as well as egg attachment sites, and this invader could potentially be a threat to the endemic *B. baicalensis*.

Fig. 4. *Radix auricularia* on sandy substrate in open Baikal littoral. Scale bar, 3 cm.

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ASSESSMENT OF CONSERVATION STATUS OF MEMBERS OF THE FRESHWATER MOLLUSC GENUS *CREMNOCONCHUS* OF THE WESTERN GHATS, INDIA

By N.A. Aravind

The Western Ghats of India, a globally recognised biodiversity hotspot, harbour unique flora and fauna with high levels of endemism (Myers *et al*., 2000). The freshwater environment within the landscape, especially lotic systems, is also a hotspot for freshwater biodiversity (Thomsen, 1999). These lotic systems are home to unique biodiversity including many species that are highly endemic and often show point endemism patterns (Aravind *et al*., 2017; Saha *et al*., 2022).

One of the most important components of the lotic ecosystems of the Western Ghats is the freshwater snail genus *Cremnoconchus*. This genus is an iconic taxon within this landscape as it represents the only entirely freshwater genus in the family Littorinidae, which otherwise is entirely marine (Reid *et al*., 2013; Aravind *et al*., 2016, 2017). The members of this genus are restricted to spray zones of waterfalls in the western escarpment of the central (between 12 and 16° N) and northern Western Ghats (between 16 and 21° N). Many members of the genus are restricted to single waterfalls, especially in the central Western Ghats (Fig. 1). A recent study using a fossil-calibrated Bayesian time tree suggests that *Cremnoconchus* diverged from its marine ancestors around 90.4 million years ago, perhaps caused by the break-up of Gondwana or fluctuating sea levels during the mid-Cretaceous (Saha *et al*., 2022).

The Western Ghats are under severe threat from various anthropogenic activities. The human population density of 420 persons per km^2 is the highest for any of the global hotspots of

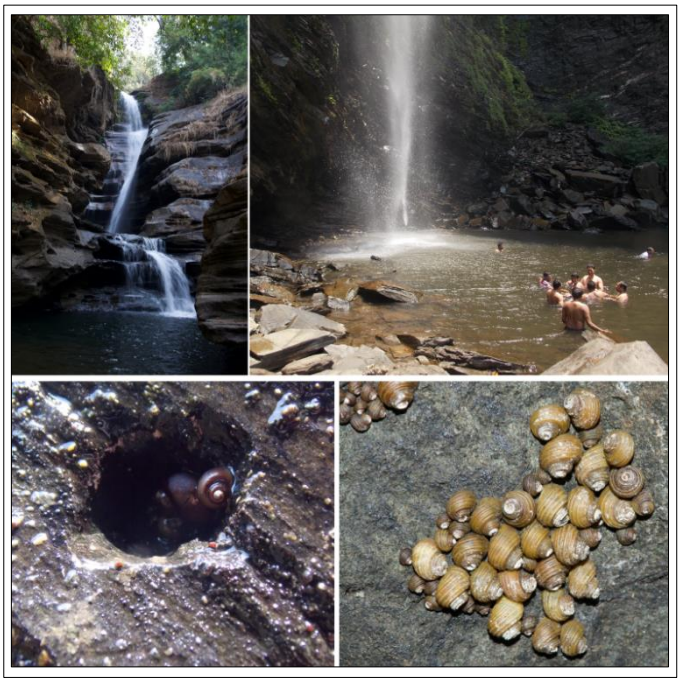

Fig. 1. Habitat, threats and dormancy in *Cremnoconchus*.

Table 1. *Cremnoconchus* species (Littorinidae) reported from lotic systems of the Western Ghats, India, with their conservation status according to IUCN categories. All species are endemic to the Western Ghats.

Species	IUCN status
Cremnoconchus agumbensis	Not Assessed
Cremnoconchus canaliculatus	Endangered
Cremnoconchus castanea	Not Assessed
Cremnoconchus cingulatus	Not Assessed
Cremnoconchus conicus	Vulnerable
Cremnoconchus dwarakii	Not Assessed
Cremnoconchus globulus	Not Assessed
Cremnoconchus hanumani	Not Assessed
Cremnoconchus syhadrensis	Endangered

biodiversity and is well above the worldwide average of 80 persons per km^2 (Cincotta *et al*., 2002). Most of the waterfalls within the landscape are common property resources and face a multitude of threats from religious, recreational and tourism-related activities as well as land use and land cover changes upstream (Fig. 1). Only three species (*C. canaliculatus*, *C. conicus* and *C. syhadrensis*) of the extant nine were assessed for their conservation status in 2010 (Table 1). The remaining six species (*C. agumbensis*, *C. castanea*, *C. cingulatus*, *C. dwarakii*, *C. globulus* and *C. hanumani*) were not described until 2013 (Reid *et al*., 2013). Hence, there is a need to assess/reassess the conservation status of all these species, especially given the changes that have taken place and continue to occur in the Western Ghats because of unprecedented infrastructure development and other anthropogenic interventions.

A project recently funded by the SSC EDGE Internal Grant programme through Re:wild will reassess the three species that were assessed in 2010 and, for the first time, assess the conservation status of the remaining six species of *Cremnoconchus* in the Western Ghats. Apart from addressing this primary objective, the project aims to: 1) document the natural history, basic ecology, population status and threats through extensive field surveys in the central and northern Western Ghats, 2) develop a comprehensive conservation action plan for the genus *Cremnoconchus* within the Western Ghats for implementation by the state forest departments, and 3) disseminate the outcomes of the project via print and electronic media to generate public awareness in this regard.

The proposed activities of the project will help strengthen the in-situ conservation of iconic species and evolutionarily distinct lineages of the freshwater ecosystems of the Indian Western Ghats. The proposed conservation action plan is of utmost importance since most species (six out of nine) are found outside protected area networks within human-dominated landscapes that require special measures for long-term conservation.

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WHY DEVELOPING METHODS AND KNOWLEDGE ON MOLLUSC COMMUNITIES REALLY MATTERS

By Ioan Sîrbu, Ana M. Benedek & Monica Sîrbu

The Web of Science (WoS) platform provides a good image of what is published, where it is published and when it is published, both in high-profile journals (with impact factor and other scientometric values), which can be found in the so-called Core Collection, as well as in other databases, grouped in the All Databases, where all kind of (additional) sources can be found. Our students used to tell us that if we were not on Facebook (or Twitter etc.), we didn't exist; we reply that if a scholar is not in the WoS Core Collection, then, and only then, he or she maybe does not exist. When searching for articles related to molluscs, we found that 'Molluscs' (compared to other spellings, like Mollusca, Mollusk(s), etc.) returned more hits. Using the keyword Molluscs returned 306,992 hits (published articles) in All Databases and 30,511 in Core Collection (representing 9.94 % of articles published in high-profile journals, that is about 1 article in 10). Of these, studies on mollusc communities (keywords 'Mollusc communities') represented 10.80 % of the hits in Core Collection and 11.26% in All Databases. The proportion of freshwater among all mollusc communities is 12.02 %, and among anything related to molluscs is 1.3 % in Core Collection. This means that 1 article in 100 dedicated to molluscs is about freshwater communities, and among the publications dealing with communities only 1 in 10 is related to freshwater. It also means that most malacologists or people who write about molluscs are spreading their information mostly in low profile and hard-to-find publications, with low or no quality check; thus, most intel on the subject is 1) diffuse and hard to find or

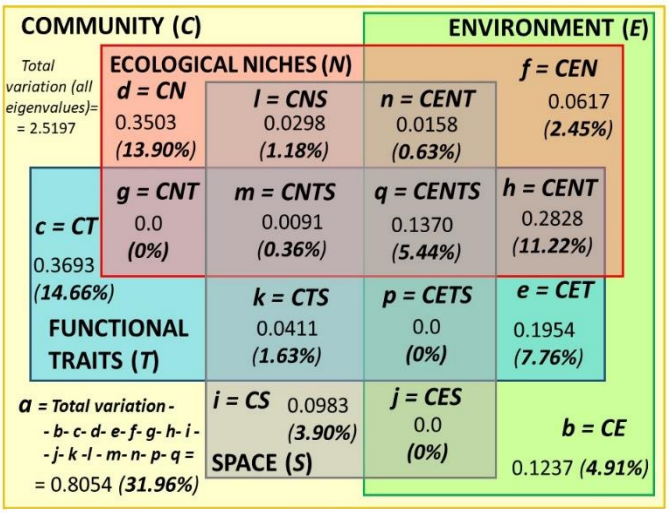

Fig. 1. VADOC diagram (Variation Partitioning in Double-constrained Ordination Analyses with Multiple Predictor Tables), showing decomposition of the variation in community composition explained by environment, traits and niches. Letters *b* to *p* represent the parts of variation explained by different combinations of predictor groups, *h* is the CENTS (acronym from Community-Environment-Niche-Traits-Space) overlap space, and *a* represents the residual variation that the selected predictors can not explain. The figures represent the components of variation in the mollusc communities, given both as the absolute variation explained and as percents of the total variation in community composition (Sîrbu *et al.*, 2021).

obscure, and 2) the peer review process is either absent or disputable, and of possibly low value, which makes 3) information sparse and questionable, if not untrustworthy. To put it short: most work dedicated to molluscs is wasted because of poor choices; or to put it shorter: malacologists have to change!

In an ever-changing world in which freshwater systems and molluscs face extreme dangers of all possible types and outcomes, all the above ideas hint at the need to do something more. Based on the evidence that studying mollusc communities, especially those living in freshwater, is an underdeveloped and undervalued subject, we have tried during recent years to improve approaches, methods and concepts for understanding not only mollusc but any ecological communities.

The structure, dynamics and functions of communities can be explored, explained, modelled and tested by multivariate mathematical methods; among them, direct ordination techniques are exceptionally useful. Constrained ordination methods were developed to link ecological communities to the environment and are a common tool for exploring the effects of various predictors on community structure. Then the double-constrained analysis was developed (Ter Braak *et al.*, 2018), integrating traits as species-related predictors (for instance, dc-CA, meaning double-constrained correspondence analysis). Further, methods have been proposed to integrate information on phylogenetic relationships and space variability. We have expanded this framework, proposing a dc-CA-based algorithm for decomposing variation in community structure and testing the effects of four sets of predictors: environmental characteristics and space configuration as predictors related to sites, and functional traits and niche (dis)similarities as species-related predictors (Sîrbu *et al.*, 2021). The unique and shared effects of explained variability in species composition were denoted as the CENTS space (Fig. 1, the acronym coming from **C**ommunity - **E**nvironment - **N**iche - (functional) **T**raits - **S**pace), and we hope that this analysis will considerably strengthen and link the fields of functional and structural ecology. This is done by generating new insights and leading to a better understanding and quantification of the mechanisms underlying species-trait-environment patterns. In addition, the algorithm we developed may be used for other predictor data tables, such as a table with ecological indicator values or with phylogenetic relationships. It may also be extended to include more than two explanatory data tables for sites or species. The novelties of this project are the introduction of new niche parameters, defining the synthetic niche-based diversity (a novel type of measure of biodiversity), which we related to environmental features, the development of an algorithm for the full variation decomposition and testing of the CENTS space, and new types of diagrams for the results. Since the classical Venn diagrams proved inefficient, we established new statistical graphics and called them 'VADOC diagrams' (a term derived from 'variation partitioning in double-constrained ordination analyses with multiple predictor tables diagrams'), which we presented in two variants (Sîrbu *et al.*, 2021). Applying these methods to a dataset on freshwater molluscs, we learned that niche predictors might be as important as traits in explaining community structure and are not redundant, outweighting environmental and spatial predictors. More specifically, the study revealed that evolutionary and adaptive signals might be of prevailing importance, compared to environmental and geographical predictors (the latter categories being used more frequently), in explaining the quantitative structure of ecological communities. Using niche measures separately from traits might bring new insights into community assembly and reveal the adaptative features acquired by species during their evolution. Our algorithm opened new pathways for developing integrative methods linking life, environment and other predictors in theoretical and practical applications, including assessing human impact on habitats and ecological systems.

The limiting condition of our method was the usual approach of relying on a single matrix of response variables, namely the community (or sites-by-species) data table. But what if there are two or several interacting communities and we want to measure and test their relations with each other and with the explanatory variables (predictor data tables)? The next step was to consider also time as an explanatory variable, to find a way to include old data (from museum collections and old literature) in the model, to split the response variables into two data tables, for instance, the natives and the invasive alien species (IAS), and to assess their shared and unique responses to the same predictors (so far, we used environmental and, separately, spatial predictors). The first results have been recently published (Sîrbu *et al.*, 2022). Based on a case study, variation partitioning showed that alien species might be as important predictors as environmental factors and time in

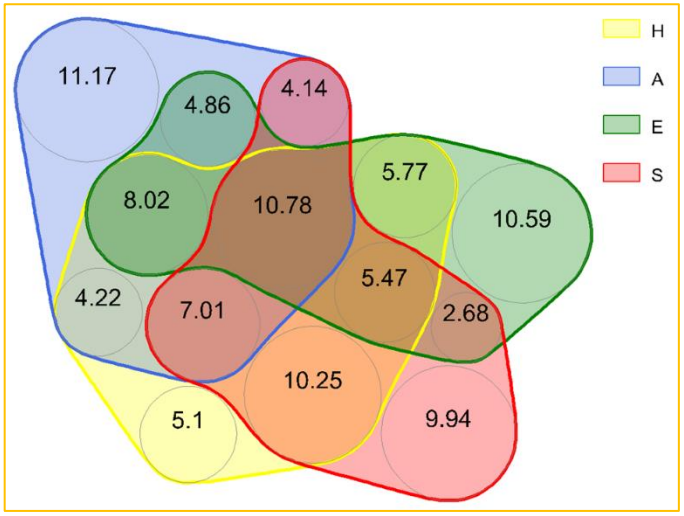

Fig. 2. CUVARP diagram (Cumulative Variation Partitioning with Multiple Response and Predictor Matrices). All datasets are synthesised through selected Principal coordinates axes (PCoA) scores of H – native species, A – alien invasives, E – environmental parameters, and S – space. No overlapping coloured circles depict unexplained (residual) variation. The percentage of variation (explained and residual) from the total variation in all matrices is shown (Sîrbu *et al*., 2022).

explaining the species composition of native freshwater mollusc communities. Aliens were more independent of environmental conditions than natives and responded to different drivers, partially explaining their invasion success. The increased abundance of some alien gastropods was positively related to taxonomic diversity, while certain alien bivalves were negatively associated with the functional diversity of native communities. We have also developed a novel approach and method for analysing and expressing relationships between native and alien communities while accounting for their common (shared and unique) responses to environment and space. Therefore, we introduced an algorithm for the complete Cumulative Variation Partitioning with Multiple Response and Predictor Matrices and its graphical representation (denoted CUVARP method and diagram, Fig. 2). A variant of this method also includes the functional traits of the species (for both the natives and the aliens), and it was introduced as the CWM-AVARP (Community Weighted Means – Average Variation Partitioning with Multiple Response and Predictor Matrices) diagram (Sirbu *et al*., 2022).

The multivariate approach is essential for understanding freshwater mollusc distributions and other ecological parameters. However, we showed that understanding the changes and responses of native freshwater mollusc communities requires more than a multivariate approach. All dimensions (i.e. matrices describing and characterising sources of explanatory variability), including time, space, environmental features, traits and distributions of IAS (and undoubtedly many more), have a significant predictive role in explaining how native communities adapt, respond and change. Therefore, a multi-dimensional approach is needed, and we advocated for a conceptual shift in future quantitative ecology from "variables to matrices" and from "multivariate analyses to multi-matrix statistical modelling", some elements that support what we have earlier termed as an "omni-spaces explanatory communities ecology" (Sîrbu *et al*., 2021). The newly developed CUVARP analysis and diagram indicate a different relationship of natives and alien species with environmental and spatial predictors and suggest a possible explanation for the success of invasive over native communities.

Conversely, residual (unrelated) variance in space and environment might be used in further studies to investigate how other communities exploit and compete for the available resources and conditions, which might bring insight into metacommunity structural and functional features. Variability of conditions, range of fluctuations and abundance of resources are also limited; thus, asking the reverse question (how life explains external variables and data tables) might be legitimate. Such analyses might show and test different higher-level relations, revealing how communities are organised and structured, how they interact and function, and how they (co)adapt to external conditions and exploit limited resources. We advanced the idea that so-called "residual variation" is a possibly valuable source of information and requires further consideration concerning its meaning in community ecology.

Another idea in our framework is the necessity and possibility of analysing variation partitioning both among predictors (as usually done) and of coexisting and interacting communities (or response matrices). Understanding interactions between communities and their relations to external descriptors also requires analysis of their simple and conditional responses, meaning discrimination between their unique and shared explained variance related to the same predictors. Thus, our approach introduces the necessity of finding ways of complete variation partitioning, meaning measuring, testing and illustrating both unique and shared effects, in matrices (data tables, arrays) of predictors as well as responses, including all related data sets, regardless of their nature, domain, type of data and role. Asking questions about how communities predict the variability in environmental features might also inspire a future quest for how different communities interfere in their relationships with external factors. We assume that a certain amount of environmental and spatial variability can sustain a specific density of interactive communities. Thus, the diversity of habitats and external factors might be linked to communities' structural, functional and niche-based diversities. This means using an unlimited number and types of explanatory data tables constraining sites and species (rows and columns).

There are several needs and urges for applying and developing these tools and concepts further. First, malacologists should recognise and include a community level approach as focal within their studies and conservation efforts. Where freshwaters are concerned, we should not focus on a single group of molluscs, or one or some species. All should be the subject of assessment and use. Particularly, projects and research should not be devoted to either bivalves (and usually the large naiads, i.e. Unionoida) and gastropods separately but to both. The same is valid when terrestrial gastropods are concerned. Thus, the species or groups of species-based

approaches should be replaced by the community-based paradigm. For this, we need to instruct and train the new generations in a broader meaning of malacology (systematics included) and, at the same time, in modern methods of quantitative ecology, applied mathematics and IT. A sound training programme should be developed for using mathematical and informatical tools devoted to multi-matrix and multi-dimensional modelling. For this, we have to build understanding, tools and methods to overcome the ecological and mathematical-informatical shortcomings for efficiently conserving molluscs and their environments. Novel concepts might be introduced and assessed by such kind of methods. For instance, next to the "niche-based diversity" and novel measures of ecological niches (Sîrbu *et al*., 2021), we have also proposed the concept of "ecological reliability" (Sîrbu & Benedek, 2018), which could be defined as a measure of the capacity of an ecological system to maintain or recover its functions when exposed to perturbing factors or after such a perturbation has altered its functional responses. In this approach, if an ecological system regains (at least partially) its former functional capacity, even though the newly established communities are different from before in terms of species composition and ecological parameters, that system can be considered as having a high value of ecological reliability. The exact method of defining, quantifying and linking this concept to functional ecology and conservation still has to be developed.

There are also other reasons for our struggle: to assess who is responsible—and how and to what extent—for the presence, abundance and composition of mollusc communities, for their responses and dynamics. Linking communities belonging to different taxa among each other and all to time and environmental gradients also requires approaches and methods rooted in multi-dimensional and multi-matrix modelling. And maybe the most important is the urgency and necessity of bringing together a multidisciplinary team of experts and building the stage for their collaboration. The work with many dimensions and matrices requires the input of data from different fields of knowledge, such as taxonomy, genetics, phylogenetics, spatial and environmental sciences, ecology mathematics, informatics and others, building and training an orchestra that has to play in harmony, synchrony and balance. One effect would be the obsolescence of the usual quarrels among scholars, such as who or what is more important in science and its applications (conservation included). In our experience, experts tend to overestimate their subjects and skills and underestimate all the others, and in some extreme variants, we have seen that (almost) everyone despises (almost) everybody else. The usual competitiveness will be replaced by a highly tolerant and collaborative network in which each field of science and discipline has to play its role and bring its load of novelty to the new integrative paradigm and related tasks. Even if stripped of other qualities, these novel methods have the ability to replace the narrow specialised, isolative science and its single-task approaches with something more complex, cooperative, objective and constructive while enhancing personal thinking, learning, questioning and evolving.

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CONSERVATION STATUS OF *SINEANCYLUS ROSANAE* (PLANORBIDAE: ANCYLINAE) IN BRASIL: A PROPOSAL

By Sonia B. dos Santos, Ximena M.C. Ovando, Luiz Eduardo M. de Lacerda & Igor C. Miyahira

Sineancylus rosanae (Gutierrez-Gregoric, 2012), was originally described from Argentina, with the Upper Iguaçu [Iguazú] River as the type locality. Recently Ovando *et al*. (2022) made the first documented record of the presence of *S. rosanae* in Brasil, in the Ocoy River (state of Paraná).

The snails were found after intensive searches in the region of Foz do Iguaçu and neighboring municipalities in the summers of 2018 and 2022. Our question was: if the species is present in the Iguaçu River, on the Argentinian side, why would it not be on the Brasilian side? One of the characteristics of science is predictability; the analysis of previous data allows us to predict possible results. After intense searches during three years (2016, 2018, 2022) in various locations, including the Iguaçu National Park, we found just one population, concentrated at a single point in the Ocoy River (where it was initially discovered in 2018) (Fig. 1).

It was not easy to find them! Among 42 collection sites surveyed, we located a single population in the Ocoy River, Medianeira municipality, state of Paraná (Ovando *et al*., 2022) (Fig. 2), adhering to black stones (Fig. 3). Some explanations for this restricted distribution can be offered: among them, the habitat change caused by the creation of the Itaipu Reservoir, which flooded the areas downstream of the tributaries (Niland, 2017). The species was originally collected in fast flowing

Fig.1. Collecting site at Ocoy River, Medianeira, Paraná, in 2022. From right to left, Luiz Eduardo M. Lacerda, Sonia B. Santos, Ximena M.C. Ovando and Leticia F. Pinto.

stretches of the Iguaçu River, allowing us to infer that it prefers lotic, highly oxygenated environments.

Restricted-range species are a priority for biodiversity conservation. Their small area of occurrence makes them intrinsically vulnerable to threats. Another issue to be considered is pollution of the surroundings, coming not only from traditional agriculture (Fig. 4) but also from recent developments related to poultry farming, because poultry waste can affect surface and groundwater if it is not adequately treated and directed (Souza *et al*., 2002; Topanotti, 2018). Another problem we observed is deforestation of the margins, which favours silting and tourist use, resulting in the accumulation of solid waste in the margins.

Thus, we propose that *Sineancylus rosanae* be included as a threatened species in the Vulnerable category (VU), for the following reasons: loss and destruction of habitats by the transformation of lotic into lentic environments, an area of occupation restricted to sites in the river with stones and rapids, and diffuse threats such as water pollution, siltation and introduction of alien species such as the snail *Melanoides tuberculata* (Müller, 1774).

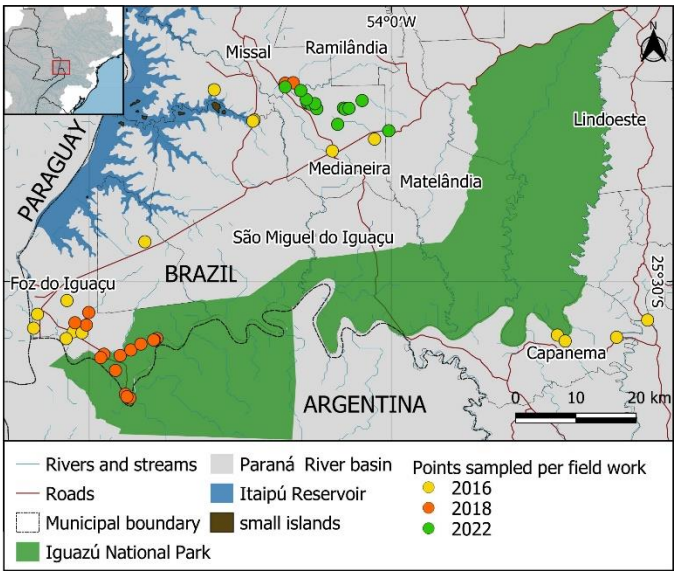

Fig. 2. Map of Southwest Paraná state showing collecting efforts to find *Sineancylus rosanae* (Gutierrez-Gregoric, 2012) in Paraná River and surroundings.

Fig. 3. Carefully removing *Sineancylus rosanae* from basaltic black stones on the Ocoy River margin.

This proposal will be submitted to the Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio) an agency linked to the Ministry of Environment (Ministério do Meio Ambiente - MMA), which coordinates the assessment of the risk of extinction of species, periodically updating the Official National List of Endangered Brasilian Faunal Species.

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CEMENTING RELATIONSHIPS FOR SUSTAINABILITY: A COLLABORATION BETWEEN INDUSTRY AND SCIENTISTS TO IMPROVE UNDERSTANDING OF LAND SNAIL DIVERSITY AND ECOLOGY IN MALAYSIA

By Thor-Seng Liew, Junn Kitt Foon, Gopalasamy Reuben Clements, Chee-Chean Phung, Pui Kiat Hoo, Yuen-Zhao Yong, Mohamad Afandi Mat Said, Lee-Peng Chong & Siti Mariam Abdul Kadir.

Industries and scientists often collaborate to promote the long-term sustainability of natural resources and ecosystems. This includes identifying ways to minimise negative impacts and conserve remaining populations (Smith *et al*., 2020). Such collaborations can help ensure sustainability of both the industry and the ecosystems. In the cement industry, for example, could companies collaborate with scientists to study the diversity and ecology of land snails? One way they could is through joint research projects. Such projects could study land snail populations in areas where cement is produced, in order to develop and implement conservation plans to protect land snail habitats within quarry sites. By sharing data and information on land snail populations and their ecological requirements, both parties could contribute to these efforts.

Malaysia is home to over 800 land snail species, many of which are endemic to limestone ecosystems (Liew & Foon, 2022). Unfortunately, Malaysia also possesses the unenviable record of the global extinction of one land snail species, *Plectostoma sciaphilum*, and an additional 28 of 75 (nearly 38 %) terrestrial animal species listed as critically endangered in the country are land snails (IUCN, 2023). This highlights the importance of protecting and restoring limestone ecosystems, which are one of the priorities in Malaysia's National Policy on Biological Diversity (NPBD) 2016-2025 (Ministry of Natural Resources and Environment, 2016). Recently, all limestone hills in Malaysia were mapped and

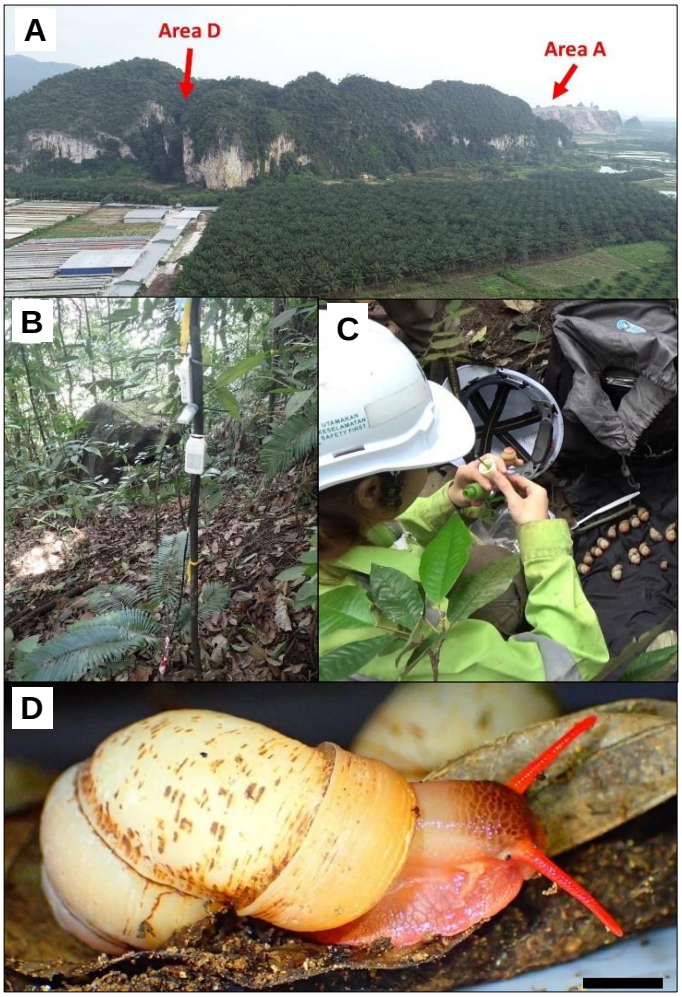

Fig 1. Gunung Kanthan and the in-situ study of *Pollicaria elephas* ecology. A – Areas A and D of Gunung Kanthan. B – Climatic data loggers installed in the plot to record ambient temperature and humidity, soil temperature and light intensity. C – Applying a capture-mark-recapture method to study population density (Photo: Donna Mae Baylis). D – An adult *Pollicaria elephas*; scale bar, 1 cm.

over 1,000 were documented (Liew *et al*., 2021a), which will help achieve part of the first key indicator of Target 7 of the NPBD: "By 2020, all vulnerable ecosystems have been mapped and by 2025, 50 % of these ecosystems are legally protected". However, the Key indicator 7.2: "By 2025, 20 % (compared to the 2020 level) of all identified degraded vulnerable ecosystems are under rehabilitation programmes" remains to be met.

In Malaysia, certain cement companies have recently shown interest in understanding and mitigating the impact of their operations on limestone ecosystems and biodiversity such as land snails, which can be sensitive indicators of the state of limestone ecosystems. While resources for research and conservation of land snails are limited, in part because of their lack of charisma, the cement industry can play an important role by providing funding for land snail conservation efforts; such funding could support research or the establishment of protected areas. Through these partnerships, scientists could contribute their expertise to help cement companies better

understand the biology and ecology of little-known, but threatened snails in their quarry sites.

Here, we share the results of our collaboration (ongoing since 2016) at one of Malaysia's limestone hills, Gunung Kanthan (Gunung = hill/mountain in the Malay language). We briefly summarise the published results from this collaboration (details are in the articles referenced). We also describe the findings from a short-term pilot project and report on ongoing research that was made possible because of the findings from the earlier published and unpublished results. Finally, we discuss some of the challenges encountered during this unique research collaboration between the cement industry and scientists.

Published research

Our first research project was a systematic species inventory study on Gunung Kanthan itself, as not much is known about its snails. Gunung Kanthan is in the state of Perak, Malaysia (4.76114°N, 101.11928°E). Limestone quarrying of Gunung Kanthan began in 1964 to supply raw materials to Malaysia's second cement manufacturing plant (Lafarge Malaysia Corporation, 2018). Area D, where Kanthan cave is located, has been designated the conservation and rehabilitation zone of Gunung Kanthan (Fig. 1).

To understand the diversity of land snails in terms of endemism and biogeography, we conducted standardised surveys in 12 other limestone hills in the vicinity of Gunung Kanthan. We concluded that limestone hills of Perak are home to diverse land snail communities, with many species unique to the region (Foon *et al*., 2017; Phung *et al*., 2018).

The material collected during the expanded inventory study not only gave us a better understanding of land snail diversity in the region, but also improved and stabilised the taxonomy. For example, two new species *Opisthostoma vermiculum* and *O. gittenbergeri*, described from the region and known only from the type locality (Clements *et al*., 2008; Vermeulen & Clements, 2008), were placed in the new genus *Whittenia* based on the additional material collected during the inventory study (Liew & Clements, 2020).The inventory study also built the foundations for a taxonomic review of the family Alycaeidae for the entire Peninsular Malaysia through its comprehensive sampling of type localities and ranges for six species in Perak: *Alycaeus conformis*, *A. gibbosulus*, *A. jousseaumei*, *Pincerna thieroti*, *Stomacosmethis perakensis* and *S. kapayanensis* (Foon & Liew, 2016; Páll-Gergely *et al*., 2020). Two new species, *Acmella paeninsularis* and *Rahula tonywhitteni*, were also discovered and described (Foon & Marzuki, 2020, 2022).

Pilot research on *Pollicaria elephas*

During the survey, we found a land snail, *Pollicaria elephas*, that occurs in large numbers only in a section of the limestone hills (Fig. 1; Area A). This gave us an opportunity to study the ecology and population of this species through in-situ and ex-situ approaches. A study of the ecology and population density of the snails was conducted in-situ in Area A (Fig. 1B-D), while growth and reproduction studies were conducted ex-situ in the cement plant nursery (Fig. 2). The in-situ study showed

Fig 2. The growth and reproduction studies were conducted ex-situ in the nursery of the cement plant next to Gunung Kanthan. A – The experimental set-up for the growth study. B – Marking scheme for juvenile shells of *Pollicaria elephas*; scale bar, 1 cm.

that: 1) the abundance of snails was positively correlated with the abundance of the four vascular plant species (leaf litter of which may be the snails' food); and 2) habitats with lower soil temperatures had more snails (Liew *et al*., 2021b).

The ex-situ study of growth and reproduction was conducted for almost a year between December 2018 and October 2019. Twelve adult snails were brought from their habitat to the nursery (Fig. 2A) and observations were made every four to six weeks. During the entire study period, only four new-born snails were recorded in the plots, between May and June 2018. The low fecundity of this snail in the nursery is consistent with our observations in the field: low numbers of juvenile snails (< 3 whorls) were found in the plots with high snail density (Liew *et al*., 2021b: File S1).

To study their growth, seven juvenile snails were taken from their habitat to the nursery, four collected on 12 December 2018 and three on 20 February 2019 (Fig. 2A). Each snail was marked with a unique ID on the dorsal side of the last whorl, using nail polish, to track shell growth (Fig. 2B). We marked the shells at this position instead of on the aperture edge, to prevent direct contact of the snail's mantle with the nail polish. Aperture and apical views of each shell were photographed after marking. All marked snails were released into the plots immediately after marking. Every 26-35 days, the snails were re-collected and the number of whorls added was recorded. Each shell was re-marked to indicate the extent of new growth. Observations ceased when the snails died or stopped growing. Based on these preliminary data, we estimated the growth rates of the juvenile snails ranged between 0.002 whorls/day and 0.004 whorls/day (Fig. 2B).

Although the growth experiment provided limited data for detailed analysis to obtain more meaningful results, they do provide baseline data to support further investigation. First, it is likely that both the reproductive and growth rates of *Pollicaria elephas* are very low. Second, based on the upper range of growth rate, it takes about 250 days for juvenile snails with a size of 4-5 whorls to grow an additional full whorl. Given that a male's shell can reach up to 6⅛ whorls and the female's can reach up to 5⅞ whorls (excluding the

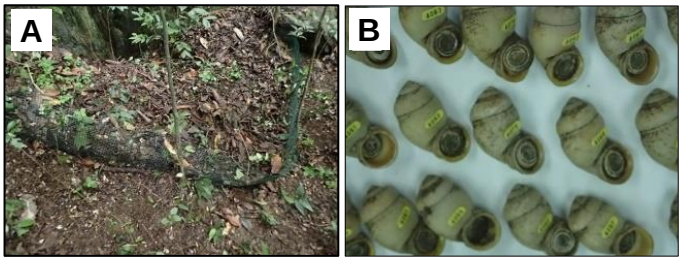

Fig. 3. A – The habitat of one of the translocation plots at Area D, bordered by a boulder on one side and fenced with wire mesh on the other. B – Translocated snails marked with flexible Hallprint polyethylene adhesive tags with unique ID.

peristome), long-term observations are needed to ascertain whether growth rate remains constant or varies with maturity.

Pilot study of translocation of *Pollicaria elephas*

Two plots in Area D where no *Pollicaria elephas* was recorded were set up (Fig. 3). The habitat at both plots is similar to plots in Area A, where the snails occur in high densities (see Liew *et al*., 2021b, for the vegetation, habitat and climatic characteristics of one of the Area D plots). Each plot is ~8 m^2. Eight snails (four females and four males) were translocated into the two plots on 12 December 2018. Thereafter, the survival of the snails in each plot and in the surrounding area was recorded on 15 January, 20 February, 20 March, 17 July, 4 September and 23 October 2019. A data logger was set up to monitor temperature and humidity in each plot. We did not observe any mortality among the translocated snails (316 days).

Ongoing research

From our studies, both published and completed pilot studies, we now have some basic knowledge of the diversity, distribution, ecology and biology of these snails on limestone hills. Notably, data on *Pollicaria elephas* are now available for the first time, including on its growth and population size, as well as on its preferred habitat regarding habitat structure, topography and climate.

Based on these data, translocations of *Pollicaria elephas*, primarily adult snails, from the quarry site in Area A to Area D were conducted (Fig. 1A). Three plots measuring 20 × 20 m and spaced about 50 m apart in Area D were set up, two of which were the pilot translocation study plots (Fig. 3). We collected live snails from Area A, cleaned and dried their shells with a dry cloth and held them in an air-conditioned room for the shells to dry. Each snail was marked with a uniquely numbered Hallprint polyethylene adhesive tag that measured 8 x 4 mm (Fig. 3B).

Two translocations to the plots were carried out, in February and October 2020, and involved 171 snails. We planned to monitor every six months for a period of four years to study mortality, dispersal and predation rates following the translocation. However, because of travel restrictions during the COVID-19 pandemic, the first resurvey could only be conducted on 21 June 2022. All live and dead snails were collected from the plots and recorded, with the live ones being returned to the plots for future monitoring. The data will be used to monitor demography, growth, reproduction and survival of the snails, and will be published in a scientific journal in the future.

Challenges faced

Our understanding of the diversity and ecology of land snails in limestone ecosystems has made significant progress as a result of our seven-year collaboration with the cement industry, which started in August 2016. The partnership began with fundamental research that examined land snail diversity in the region and subsequently delved into the ecology and biology of a specific species, which has laid the foundation for applied research on conservation efforts. We anticipate that the translocated populations will thrive as the translocation location is close to their native range, thus posing low risk and minimal potential for negative impacts on the habitat. Also, this species feeds primarily on leaf litter and is not a predator.

In many cases, such as ours, habitats with healthy land snail populations may occur in operational industrial areas and on private lands, making it almost impossible to avoid habitat loss due to extraction activities or human disturbance (e.g. Hadway & Hadfield, 1999; Stanisic, 2008; Walker *et al*., 2008). Through collaboration, industry and scientists can work together to safeguard land snail populations, while allowing continued operation of the cement industry. However, several challenges may arise from this partnership in our efforts.

It is crucial to acknowledge that some stakeholders may adopt a zero-sum viewpoint on conservation and may view the cement industry's partnership with scientists as a potential conflict of interest and as a form of greenwashing. To ensure the credibility of the research, it is essential for scientists to maintain scientific integrity and prioritise objectivity when collecting, analysing and interpreting data. In line with appropriate scientific practice, it is crucial to ensure that funders have no influence on study design, data collection, analysis, decision to publish or manuscript preparation.

The key to successful collaboration between the cement industry and scientists is the sustainability of the research programme through shared goals and resources. In our first project, both parties made efforts to overcome communication barriers and understand each other's needs and perspectives. However, the cement industry and scientists 'speak' different languages and have different work cultures, so communication must be a continuous process as management of the cement companies may change, leading to changes in their needs. Also, resources, including funding, may be limited for long-term research commitments such as monitoring translocated populations of slow-growing and long-lived land snails.

As highlighted by Liew *et al*. (2021a), Peninsular Malaysia has over 900 limestone hills. This abundance of limestone hills presents opportunities not just for conservationists to help preserve these ecosystems and their biodiversity, but also for the cement and limestone industry to meet the needs of infrastructure development in Malaysia. However, with the biodiversity of over 700 limestone hills yet to be documented, significant gaps in baseline knowledge exist. To address this, it is crucial to foster more collaborative research across many taxonomic groups to generate essential biodiversity data for

holistic conservation strategies. This will enable identification and conservation prioritisation of those limestone outcrops with the most threatened biodiversity in Peninsular Malaysia.

Overall, collaboration between the cement industry and scientists can have a positive impact on both the science of land snails and limestone ecosystems. To achieve this, it is essential to uphold scientific objectivity, maintain effective and transparent communication lines, build trust, and have a willingness to work towards the common goals of sustainability for the sake of our planet's health.

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THE SNAIL *CHILINA ANGUSTA*: A CRITICALLY ENDANGERED FRESHWATER SPECIES OF THE ATACAMA DESERT (CHILE)

By Claudio Valdovinos

Freshwater faunas are in a critical situation on a global scale, exhibiting high extinction rates that exceed those of terrestrial and marine populations. Among freshwater invertebrates, gastropods are one of the most threatened groups. Among the total number of freshwater invertebrates assessed so far by the IUCN, 65.9 % are threatened gastropods, mainly Littorinimorpha, Sorbeoconcha and Hygrophila (Valdovinos & Fierro, 2021).

Chilinidae is a family of freshwater gastropods endemic to central and southern South America. This is a monotypic group of Gondwanan origin, which includes primitive pulmonates belonging to the genus *Chilina*, phylogenetically related to the family Latiidae, which occurs in rivers in New Zealand (Jarne *et al*., 2010). Although they are pulmonates, *Chilina* species share some anatomical characters with primitive opisthobranchs. For example, in the early developmental stages of *Chilina* there is an operculum, which is subsequently lost (see Bórquez *et al*., 2015). In Chile, the family Chilinidae (etymologically derived name from Chile) occurs mainly in rivers and lakes extending over ~2,500 km from 32°S to 53°S, an extensive area in which there are

important watersheds draining the Andes (Valdovinos *et al*., 2021). Because of their high abundance and biomass in many of these ecosystems, they are one of the most ecologically relevant benthic invertebrates. Despite being mainly freshwater invertebrates, it is also possible to find them in mixohaline estuarine waters (Quijón *et al*., 2001).

One exception to the continuous distribution of this family in central and southern Chile is the small isolated population of *Chilina angusta* Philippi, 1860 ("Paposo Snail", Fig. 1), located 1,500 km further north (25ºS). The species lives in extreme isolation in an artesian freshwater spring, in the Quebrada de Paposo (QP) (25º01'47"S, 70º27'20"W), on the edge of the Atacama Desert, one of the driest areas in the world. *Chilina angusta* was discovered by Philippi (1860), who reported it at the end of the 18th century in several "wells of the Atacama coast" (without indicating specific localities). It was recorded by our research group in 1987 (133 years later), in only three small wetlands (artesian springs type) in QP. In 1996, we visited the area again, observing habitat degradation, a decrease in population size and disappearance of one of the three springs, filled as a result of flooding.

Chilina angusta was classified by the IUCN as Vulnerable, considering the information available at the time of classification. New information, however, indicates that it should be reclassified as Critically Endangered. After several failed attempts to obtain funding to explore different freshwater bodies within the Atacama Desert, in 2021 the Mohamed bin Zayed Species Conservation Fund provided US$8,000 to support an 18-month project, with the central objective of providing essential information to assess the conservation status of the species, the main threats to it and to define the main conservation actions to be taken. The present report presents the main results and recommendations of this project, which is currently being finalised (by April, 2023), with a focus on the proposed conservation actions.

A survey of the Antofagasta Region (Chile) was conducted in May and August 2022 to establish the extent of occurrence and area of occupancy of *C. angusta*, and the species was only detected in QP. A habitat assessment was carried out in QP, including surface area, physical habitat structure, discharge, water quality, sediments, periphyton, vascular flora and associated fauna. A population census of *C. angusta* was carried out, and a size frequency analysis developed, and direct observations were made on the behaviour of the snails.

The topography of the territory in which QP is located is characterised by a mountain range scarp close to the coast that reaches elevations of 1,500 m above sea level only 4 km from the sea. The adjacent coastal area is influenced by the cold Humboldt Current, which creates conditions of thick aerosol fog ("camanchaca") condensing in the higher mountain areas (Chand *et al*., 2010). In these mountainous areas, fog oasis ecosystems are generated, in which there are columnar cacti with long spines filled with lichens, which condense aerosols from the air, producing a slow dripping of water that infiltrates into the rocky soil. At cetain points this fresh water reaches deep valleys below, forming five small wetlands (artesian wells) at elevations between 295 and 375 m above sea level,

Fig. 1. *Chilina angusta* exhibiting its amphibious behaviour crawling over a mass of filamentous chlorophyte algae.

with outflow rates between 0.05 and 0.4 L/s. These freshwater runoffs travel <15 m and then again infiltrate into the ground, forming freshwater wetlands visually identified on the ground by the presence of intense green herbaceous vegetation of 1-55 m^2 in area which contrasts with the colour of the dominant exposed rock.

An extensive field exploration of the main wetlands (artesian wells) in the region was carried out, and *C. angusta* was detected only in QP. Inside this area, five small freshwater wetlands were identified, but only three contained *C. angusta*. The wetlands are in close proximity (<50 m) and evidently interconnected underground, and at different elevations within the same valley. Sometimes during rainy years there is sufficient surface runoff to connect the three sectors. Outflow from these wetlands measured in the field ranged from 0.05 to 0.40 L/s (point measurements). Because of the proximity of the three sectors and their intermittent connection, we consider this to represent a single population of *C. angusta* with three contiguous subpopulations. The three sectors are located next to (and under) a bridge on a high-traffic road that connects the coast with the Cerro Paranal Astronomical Observatory (European Southern Observatory) and the city of Antofagasta. Because of the presence of fresh water at the location, i.e. the *C. angusta* habitat, there is a small farm, including six rural cabins less than 30 m from the *C. angusta* habitat. The owners extract water mainly for irrigation of some fruit trees (mainly pears).

The estimated extent of occurrence of *C. angusta* was 25,346 m^2 and its area of occupancy was 9.6 m^2 (the latter calculated on the basis of the three subpopulations). The distribution of the species is outside official wildlife protection areas. The nearest reserve is the Monumento Natural Paposo Norte, 65 km north of QP. The population density in the area of occupancy ranges from 67 to 3,297 individuals per m^2. Most individuals were immature juveniles (~95 % had a maximum shell length <7 mm).

The structure of the physical habitat of the three wetlands is highly modified by anthropogenic activities, principally 1) construction of a well for agricultural water storage (6.5 m diameter, 0.5 m deep), 2) construction of a road bridge that changed the natural runoff channel, 3) construction of a 7 m

Fig. 2. One of the three areas of the Quebrada de Paposo, in which *Chilina angusta* survives. The road and solid residues from traffic accidents are shown (the photo in Fig. 1 was taken at this site).

wide dike at the base of the valley to store water and supply the village of Paposo (currently completely clogged with sediment and not in use, 4) large deposits of solid waste on one of the three sites, as a result of multiple road accidents that have affected the aquatic and riparian habitat (Fig. 2). Regarding water quality, one relevant parameter is salinity, which was elevated for a typical freshwater ecosystem, ranging from 3.2 to 5.8 PSU. Salinity is an important consideration in the development of a captive breeding programme for the species. Ranges of other water quality parameters were as follows: temperature 15.4-17.9 ºC, pH 7.0-8.1, dissolved oxygen 7.4-10.0 mg/L, turbidity 1-3 FTU, total suspended solids 1.0-2.8 mg/L, nitrate 0.10-0.15 mg/L and orthophosphate <0.02 mg/L.

The banks of the areas inhabited by *C. angusta* are generally surrounded by a thick mattress of low grass caused by grazing (mainly donkeys and goats), in which there are small channels with muddy bottoms through which the water drains. Individuals of *C. angusta* have a clear preference for flowing water but are also seen in areas of shallower water (<10 cm deep). The species also has an amphibious behaviour similar to other Chilinidae; it is common to see individuals out of water for 2-3 hours, always in humid areas. This species occurs on a wide range of aquatic substrates, including soft bottoms of sand and mud, hard substrates of semi-submerged rocks or concrete dikes, biological substrates constituted by riparian grasses with their roots in the water and masses of filamentous green algae, and solid waste, mainly metals and plastic in contact with the water and derived from the many road accidents in the surrounding area. Like other species of the family, *C. angusta* has a broad foot, which allows it to move easily over soft sandy and muddy bottoms, leaving clearly recognisable tracks. When the sediment of the bottom is very soft, they can move semi-buried. They do not have the ability to move through the water by flotation, as do many Physidae and Lymnaeidae.

Chilina angusta is found in both shaded and sunny areas, grazing on periphytic microalgae. Various species of diatoms dominated the stomach contents. The species coexists with the snail *Heleobia* sp. (Cochliopidae), but with clear microhabitat segregation. *Heleobia* sp. has preference for filamentous chlorophyte algal mass habitats, on which *C. angusta* is scarce. *Heleobia* sp. was recorded in most aquatic ecosystems in the region, which suggests that it has a high dispersal capacity compared to *C. angusta*. Field observations suggest that dispersal of *Heleobia* sp. occurs through occasional consumption by passerine birds. Unlike *C. angusta*, the fusiform shape of *Heleobia* sp., its small size and presence of an operculum, may allow it to travel from one wetland to another inside the digestive tract of the birds. Other benthic macroinvertebrates abundant in the area include immature stages of aquatic insects of the families Baetidae (Ephemeroptera), Chironomidae (Diptera), Simuliidae (Diptera) and Anysoptera (Odonata). Talitridae (Amphipoda) crustaceans and Lumbriculidae (Oligochaeta) worms are also common. The only species of aquatic vertebrate found in the area is the anuran amphibian *Rhinella atacamensis* Cei, 1962 (Bufonidae), that lays its eggs in the green filamentous algae. Swimming larvae of these amphibians are common in the area. No fish or aquatic macrophytes occur in the habitat of *C. angusta*. However, the introduced fish *Gambusia holbrooki* Girard, 1859 (Poeciliidae) and the introduced macrophyte *Potamogeton pusillus* (Linnaeus, 1753) (Potamogetonaceae) have been recorded in an artificial well used by the mining industry, 3.5 km above the *C. angusta* habitat within QP. It is probable that water trucks transporting water from one well to another for mining activities and road construction are spreading these invasive species. These non-native species represent a potential threat to *C. angusta*, as it is highly likely that they will invade its habitat. The principal predators of *C. angusta* are apparently birds, amphibians and rodents.

Similar to *Chilina dombeiana* (Bruguière, 1789) (see Bórquez *et al*., 2015) and other species of the order Hygrophila (see Jarne *et al*., 2010; Nakadera *et al*., 2014), *C. angusta* is a simultaneous hermaphrodite, capable of self- and/or cross-fertilisation. Their egg clutches can be observed from late August (late winter) to February (mid-summer).The clutches are small, tightly folded and compact gelatinous belts (8-15 mm long) attached to hard substrates in the water (including *C. angusta* shells). Each clutch develops 40-120 embryos, which have characteristics typical of Chilinidae (see Bórquez *et al.*, 2015).

The aquatic ecosystem inhabited by *C. angusta* is surrounded by steep mountains in an area of high seismic activity. The slopes are very unstable because of the presence of highly fractured rocks and free materials that are susceptible to landslides and the generation of alluvium with rocky debris flows. The main triggering factor is extremely intense and short duration rain that removes the material from the slopes. An estimated rainfall of over 30 mm in 24 h is sufficient to generate alluviums, which mainly occur in the winter period of the El Niño event phase. Debris flows are a major threat to existing populations of *C. angusta*, as they severely disturb the ecosystem by filling the aquatic habitat with sediment. The regional climate is arid and stable, with a mean annual rainfall of 0.6 mm/year and temperatures of 15-25 ºC. In some years no rain occurs, but other years have brief rain events, disturbing *C. angusta* significantly. As an example, one of the

two populations surveyed in 1987 was extirpated and absent in the 1996 survey. This was because of the disappearance of the aquatic habitat in the sector in 1991, caused by an intense flood following a 54 mm rainfall on 18 June 1991 (currently, one of the two populations recorded in 1987 persists, with three subpopulations). The last relevant alluvium in QP occurred in 2015 and it is expected that with global climate change their frequency and intensity will increase.

In addition to natural floods that impact the area, there are other threats of anthropogenic origin. These freshwater areas have been historically inhabited by small aboriginal communities called Camachangos (fog people) since at least 7,000 years BP. At present, the closest population center to QP within a 50 km radius is the village of Paposo, on the coast 3 km from QP. Paposo is a fishing village of about 450 people that originally depended on water collected from QP. Fresh water is so important in the area that the word Paposo in the Kunza language means "place of crystalline waters" because of the freshwater wells on which it depended. More recently, Paposo is supplied with fresh water for human consumption by a reverse osmosis sea water desalination plant (since 2013). This has reduced freshwater withdrawal from QP. However, it continues to obtain water mainly for irrigation, which is still a threat to *C. angusta.*

The principal ten threats identified and the possible conservation actions are the following.

Floods and climate change

High rainfall associated with El Niño produces natural flooding that severely disturbs the habitat. The regime of such disturbances is changing as a result of global climate change. Recommendations: 1) Breeding in captivity for repopulation of the original habitat and/or ex-situ conservation; 2) Migration assisted to other sectors of the region with suitable habitats (they may require prior restoration measures); 3) Develop measures to restore the physical habitat filled with sediments by the flooding.

Irrigation

Withdrawals of water for irrigation of fruit trees, vegetables, gardens and livestock, existing in the immediate area and in the coastal area at the base of the valley; the presence of an artificial well (6.6 m diameter) and a concrete dike (currently clogged, 7 m wide), for water storage and distribution. Recommendations: 1) Restrict water withdrawals for irrigation to volumes that do not affect the hydric balance of the ecosystem, establishing a "minimum ecological flow"; 2) Satellite monitoring of the discharge; 3) The water withdrawals should be carried out in the runoff downstream of the habitat and not in the water source sectors; 4) Do not carry out cleaning or other manipulation of the well and dike, since each contains a subpopulation of *Ch. angusta* (it is probable that the survival of the species has been favoured by these two structures).

Changes in land use

There is increasing settlement in the direct surroundings of the habitat (construction of cabins) and expansion of subsistence farming activities. Recommendations: 1) Develop an integrated management plan for the *C. angusta* habitat and its surroundings, in collaboration with the community, based on an ecosystem and watershed approach; 2) Designate the area as an "urban wetland" in the Taltal commune in order to protect it through Chile's Urban Wetlands Law 21,022; 3) Incorporate the area into Chile's Paposo Norte Natural Monument protected wildlife area, to be protected by Chile's National Forestry Corporation (CONAF).

Solid waste

A road bridge over part of the habitat is located on a sharp curve with a steep slope. As a result, there have been 15 vehicle overturns and their cargo in the habitat (one bus, two heavy trucks and 12 automobiles), causing the accumulation of tons of solid waste (metals and plastics). Recommendations: 1) An immediate action is the manual removal of smaller solid waste (<40 kg); 2) Design in detail and execute a plan to remove the destroyed vehicles and other major waste (this activity should be carried out carefully so as not to generate greater damage to the existing damage); 3) Until an adequate plan for cleaning the area guided by specialists exists, it is recommended not to attempt to remove the solid waste so as not to do additional damage to the ecosystem.

Building sanctuaries and religious processions

Because of accidents (see above), there have been 25 deaths in the habitat of *C. angusta* in the past 10 years. Family members have created a sanctuary a few meters from the wetland and they visit it massively on some days of the year. Recommendations: 1) Demarcate the area that may not be visited so as not to affect the aquatic and riparian ecosystem; 2) Provide signals with information about the importance of conserving *C. angusta* and its ecosystem; 3) Provide trash containers in the sanctuary to prevent disposal of waste (it should be removed periodically); 4) Prohibit bathing and taking water from the wetland; 5) Prevent the free entry of pets into the area.

Road construction

In order to access the religious sanctuaries (see above), the construction of gravel roads, vehicle parking areas and landfills has been occurring on the edges of the wetland. Recommendations: 1) Prevent construction of new roads and new parking spaces around the area; 2) Removal of some of debris that has been dumped in some of the wetland's riparian sectors.

Recreation

Because of the extreme aridity of the region, people visit the area all the time for recreation. They also make campfires for cooking, increasing the risk of fire in the scarce vegetation and the accumulation of waste. Recommendations: 1) Prohibit lighting fires; 2) Prohibit disposal of waste; 3) Provide information about campfires and waste disposal.

Livestock grazing

There are feral donkeys (without owners) in the area, which in a variable number of 1-5 disturb the grasslands by trampling and overgrazing (occasionally grazing by goats has also been

observed). Grasses create a 'sponge' of roots saturated with water, regulating water flows that can be altered. Recommendations: 1) Avoid bringing donkeys and other large grazers into the area (except the guanaco, which is native); 2) Fence off the most sensitive areas.

Thermoelectric generation

There is a 370 MW diesel thermoelectric power plant 2.7 km from the wetland (Central Termoeléctica Taltal, ENEL), mainly to supply the mining industry. It generates sulphur dioxide (SO_2) atmospheric emissions that may acidify the wetland, producing, among other potential effects, decalcification of the shells and increased toxicity of heavy metals. The estimated SO_2 emissions of this power plant are 3,000 metric tons yr^{-1} (Chand *et al*., 2010). There is also a risk of diesel oil spillage over the wetland because tanker trucks cross the area. Recommendations: 1) Tanker trucks transporting diesel oil in the vicinity of the area should operate at less than 20 km/h (downhill direction) to avoid accidents involving oil spills in the wetland (this requires installation of visible signage and speed control by photoradar); 2) Permanently monitor SO_2 to detect atypical pH changes; 3) Ex-situ captive breeding in case of catastrophic loss of the field population.

Mining

The main economic activity in the area is iron mining (the nearest mine is 8 km from the site). This generates heavy truck traffic in the vicinity of *C. angusta* habitat, with risk of accidents and chemical contamination. Also, tanker trucks sporadically extract fresh water, with the risk of spreading invasive species (*Potamogeton pusillus* and *Gambusia holbrooki*). Recommendations: 1) Monitoring the presence of invasive aquatic species and develop eradication protocols if detected; 2) Control the speed of trucks (see above).

The main conclusions of the project are the following. 1) *Chilina angusta* is subject to serious conservation threats, as stressors of natural and anthropogenic origin are combined with its intrinsic vulnerability. This vulnerability depends on the combined effects of reduced geographic range, scarce habitat, low vagility and low population density. 2) Ten main threats currently affecting *C. angusta* were identified, many of which may act in combination and have synergistic effects. 3) *Chilina angusta* therefore qualifies according to the IUCN criteria (version 3. 1), as Critically Endangered (CR, B1ab(iii) + 2ab(iii)). 4) There is thus an urgent need to adopt conservation measures to prevent extinction of the species.

I thank my recently deceased teacher, Dr. José Stuardo B. (Ph.D. Harvard), with whom I began the study of *Chilina angusta* and shared more than 30 years of fascination with molluscs. I also thank the Mohamed bin Zayed Species Conservation Fund for financing project No. 212527355.

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CONSERVATION OF SIX CRITICALLY ENDANGERED LAND SNAILS SPECIES FROM TENERIFE (CANARY ISLANDS: SPAIN)

By Dinarte Teixeira, Marco T. Neiber & Klaus Groh

In 2022 a joint initiative of the Loro Parque Fundación (Tenerife), the IUCN SSC Mid-Atlantic Islands Invertebrates Specialist Group (MAIISG) and the Universidad de La Laguna (ULL) started a three-step conservation approach addressing the six critically endangered land snail species of Tenerife (Canary Islands, Spain) listed by the IUCN (Groh & Alonso, 2011a-c; Groh & Neubert, 2011; Groh, 2017; Neiber, 2019).

These island endemics have small distribution areas, usually restricted to a single location, sharing threats and pressures such as habitat fragmentation and decline, and are currently on the brink of extinction.

The goal was to collect updated information about the endangered species, assess their conservation status, report and discuss the results with the local conservation authorities to support future conservation strategies and to train local experts.

In February 2022, a targeted survey of 50 sites was conducted on Tenerife (Fig. 1) to identify the current conservation status of the relict endemic snail species *Hemicycla modesta*, *H. mascaensis*, *H. plicaria* (Helicidae), *Insulivitrina reticulata* (Vitrinidae), *Napaeus teobaldoi* (Enidae) and *Keraea garachicoensis* (Geomitridae) (Fig. 2).

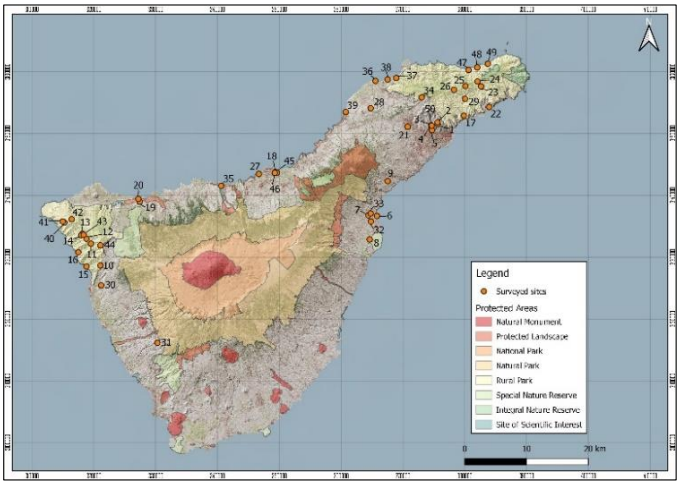

Fig. 1. Site locations in Tenerife, where surveys were conducted.

As a result, all target species, except *K. garachicoensis*, were re-discovered in vital populations, enabling redefinition of the species' distributions (extent of occurrence and area of occupation) and evaluation of their conservation status and extinction risk. This information is available in the report of Portolés & Delponti (2022).

From a broader perspective, 71 terrestrial and two freshwater gastropod species were found at the 50 sites studied during this survey, roughly representing two-thirds of the terrestrial species diversity known from Tenerife. In addition, new records for Tenerife were made, namely *Microxeromagna lowei* (Potiez & Michaud, 1838) and two *Napaeus* species, which are probably new to science.

In November 2022, a conservation workshop was organised in Tenerife involving the governmental conservation authorities, local experts and other conservation stakeholders to discuss the results reported and to plan future species conservation actions and strategies. As a result, an annual monitoring scheme directed at the target species will be conducted, during which species distributions, population sizes and trends, ecology, and habitat conservation data will be collected. This

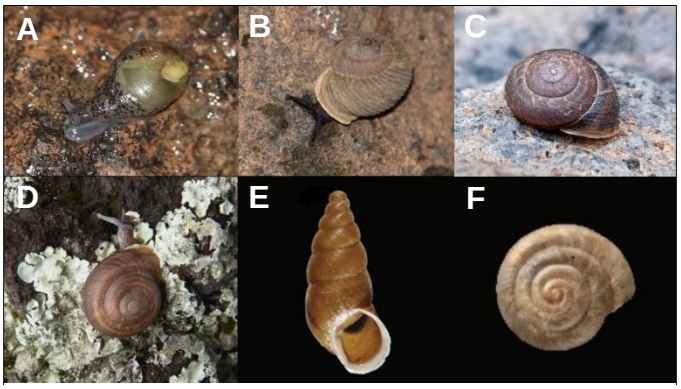

Fig. 2. Critically endangered land snail species targeted by the project: A – *Insulivitrina reticulata* (Photo: C. Renker), B – *Hemicycla plicaria* (Photo: C. Renker), C – *Hemicycla modesta* (Photo: C. Renker), D – *Hemicycla mascaensis* (Photo adapted from Portolés & Delponti, 2022), E – *Napaeus teobaldoi* (Photo adapted from Yanes *et al*., 2009), F – *Keraea garachicoensis* (Photo adapted from Holyoak *et al*., 2011).

Fig. 3. Exibithion in Santa Cruz de Tenerife, addressing Tenerife's six critically endangered species.

information will then be used to evaluate the species' conservation status, available on the BIOTA database, the Canary Islands Biodiversity Database. Parallel to the workshop, an exhibition with large-format images of the target species (Fig. 3) was opened in the Sala del Parque García Sanabria in Santa Cruz de Tenerife and short films on the spring activities were shown.

Furthermore, in collaboration with the ULL and the Loro Parque Fundación, a training workshop was implemented in November 2022, involving 18 masters students from ULL, addressing gastropod systematics, taxonomy, species planning and conservation. In the course of a week, they learned baseline theoretical concepts and practical tools to support their future initiatives in molluscan conservation.

Finally, we wish to acknowledge the support of the local authorities—Ayuntamiento de Santa Cruz de Tenerife, Ayuntamiento de Candelaria and Cabildo Insular de Tenerife—for providing the necessary collection licenses and financial support. In addition, we are thankful for the financial support of the Loro Parque Fundación and the Molluscan Science Foundation, Inc., Owings Mills, Maryland, USA. We also thank the masters students of the ULL Faculties of Edaphology and Geology and those from Communication Sciences and Social Work for their support during the fieldwork. Finally, we are grateful for the logistic support of AutoReisen rent a car and GIGANSA, which provided transport during the field surveys, and the Museo de Ciencias Naturales de Tenerife for access to the collection.

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PACIFIC ISLAND LAND SNAILS – AND EX-SITU BREEDING PROGRAMMES AROUND THE WORLD

Preventing extinction: the past decade of snail conservation at Chester Zoo

By Kieran Richardson, Heather Prince, Katie Kelton, Karen Lambert, Tamas Papp & Gerardo Garcia

Terrestrial molluscs are among the most widely threatened of all organisms, with some research suggesting around 50 % of all known extinctions since the year 1500 are molluscs, with the vast majority of these being terrestrial (Régnier *et al*., 2009). Many are island endemics threatened by invasive species, but habitat loss and over-collection also threaten terrestrial molluscs in a range of environments. Their small size and rapid reproduction make many threatened snails ideal candidates for ex-situ conservation in zoos. This article summarises the snail conservation work undertaken by the team at Chester Zoo over the last ten years.

The best long-term example of terrestrial mollusc ex-situ conservation has been the Polynesian tree snails of the genus *Partula*, and it was with these species that Chester Zoo began working. Long studied as an example of island biodiversity, partulids speciated into a range of niches across islands in the Pacific (Cowie, 1992). Unfortunately, the predatory rosy wolfsnail, *Euglandina rosea* (now known to be a species complex; Meyer *et al*., 2017), was introduced across the Pacific to control the giant African land snail, *Lissachatina fulica*. *Partula* species had no defence against this predator, and rapidly declined, with many species becoming extinct in the wild (Clarke, 2019). Fortunately, populations of some *Partula* species were brought into captivity and have been maintained since the 1980s as part of an international conservation programme. Chester began working with *Partula* species in 1989. Colonies were initially housed in plastic breeding boxes, off-display within the Zoo's tropical house. These were replaced with glass tanks in 2005 in line with rearing practices in other zoos involved in *Partula* ex-situ conservation. In 2012, Chester Zoo was working with 5 *Partula* species (Table 1) with a sixth, *P. rosea*, joining the collection in 2016. However, there was no direct involvement in reintroduction efforts prior to this, and the decision was made to focus on the species from the island of Huahine, *P. varia* and *P. rosea*, sending the other species to other collections involved in the international *Partula* programme. Initially the husbandry of these delicate snails, sensitive to minor changes in environmental conditions, proved challenging; however eventually the zoo built up large thriving populations of both species. Meanwhile in-situ partners within the International Partulid Conservation Programme, after long-term monitoring of populations of both rosy wolfsnails and an emerging invasive predator, the flatworm *Platydemus manokwari*, had begun to identify sites where *Partula* may be able to survive. Preliminary surveys on Huahine found *P. manokwari* was abundant and widespread, but the presence of live leaf litter snails and absence of flatworms in the trees or anywhere except under rocks, rotting logs and coconuts suggested that they should be no more of a menace on Huahine than on Tahiti or Moorea where they exist in similar habitats and densities, and where reintroductions have been able to establish *Partula* populations (Clarke,

Table 1. Land snail species Chester Zoo has worked with.
* reintroduction carried out

Species	Location	Period
*Partula varia**	French Polynesia	1989-2021
P. tohiveana	French Polynesia	1989-1996
P.suturalis vexillum	French Polynesia	1989-1998
P. taeniata elongata	French Polynesia	1989-2002
P. mirabilis	French Polynesia	2000-2015
P. hyalina	French Polynesia	2004-2014
P. otaheitana	French Polynesia	2005-2007
P. faba	French Polynesia	2005-2006
P. taeniata nucleola	French Polynesia	2010-2016
P. affinis	French Polynesia	2010-2015
*P. rosea**	French Polynesia	2016-2021
*Poecilozonites bermudensis**	Bermuda	2016-
*P. circumfirmatus**	Bermuda	2017-
Bertia cambojiensis	Vietnam, Cambodia	2017-
Discula lyelliana	Desertas, Madeira	2021-
Geomitra grabhami	Desertas, Madeira	2021-
Atlantica calathoides	Desertas, Madeira	2021-
Platymma tweediei	Malaysia	2022-
Geomitra coronula	Desertas, Madeira	2023?-

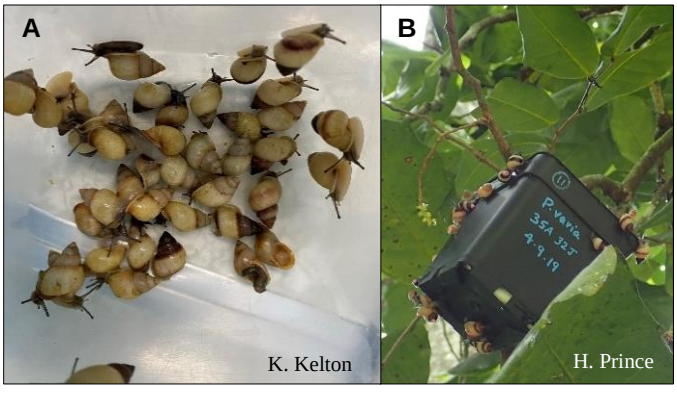

Fig. 1. *Partula varia*. A – undergoing a census at the zoo; B – dispersing into the trees on Huahine during their reintroduction.

Fig. 2. Invasive flatworm *Platydemus manokwari* preying on a just reintroduced *Partula varia* on Huahine, French Polynesia.

Fig. 3. Zoo-bred *Poecilozonites circumfirmatus* clustered on a piece of cuttlebone.

2019). In 2019, with release sites having been identified on Huahine, a total of 2,240 *Partula varia* and *P. rosea* bred at Chester Zoo were reintroduced into the wild on Huahine (Fig. 1). Monitoring has been impeded by the COVID-19 pandemic, but the surveys immediately after the reintroduction showed that the *P. manokwari* did access the trees, predation of released *Partula* was observed (Fig. 2) and it seems both species may have failed to establish (Coote & Taputuarai, 2020). With these discouraging results and the impossibility of removing invasive flatworms, Chester Zoo decided to stop participation in the reintroduction programme in Huahine in 2020.

After many years of working with *Partula* and gaining experience, in 2016 Chester Zoo became involved with the conservation of the recently rediscovered greater Bermuda land snail, *Poecilozonites bermudensis*. Although abundant in the Bermudian fossil record, the endemic land snails of the genus *Poecilozonites* declined sharply in the 20th century because of habitat destruction and the introduction of invasive predators to Bermuda, including, as with the *Partula* snails, the rosy wolfsnail (Outerbridge *et al*., 2019). *Poecilozonites bermudensis* was believed to be extinct, having last been seen alive in the 1990s, and the smaller *P. circumfirmatus* was thought to be extinct in the wild, having last been seen in 2004 when individuals were brought into captivity (Outerbridge *et al*., 2019). In 2014 *P. bermudensis* was unexpectedly rediscovered in an alleyway in the city of Hamilton, and some were brought into captivity. Both *Poecilozonites* species were assessed as Critically Endangered on the IUCN Red List in

Fig. 4. The biosecure snail breeding facilities at Chester, showing enclosures for *Poecilozonites* land snails from Bermuda.

2019 (Outerbridge *et al*., 2021). Chester received 60 *P. bermudensis* from the Zoological Society of London (ZSL) in 2016, and 60 *P. circumfirmatus* from the ZSL in 2017. Both proved much less sensitive than *Partula* and began to breed well (Fig. 3) after their enclosures were changed from the sterile setups recommended for *Partula* breeding to more natural systems. As a result of this, in 2019 18,000 Chester-bred *P. bermudensis* were returned to Bermuda to be released and establish new populations in areas free of invasive predators. In February 2020, in addition to more *P. bermudensis* exports, the zoo was able to send 950 *P. circumfirmatus* back to Bermuda and confirm the successful breeding of previously released *P. bermudensis* (Outerbridge *et al*., 2021). That summer the snails at the zoo were moved to a custom-made off-display snail breeding facility (Fig. 4). The 'snail pod' is essentially a converted shipping container, climate-controlled to allow for the re-creation of wild conditions for optimum breeding and divided with sliding doors down the middle to allow separation into two separate areas for different breeding-for-reintroduction projects. There is an emphasis on biosecurity, with hand-washing points on entry and specific overalls and footwear to be worn by zoo staff while servicing the snail enclosures. The importance of biosecurity in these projects is paramount, as there is a risk of harming wild populations further by reintroducing novel parasites or diseases along with captive-bred snails, and as parasites have led to the extinction of snail species maintained only as captive colonies in the past (Cunningham & Daszak, 1998). These new facilities are separate from any other areas of the zoo housing invertebrates, allowing the team at Chester to minimise the risk of disease transmission between species while also increasing the space for the snail species being worked with for direct reintroductions back to the wild. This development coincided with the onset of the COVID-19 pandemic, which, as everywhere else, had a considerable impact on the team at Chester, with reduced staffing making animal care more difficult. There was no possibility of exporting snails for reintroduction after February 2020 and coupled with the new facilities this led to a rapid increase in their populations, particularly *P. bermudensis*; large reintroductions were therefore possible once restrictions eased.

Fig. 5. *Bertia cambojiensis*. A – adult, shell width ~70 mm; B – one-week-old hatchling, shell width ~14 mm

Fig. 6. Hatchlings of two of the Critically Endangered endemic Desertas Islands snail species under an optical microscope. A – *Discula lyelliana*, shell width 1.6 mm; B – *Atlantica calathoides*, shell width 1.4 mm.

The scale of the Bermuda snail project has continued to grow and to date, across both species, more than 111,000 Chester Zoo-bred snails have been reintroduced in Bermuda at over 20 sites, with ongoing monitoring, using marking techniques trialled at the zoo, confirming the successful establishment of populations at many of these sites.

Simultaneously with the Bermuda programme, Chester Zoo began working with another Critically Endangered species, the giant magnolia snail (*Bertia cambojiensis*). This snail, the largest known from Southeast Asia, was first described in 1860 (Hun *et al*., 2019). The species was then lost to science for over 150 years and considered extinct until its rediscovery in Cat Tien National Park in Vietnam in 2012 (Naggs, 2014). It was assessed as Critically Endangered because of its very limited range and the threat posed by over-collection for food and the shell trade, although its known range has since been expanded by its rediscovery at a site in Cambodia, near the Vietnamese border (Hun *et al*., 2019). Chester Zoo received individuals of this species from the ZSL London in 2017. They first reproduced in Chester in 2018 and have bred regularly since. This large, striking snail (Fig. 5) poses several challenges, including needing large quantities of fresh leaf litter that must be changed regularly, and high protein and calcium requirements that fuel the exceptionally fast growth rates of juveniles. Chester Zoo has now achieved the breeding of an F2 generation, and with 80 individuals is maintaining more than two thirds of the European population. Husbandry guidelines for this species are currently in preparation, to enable other collections to assist with its breeding and preservation.

In 2021, with the easing of COVID-19 restrictions, another project was able to begin, with the arrival of some endemic snail species from the Desertas Islands, in the Madeiran

Fig. 7. A petri dish for rearing hatchlings of *Geomitra grabhami.* The hatchlings are just visible on the cuttlebone on the left.

archipelago. The Desertas Islands, like elsewhere in Madeira, have a rich fauna of native land snails, many of which are endemic. However habitat loss through deforestation and overgrazing by goats, as well as predation by invasive mice, have driven up to 50 % of the Desertas' native snails locally or globally extinct (Cameron *et al*., 2021). Four endemic species, all believed extinct, were rediscovered between 2008 and 2018. All had very small populations of fewer than 50 adults, so were listed as Critically Endangered on the IUCN Red List (Teixeira, 2021a) and a rescue project was launched, a collaboration between IFCN Madeira, the Mid-Atlantic Island Invertebrate Specialist Group (MAIISG) of the IUCN SSC, Mossy Earth, Chester Zoo and the Bristol Zoological Society (BSL) (see the article by Dinarte Teixeira *et al*. beginning on page 51 of this issue of *Tentacle*. In spring 2021, the first two species, *Discula lyelliana* and *Geomitra grabhami*, were collected from the wild on Deserta Grande and brought to Chester, where they were housed in the biosecure snail breeding facility. These were followed later the same year by a third species, *Atlantica calathoides*. The natural history of each species was little-known because of the difficulties of studying these small species in the wild, so the team had to experiment, tweaking the husbandry and parameters as they went. All three species have now bred at the zoo (Teixeira, 2021b; Fig. 6), and the care and rearing of the very small hatchlings posed additional challenges, which required innovations such as the use of petri dishes (Fig. 7). Numbers have now grown significantly from the founding groups of 30-40 individuals of each species, providing vital ex-situ populations that can act as insurance against extinction and also a source for potential future reintroductions, once ongoing invasive species eradication and habitat restoration have been completed on Deserta Grande. The fourth species, *Geomitra coronula*, was not found in sufficient numbers in either 2021

Fig. 8. *Platymma tweediei*, the Malaysian fire snail, a species threatened by habitat loss and overcollection in Malaysia.

or 2022 to start a captive population, so establishing this species ex-situ remains a future target for the project.

Looking forward, there are a number of upcoming developments to Chester Zoo's snail conservation work. The captive breeding of *Poecilozonites* spp. will continue, with a main focus on breeding more lesser Bermuda land snails, *P. circumfirmatus*, for reintroductions. Breeding of Critically Endangered Desertas endemics will continue, with ongoing research into their husbandry leading to the dissemination of information on each species' biology that would be difficult to obtain in the wild. The three Desertas species already at Chester will hopefully be joined by *Geomitra coronula* in 2023, and these captive populations will be vital for future reintroductions back to the Desertas once habitat restoration has been undertaken. The publication of husbandry guidelines for both species of Bermuda snails as well as *Bertia cambojiensis* is planned for this year, enabling collaboration with in-country partners and other zoos, as well as aiding the development of a EAZA (European Association of Zoos and Aquaria) EEP (European Ex-situ Programme) for *B. cambojiensis*. Our latest project, which began in 2022, is for the fire snail *Platymma tweediei* (Fig. 8), a highly colourful species endemic to the cloud forests of Peninsular Malaysia, seemingly highly threatened in the wild by habitat loss, logging and over-collection (Foon, 2014). Chester received a group of adult specimens in 2022 which then laid eggs, and hatchlings are now being reared (Fig. 9). The aim with this species is to draw on the team's extensive experience with other snail species to breed it and establish a robust self-sustaining captive population, alleviating the pressure on this species in the wild.

We thank our partners in all our snail conservation projects: the teams at the Department of Environment of Bermuda, Bermuda Zoological Society, IFCN Madeira, Service Direction de l'environnement de la Polynésie Française, the MAIISG of the IUCN SSC, Mossy Earth, ZSL, BSL and the Partulid Global Species Management Programme.

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Fig. 9. Newly hatched Malaysian fire snail (*Platymma tweediei*), shell width 4.5 mm. Note the green colouration from food in the stomach through the translucent shell.

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The land snail fauna of the Kita-iwo (Kazan Islands) and its current status

By Shinichiro Wada, Hideaki Mori & Satoshi Chiba

The Ogasawara Islands in the northwest Pacific harbour more than 100 species of endemic land snails, which have made significant contributions to evolutionary biology and are well-known for their high conservation significance (IUCN 2011; Chiba & Cowie, 2016; Cowie, 2022). Numerous conservation programmes have been implemented for these endemic land snails, which have been threatened by invasive non-native predators (Mori *et al*., 2020). In contrast, the land snail fauna of the Kazan Islands, located 200-300 km south of the Ogasawara Islands, is less well-known.

The Kazan Islands comprise three islands, from north to south: Kita-iwo (Kita-iwo-to), Iwo (Iwo-to), and Minami-iwo (Minami-iwo-to) Islands. While the Ogasawara Islands are older islands, formed millions of years ago, the Kazan Islands are newer volcanic islands formed after the Middle Pleistocene (Umino *et al*., 2009); recorded volcanic activity 140 ± 50 thousand years ago (Nakano *et al*., 2009) is in accord with this. The species composition of the land snail fauna of the Kazan Islands remained largely unknown until the 21st century, when land snail surveys began, in 2007. Although a preliminary examination was conducted on Kita-iwo prior to World War II, its scope was quite restricted and only two species (*Elasmias kitaiwojimanum*, *Lamprocystis hahajimana kitaiwojimana*) were recorded (Kuroda, 1930; Habe 1969).

Kita-iwo Island, the northernmost island of the Kazan Islands, boasts the highest point at an elevation of 792 m, and a cloud forest has formed on the upper part of the island (Fig. 1). The island was settled and inhabited before World War II, but has been uninhabited since the end of the war. Surveys of land snails of Kita-iwo were conducted in 2008 by Satoshi Chiba and Shinichiro Wada, and in 2018 by Wada and Hideaki Mori (Chiba & Wada, 2008; Wada & Mori, 2021). As a result, eleven species of land snails were recorded (Table 1). At least three of these species are non-native, and supposed to have been introduced before World War II. However, the others are thought to be native to Kita-iwo. One species is believed to be endemic to the island. Five of the eight native species are also found on the Ogasawara Islands. The commonality with the land snails of the Mariana Islands is unknown.

The undescribed species *Elasmias* sp. is believed to be endemic to Kita-iwo and its close relative, *E. kitaiwojimanum*, is also present on the island. This species is also distributed across the Ogasawara, Izu and Daito Islands. Three other achatinellid species, *Pacificella hataiana*, *Tornatellides tryoni* and *Lamellidea* sp., are abundant in the lowland parts of the island. The largest land snail species found on Kita-iwo, *Lamprocystis hahajimana*, is primarily located in sites above 700 m in elevation. While this species is also present in the lowland regions of the Ogasawara Islands, it is restricted to small areas near the summit on Kita-iwo.

Nipponochlamys chaunax, a species of particular conservation significance on Kita-iwo, is commonly found in cloud forests above 500 m in elevation and is primarily arboreal. This

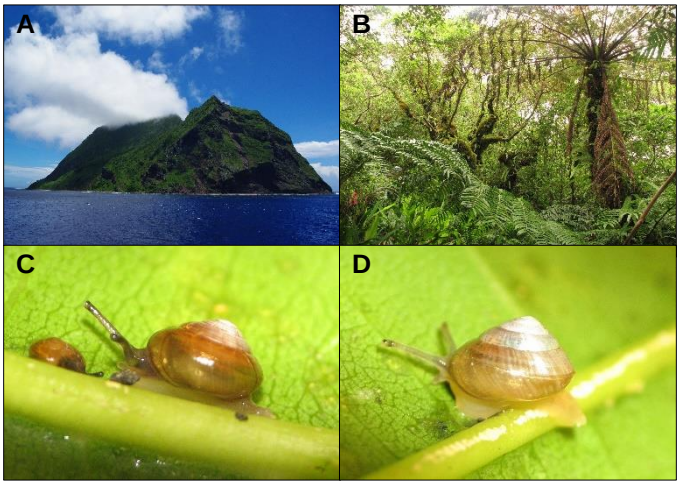

Fig. 1. A – Kita-iwo Island; B – cloud forest at 700 m; C – *Nipponochlamys chaunax*, flat type; D – *N. chaunax*, conical type.

species is prevalent on the leaves and trunks of *Boninia grisea* and *Elaeocarpus sylvestris*, and is also found in the cloud forests of Hahajima in the Ogasawara Islands. However, the Hahajima population of *N. chaunax* lives primarily on the leaves of trees, while the Kita-iwo population uses a wider range of habitats, including dead wood on the ground. Additionally, the Hahajima population of *N. chaunax* possesses a flattened, disk-shaped shell, while the Kita-iwo population displays a wide range of shell shapes, from flattened to conical (Fig. 1). These ecological and morphological differences between the Hahajima and Kita-iwo populations of *N. chaunax* are of interest from an evolutionary biology perspective, as the Kita-iwo population is believed to have migrated from Hahajima relatively recently, as inferred from our preliminary genetic assessments.

In our previous report (Chiba & Wada, 2008), we were unable to identify specimens now known to be *N. chaunax*, and there was no record of *N. chaunax* from Kita-iwo before World War II; so we tentatively treated it as *Lamprocystis hahajimana kitaiwojimana*, which was described from the island by Pilsbry & Hirase (1905). In addition, characteristics of *L. h. kitaiwojimana* differ from *L. hahajimana* found on Kita-iwo.

Table 1. Species list of the land snails of Kita-iwo Island.
* Species not found in the 2018 survey.

Family and species	Ecotype	Distribution beyond Kita-iwo Island
Achatinellidae		
Pacificella hataiana	arboreal	unknown
Lamellidea sp. A	arboreal	Ogasawara
*Lamellidea ogasawarana**	arboreal	Ogasawara
Tornatellides tryoni	arboreal	Ogasawara
Elasmias kitaiwojimanum	arboreal	Ogasawara
Elasmias sp.	arboreal	unknown
Euconulidae		
Nipponochlamys chaunax	arboreal	Ogasawara (Hahajima)
Lamprocystis hahajimana	ground	Ogasawara
Liardetia boninensis	arboreal	Ogasawara, Daito
Discoconulus sp.	ground	unknown
Spiraxidae		
Gulella bicolor	ground	cosmopolitan
Subulinidae		
Allopeas pyrgula	ground	Asia
Ferussaciidae		
Geostilbia caledonica	ground	Asia

However, both flat and conical forms of *N. chaunax* found on Kita-iwo (Fig. 1) correspond genetically and anatomically to *N. chaunax* from Hahajima. The description of *L. h. kitaiwojimana* was perhaps assigned to a species or variant that is now extinct.

The species *N. chaunax* has been recorded as present solely on the islands of Hahajima and Kita-iwo. Unfortunately, recent observations indicate that *N. chaunax* may have become extinct on Hahajima due to predation by the introduced flatworm *Bipalium vagum*. As such, the population of *N. chaunax* on Kita-iwo holds considerable conservation importance. Threats to the land snails of Kita-iwo include the malacophagous non-native snails *Gulella bicolor* and an undescribed small flatworm species, which do not possess arboreal capabilities. As a result, the population of *N. chaunax* on the island remains in a favorable condition thus far. The impact of these non-native predators on the ground-dwelling land snails on Kita-iwo remains poorly understood, though their impact is considered less severe in comparison to the Ogasawara Islands. It is likely that these invasive predators, as well as other non-native land snails, were introduced to the island prior to World War II, with minimal recent introductions due to limited human traffic to the island. If the impact of *Bipalium vagum* increases in the future on Hahajima, Kita-iwo may serve as a suitable site for the translocation of Hahajima's endemic arboreal species.

We thank the Tokyo Metropolitan Office, Institute of Boninology, and all members who participated and supported the expedition to the Kazan Islands.

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"Saving Private Snail". The endemic *Partula obesa* is in grave danger in Wallis and Futuna (South Pacific islands)

By Jean-Yves Meyer

Fig. 1. Panoramic view of Alofi from Pointe Vele, Futuna.

We recently (November-December 2022) conducted a biodiversity survey in the French overseas territory of Wallis and Futuna, comprising three islands (‘Uvea, Futuna and Alofi) in the South Pacific, and belonging to the biogeographical subregion of Western Polynesia (with Tonga, Samoa, Niue). One of the main goals of this field trip organised by the Service Territorial de l’Environnement (Department of the Environment) and funded by the Office Français de la Biodiversité, was to assess the conservation status of the endemic tree snail species *Partula obesa* Pease, 1868 (junior synonym *Partula subgonochila* Mousson, 1871), ~14 years after the last census, which was done in November 2008.

We surveyed three sites intensively: Pointe Vele on the eastern point of Futuna, Alofitai on the western coast of Alofi (Fig. 1), and mount Kolofau, the highest summit on Alofi (417 m above sea level) and where populations of *Partula* have been observed in the past. Indeed, in her report on land molluscs of Wallis and Futuna, Ira Richling (2010) mentioned that “the eastern end of Pointe Vele is outstanding for the probably only remaining *Partula* population on Futuna” and that “on Alofi […] the coastal part still harbours good *Partula* population while at least *Partula* has been significantly reduced (already gone extinct?) in the forested slopes”. Subsequently, a few living individuals were found on the forested slopes of Mount Kolofau in May 2011 and a population of ten individuals on the northeastern coast towards Pointe Ava‘afi in September 2014 during botanical field trips (J.-Y. Meyer, unpublished).

In 2022, a single population of about ten individuals (five adults and five juveniles) was found after hours of intensive search at Pointe Vele (Figs. 2, 3A) showing that *Partula obesa* is still surviving in this relictual dense native forest growing on raised limestone (or karstic soil), thus somewhat protected

Fig. 2. Bernadette "Pele" Tufele finding *Partula obesa* under the leaves of a native tree, *Planchonella*, Pointe Vele, island of Futuna.

Fig. 3. Native arboreal snails at Pointe Vele on the island of Futuna. A – *Partula obesa*; B – *Trochomorpha corallina*.

from agriculture and other anthropogenic disturbances such as fires. Not a single individual was observed on the Alofitai coast where the species was still common in 2008, as well as on Mount Kolofau and nearby ridges and slopes.

The only "good news" is that a relatively large population (more than 50 individuals) of the endemic tree snail *Trochomorpha corallina* Mousson, 1870 was also found in Pointe Vele in the same habitat, and on the same native host plants (Fig. 3B), despite the presence of *Euglandina rosea* on Futuna. This carnivorous alien snail is also present on Alofi, but deforestation and slash-and burn agriculture on the Alofitai coast during the past decade (personal observations, 2014, 2016, 2022) might also have played an important role in the decline of *Partula obesa*, which should be classified as a Critically Endangered species (CR according to the IUCN Red List criteria) on Futuna and Alofi.

We have proposed to the Service Territorial de l'Environnement the organisation of another field expedition to Alofi in 2023 in order to explore other coastal sites, especially the northeastern coast, and to collect some living specimens from Futuna or Alofi to be send to zoos in Europe or the US for ex-situ conservation, as has been done successfully with endemic *Partula* species of the Society Islands of French Polynesia.

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Ex-situ efforts for the conservation of the endangered Obô giant snail *Archachatina bicarinata* in the Gulf of Guinea, Central Africa

By Martina Panisi

The Obô giant land snail *Archachatina bicarinata* (Bruguière, 1792) only occurs on the islands of São Tomé and Príncipe and has suffered a steep and rapid decline on both islands since the 19th century due to overharvesting coupled with forest modification and biological invasions (Dallimer & Melo, 2010; Panisi *et al*., 2022a). Mass mortality events have been recorded for the species, which are thought to be linked to outbreaks of an introduced disease that is feared to wipe out much of its genetic diversity in little time (Panisi & de Lima, 2022). The species' distribution is now restricted to small remote patches of native and secondary forests on both islands, requiring urgent ex-situ and in-situ interventions (Panisi *et al*., 2020). As a result, its IUCN Red List conservation status was recently updated from Vulnerable to Endangered (Panisi *et al*., 2022b).

After a first preliminary study on the species in São Tomé (Panisi, 2017), three juveniles that hatched in captivity were systematically measured in Lisbon Zoo, Portugal, for two years, providing the first observations on the slow growth of the species (Panisi *et al*., 2020). The species is culturally important and widely recognised by people and, in 2018, local communities were consulted to evaluate possible local collaborative interventions for its conservation. In 2019, a small ex-situ conservation centre was built in the Botanical Garden of Bom Sucesso, in São Tomé, to obtain information on the ecology of the species and to spread awareness of its decline with the local and international public, using it as a flagship for the protection of the unique malacofauna of the islands, their forests and endemic wildlife (Figs. 1 and 2; CEPF, 2022; Forest Giants Project, 2020; Panisi *et al*., 2020). The maintenance of this captive breeding programme has been identified as a priority in the first Single Species Action Plan for the conservation of the species (action 1.2a; Panisi *et al*., 2020). Between September 2019 and April 2021, more than 1,170 tourists visited the centre and were educated about the urgency to protect this species, and data about the reproduction and feeding habits of up to 46 snails were collected (Alisei Onlus ONG, 2021).

Mating and egg-laying have been observed during the wet seasons (March to May and September to November), with hatching occurring both during the wet and dry seasons (i.e. in June and November). Eggs have been found in clutches of

Fig. 1. The Obô giant land snail ex-situ centre in the Botanical Garden of Bom Sucesso, São Tomé Island. (Photo: Vasco Pissarra for the Forest Giants Project)

Fig. 2. Environmental education activity at the Obô giant land snail ex-situ centre. (Photo: Alisei Onlus ONG)

Fig. 3. Mature individual, juveniles and an egg laid in captivity. (Photo: Vasco Pissarra for the Forest Giants Project)

three to seven, laid on the soil surface or superficially buried, and took 40-42 days to hatch (Fig. 3). Mating individuals in captivity and in-situ became sexually mature with a shell length of about 12 cm, which corresponds to about three year-old individuals raised in captivity. These observations were confirmed by the anatomical analysis of the reproductive structures of five dead individuals.

The snails started to reproduce in captivity in 2019, but in 2020 three

Fig. 4. One of the new boxes constructed after the disease outbreaks. (Photo: Vasco Pissarra for the Forest Giants Project)

separate disease outbreaks affected the captive population, which was being kept in open air cages (Fig. 1). Fifty-eight percent of the individuals showed symptoms of a disease and most of them, including some juveniles that had been born ex-situ, eventually died (Panisi & Lima, 2022). In 2021, the centre was restored with the construction of new boxes that are not in contact with the ground (to avoid problems due to soil contamination), provided with copper tapes around the legs of the boxes to keep other snails out (such as the invasive *Archachatina marginata*) and with nets under the bamboo roofs to keep out possible insect parasites/predators (Fig. 4). To avoid possible contamination, the snails (18 individuals) have been divided into three separate groups and are no longer kept exclusively in the Botanical Garden, but also in two additional sites in local communities around the Botanical Garden. Since the restoration of the centre, the ex-situ population did not show any signs of disease, but no reproductive activity was recorded from the disease outbreak until 2022.

Finally, on the last day of 2022, two individuals of Obô giant land snails kept at the Botanical Garden produced two clutches of eggs, with a total of nine eggs. This joyful event at the beginning of this new year is a sign that there may still be hope for the conservation of this species.

The captive breeding programme is being undertaken under the umbrella of the Forest Giants Project, implemented by Alisei Onlus ONG. The project was supported by the Critical Ecosystem Partnership Fund and BirdLife International (109607), the Mohammed bin Zayed Species Conservation Fund (190521916) and Mossy Earth. A special thanks to Ineias Dias, Ricardo Faustino de Lima, Vasco Pissarra and Gabriel Oquiongo for supervision, data and media collection, and the Direção das Florestas e da Biodiversidade de São Tomé e Príncipe (Department of Forests and Biodiversity of São Tomé and Príncipe) for providing permits.

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The return of *Pachystyla bicolor*

By Christine Griffiths & Nicolas Zuël

Endemic snails, once abundant throughout Mauritius, are practically unknown today as few people have seen them. Habitat destruction and the introduction of alien predators, mainly rats, tenrecs and toads, have led to their widespread reduction in abundance and distribution. Of the 81 known endemic Mauritian species of land snail, 36 species are extinct and the remaining species are threatened with extinction. Yet there is reason for hope, following the successful captive breeding of *Pachystyla bicolor* by Ebony Forest, La Vanille Nature Park and Owen Griffiths. We must act soon though!

Pachystyla bicolor has a depressed and reasonably robust shell, chestnut to light brown in colour, with a width and height ranging from 32-49 mm and 22-26 mm, respectively. Alarm bells were raised when we struggled to find live snails and they appeared to be locally extinct at many of the previously known sites. Since there was no organisation in Mauritius working on snail conservation, we joined forces with the National Parks & Conservation Service to prevent *Pachystyla bicolor* from following the Dodo's fate. Our first challenge was to collect some individuals to start a captive breeding programme to save the species.

After long hours of searching, four adult individuals were found to start an ex-situ captive breeding programme at La Vanille Nature Park. With the support of the Mohamed bin Zayed (MBZ) Species Conservation Fund, three special outdoor enclosures were built to provide suitable conditions

Fig. 1. Owen Griffiths in front of the outdoor enclosure used to breed snails at La Vanille and the snails produced from the 4 original adult snails.

for the snails to breed, while excluding potential predators (Fig. 1). To our relief, the snails adapted quickly and we were able to breed more than 500 individuals, enabling us to translocate and release the offspring in two fenced predator free areas at Vallée de L'Est, a restoration site managed by Ebony Forest.

Predators are the main threat to endemic snails so it was paramount that we reduce their abundance in and near the release enclosures. Funding from the MBZ Species Conservation Fund was used to build two 5 m x 5 m (with a 1m high fence) predator proof enclosures (Fig. 2) in native forest, presumed to be ideal snail habitat. The enclosures were built to exclude all possible snail predators. Five toad and tenrec pitfall traps within the enclosure captured any remaining or potentially invading animals. Nine A24 Goodnature traps were placed at 25 m intervals in a grid around the enclosures to reduce the number of rats. Habitat features, such as logs, leaves, stones and litter, favoured by snails, were added to the area.

Between December 2020 and December 2022, 349 adult snails were released in the two predator proof enclosures in Vallée de L'Est. By December 2022, 166 of the 239 released snails in enclosure 1 and 64 of the 110 released snails in enclosure 2 were still surviving; many of those that had died had drowned during flash flooding. We observed breeding after nine months

Fig. 2. The 5 m x 5 m (with a 1m high fence) predator proof release enclosure in native forest.

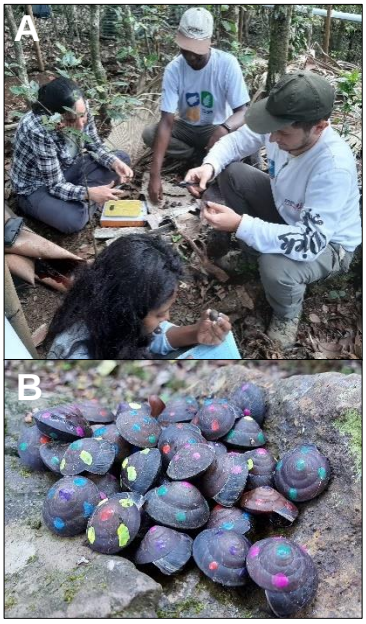

Fig. 3. A – counting, measuring and weighing snails, B – snails with individual marks.

in the enclosures and at the end of December 2022 had produced 217 juveniles since the start of the project.

We continue to monitor both enclosures monthly and count, measure shell width and weigh all the snails (Fig. 3A). All the snails are marked with nail varnish with a unique colour code, so that they can be identified individually (Fig. 3B). After two years, the average weight of the snails had increased from 5.15 g to 9.69 g and average size from 29.51 mm to 34.90 mm in shell width. The captive-bred population at La Vanille will be maintained as an assurance colony that can be used to reinforce populations elsewhere, provided there is predator control. Encouraged by the successful breeding and release of the snails, we are working on building more release enclosures at Vallée de L'Est and Ebony Forest, another conservation site managed by Ebony Forest, as well as captive breeding other rare snails. Our first challenge is finding the snails, as each survey reveals that most species are on the brink of extinction. The next challenge is finding out what conditions they like in order to breed and being able to replicate these conditions. It's a steep learning curve, but we are helping to train and cultivate the next generation of snail champions!

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Partula conservation programme update

By Paul Pearce-Kelly & Justin Gerlach

Fig. 1. A poster/painting commissioned by the Zoological Society of London from Richard Allen, illustrating the Society Islands *Partula* conservation programme.

Now well into its third decade, the *Partula* conservation breeding programme has continued to maintain all 15 (11 Extinct in the Wild, 3 Critically Endangered and 1 Vulnerable) *Partula* taxa (Fig. 1). The majority of these taxa are doing well and are in sufficient numbers to enable the participating zoos in Europe and the US to continue providing snails for the reintroduction programme. Unfortunately the logistical constraints imposed by the COVID-19 pandemic prevented resumption of the reintroductions in 2022 but continued close collaboration with French Polynesian Government's Direction de l'environnement (Diren) colleagues over the last year has enabled the scheduling of reintroductions to resume for Tahitian and Moorean *Partula* species in late March 2023 followed by Huahine and Raiatea species reintroductions in September 2023.

This will be the sixth year of reintroductions and whilst it is certainly too early to consider any of the released populations to be successfully established, initial analysis of the post-release population monitoring by Diren colleagues and Justin Gerlach provides cautious optimism for the majority of the

released species. The forthcoming 2023 reintroductions will provide a valuable opportunity for improving post-release dispersal behaviour and hopefully improved monitoring of snails in the high canopy environment. Hopefully the combined and highly interconnected conservation breeding, reintroductions and population/site monitoring aspects of the programme will provide the best chance of realising successful conservation outcomes for our target species whilst also informing the wider mollusc conservation endeavour. What is in no doubt is that continued collective collaboration is *the* key factor for realising progress.

In the meantime, 44 of the Partulidae have been updated or added to the Red List. Of these 32 are Extinct, 13 Extinct in the Wild, 19 Critically Endangered, 7 Endangered, 1 Vulnerable and 2 Least Concern. A further 54 assessments should be published later this year, at which point all Partulidae will be fully assessed for the first time.

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Rescuing four Critically Endangered land snails from extinction (Desertas Islands: Portugal)

By Dinarte Teixeira, Gerardo Garcia, Melissa Bushell & Tiago de Zoeten

Four island endemic species were rediscovered in the Desertas Islands (Madeira, Portugal) between 2008 and 2012 after 130 years without a live record: *Discula lyelliana* (Geomitridae), *Geomitra grabhami* (Geomitridae), *Geomitra coronula* (Geomitridae) and *Atlantica calathoides* (Gastrodontidae) (Fig. 1). These critically endangered species are each restricted to a single location with fewer than 100 mature individuals and are currently on the brink of extinction because of the decline and fragmentation of their habitat as a result of feral goats (*Capra aegagrus hircus*) grazing the natural vegetation and because of direct predation by mice (*Mus musculus*) (Seddon, 2011; Teixeira, 2017; Teixeira *et al*., 2018 a,b). The Desertas Islands exhibit the highest extinction rate within the Madeira archipelago, with 48 % of their known fossil land snail fauna currently extinct (Cameron *et al*., 2021; Teixeira *et al*., 2022).

A monitoring scheme conducted by the Instituto das Florestas e Conservação da Natureza (IFCN) between 2013 and 2019 revealed population declines for each of the four species,

Fig. 1. Critically endangered land snail species targeted by the project: A – *Discula lyelliana*, B – *Atlantica calathoides*, C– *Geomitra grabhami*, D – *Geomitra coronula*. (Photos: D. Teixeira)

culminating in the loss of an *Atlantica calathoides* population in the north of Deserta Grande (Fig. 2).

In 2021, a joint effort involving IUCN, local partners in Madeira itself and ex-situ experts launched a rescue programme to save these four species from extinction. The project had five primary goals: 1) rescuing the founding specimens from the wild; 2) implementing a captive breeding programme for the four target species; 3) continuing the in-situ conservation actions directed at the target species; 4) elaborating a species conservation strategy and 5) starting a public awareness programme.

Between May and November 2021, founder specimens of *D. lyelliana* (38), *G. grabhami* (80) and *A. calathoides* (36) were captured in the wild and transported to the facilities of the husbandry experts of Chester Zoo (CZ) and Bristol Zoo Gardens (BZG) in the UK.

These two institutions have bred these three species for the first time, with hatchlings appearing just three months after the programme's start (Fig. 3). All three species have reached the

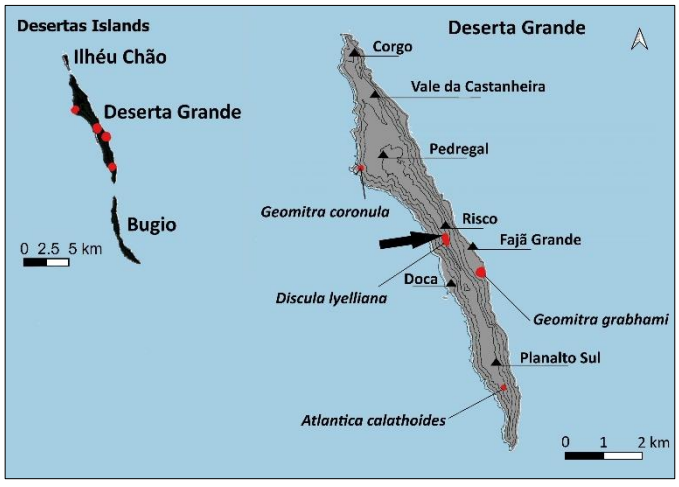

Fig. 2. Current species distribution areas on Deserta Grande, with the locations of the single populations of the target species. Black arrow indicates the site of the *A. calathoides* population lost in 2018.

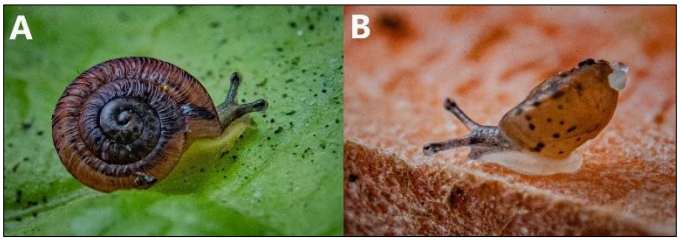

Fig. 3. First hatchlings of *Discula lyelliana* (A) and *Geomitra grabhami* (B) resulting from the ongoing captive breeding programme (Photo: Chester Zoo).

F2 generation, with more than 2,000 specimens including adults, juveniles and hatchlings. The ex-situ programme also collected crucial information about the species' ecology, life history and diet, of which little was known.

In-situ conservation actions were also implemented. Data regarding population sizes and trends, environmental requirements of the species and their traits have been collected continuously since 2021. Based on its size and conservation status, habitat availability has also been evaluated based on an orthophoto mosaic taken every six months with a drone. Parallel to these activities, a network of 18 data loggers distributed among the population sites has enabled us to gather specific climatic data regarding the relative temperature and humidity at different levels (within the soil, at the soil level and above the ground). This information is crucial to determine not only the specific climatic requirements of these species but also as essential information to support the ex-situ programme.

We have also established a predator control programme on-site directed at mice (*Mus musculus*). Using two trapping methods, a buffer zone was set within the population area. The preliminary results have shown a 23 % average increase in the snail populations, significantly an increased number of juveniles.

Public outreach has been undertaken through the project website and documentary videos available online, which report and explain the ongoing in-situ conservation activities in the field.

The support of Mossy Earth has been fundamental to broadening the Desertas snail conservation efforts and message, reaching audiences that would otherwise not be reachable. As a vital next step, the IUCN SSC Mid-Atlantic Island Invertebrates Specialist Group will lead the elaboration of species conservation strategies, which will be discussed by stakeholders during a workshop in Madeira in October 2023. Furthermore, the ex-situ conservation efforts will gain a new partner, Beauval Nature Association, joining the captive breeding programme by mid 2023. The husbandry techniques and methodologies will be published in the Best Practice Guidelines section of the EAZA website (European Association of Zoos and Aquaria) during 2023.

A huge milestone will be the reintroduction of *D. lyelliana* and *A. calathoides* on the southern island of Bugio (Fig. 4), the predator-free island (mice, rabbits and goats were recently eradicated) once home of three of the four target species: *D. lyelliana*, *A. calathoides* and *G. coronula* (Teixeira *et al*., 2019). This action is planned to take place in late 2023 or early 2024 and will require a tremendous logistic and technical effort, which will count on the expertise of Chester Zoo and the IFCN malacologists.

Fig. 4. In the foreground, the south plateau of Bugio, the southernmost island of the Desertas sub-archipelago, where the species reintroduction programme will be implemented.

Finally, the climatic data network will be vastly enhanced with two weather stations on Deserta Grande and Bugio. The equipment will provide live online data, which will help inform both the conservation action planning and the ex-situ programme.

We thank the project partners for their support. The IUCN SSC Mid-Atlantic Islands Invertebrates Specialist Group (MAIISG), along with the local partner Instituto das Florestas e Conservação da Natureza (IFCN), Chester Zoo (CZ), Bristol Zoo Gardens (BZG) and Mossy Earth (ME).

We are also grateful to the project funders. Re:wild was the initial funder of the project (2021), with the financial support of CZ and BZG for the ex-situ programme. Since 2022, ME and Beauval Nature Association have been the primary funders of the in-situ conservation actions, with the logistic support of the IFCN.

We also acknowledge the excellent effort of CZ and BZG, which have been masterfully conducting the ongoing ex-situ programme.

The current conservation activities involve more than 20 people, including malacologists, ex-situ experts, keepers, nature wardens, conservation biologists and volunteers involved in the project. We acknowledge all of these for their contributions and willingness to help to protect these marvellous land snail species, the true Madeirans for millions of years.

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MARINE MATTERS

Sub-Antarctic marine molluscs most at risk from global warming

By Aoife Molloy, Katrin Linse, Rahul Sivankutty & Julia Sigwart

Over the last year, we have been working on assessing the extinction risk of Antarctic molluscs together with a number of collaborators and regional experts. This project was funded by the Darwin Initiative, a UK government grant scheme within the Department for Environment, Food and Rural Affairs to support conservation in UK Overseas Territories (OTs). The aims of our 12-month project, “Red Listing can protect UK Overseas Territories marine biodiversity”, were specifically to increase the number of Southern Ocean marine invertebrate assessments on the IUCN global Red List, and provide Red List assessor training to marine invertebrate experts, focusing on those working in the regions of UK OTs. A training workshop was carried out in April 2022 and attended by 16 researchers from around the world, both online and in-person; all were invertebrate specialists from across terrestrial, freshwater and marine systems, with 13 specialising in mollusc research. This will hopefully contribute to an increase in marine mollusc assessments published on the Red List.

Over the past year, we have compiled 57 assessments of benthic marine molluscs (from three classes: Gastropoda, Bivalvia, Polyplacophora) from the Southern Ocean, which are in the process of being reviewed for publication in a Red List update in 2023. In collaboration with mollusc experts from the British Antarctic Survey (BAS), we determined that the major threats faced by these organisms are ocean warming, acidification and deoxygenation. These species have adapted to a stable, cold environment, and as the ocean warms and they are forced to migrate further south, high latitude species will be left with nowhere to go. Global projections for the response of Antarctic marine organisms to climate change based on sea surface temperature data show that Southern Ocean species will face species turnover, local extinction, invasion of non-native species and loss of species richness (Griffiths *et al*., 2017).

Limited data for these species has been a major obstacle in assessing for the Red List. Many species appear to be under-recorded, and although there are detailed studies of a few species, most have little physiological or life history data. Our collaboration at BAS produced climate models based on warming seafloor temperatures, using CMIP6 models (Coupled Model Intercomparison Projects; Hausfather, 2019) based on seafloor temperature data, combined with historical Southern Ocean seafloor temperature data from 1995 to 2015 (Fig. 1A) to estimate the average temperature ranges where each of our 57 species occurs. The models predict what Southern Ocean seafloor temperatures will be in 2040-2060 (Fig. 1B) and 2080-2100 (Fig. 1C). We have examined both best-case scenario (~1.5 °C warming, which is not looking likely) and worst-case scenario (~3.5 °C warming) models, but to exercise a precautionary approach, the worst-case scenario distributions were used for the assessments.

South Georgia endemics are predicted to suffer most from ocean warming, with other Sub-Antarctic species expected to suffer because of temperatures surpassing their current thermal range. On the Antarctic continent, areas of the Western Antarctic and Antarctic Peninsula are predicted to surpass the temperature range of many of these Southern Ocean species.

While most of the 57 species are predicted to lose range with predicted warming, areas around the Antarctic continent are expected to remain within many of their thermal ranges. For Sub-Antarctic island species, however, their ability to migrate from warming temperatures onto the continent will probably be determined by their reproductive mode, and their ability to cross the Antarctic Circumpolar Current (ACC). Some smaller molluscs disperse via rafting, attached to macroalgae, which allows them to drift over large distances and may aid in allowing Sub-Antarctic species to escape warming temperatures. However, rafting species can also act as indicators of changing environmental conditions because of their reliance on hydrodynamics for transport and food availability (Puccinelli *et al*., 2018), and therefore any changes ocean warming may have on the ACC could impact the dispersal capabilities ofthese species.

While many of our study species are threatened by ocean warming, other threats must be taken into account: the invasion of alien species due to ocean warming, particularly shell-crushing crabs that are currently limited by physiology because of their inability to survive in waters constantly below 0 °C, the exploitation of species in the Falklands/Malvinas and in South American waters, the calving of icebergs causing disturbance to benthic communities (Barnes & Conlan, 2007), and the aforementioned threats of ocean acidification,

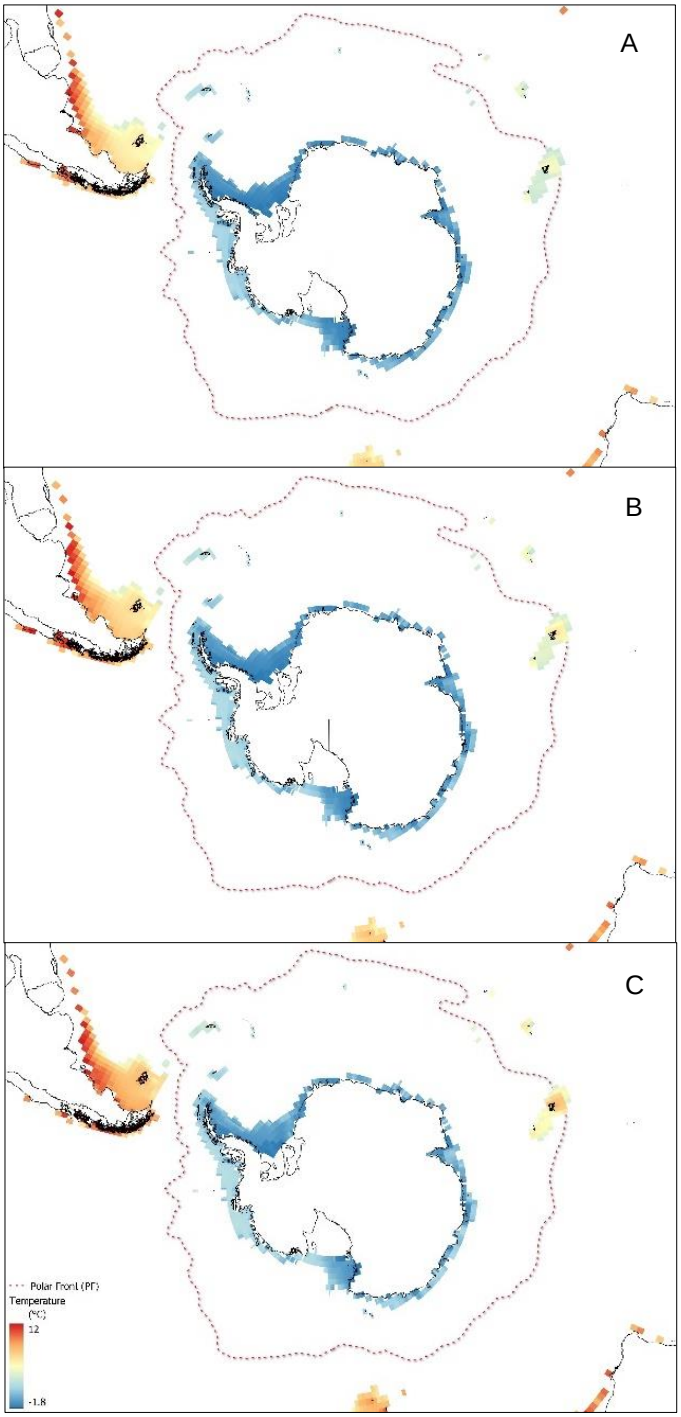

Fig. 1. A – Historical temperatures based on average seafloor temperatures 1995-2015, B – predicted average seafloor temperatures based on CMIP6 models for 2040-2060, and C – predicted average seafloor temperatures based on CMIP6 models for 2080-2100.

potentially causing shell dissolution (Figuerola *et al*., 2021), and deoxygenation, with models predicting that O_2 will decrease at 200-400 m bsl around 60 °S, associated with reduced Antarctic convection (Keeling *et al*., 2010).

The overall threat situation is worst for Sub-Antarctic species, but the extinction risk is tempered by the protection already in place around South Georgia and the South Sandwich Islands. This underscores the importance of effective marine protected areas. Compliance with the regulations of the Antarctic Specially Protected Areas and Sub-Antarctic Island Marine Protected Areas must also be enforced regarding the exploitation of these regions, to ensure no further threats are impacting these species and their habitats.

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More marine activity for the global Red List – announcing a new Marine Invertebrate Red List Authority (MIRLA)

By Julia Sigwart

The IUCN global Red List is perhaps the world's most widely recognised conservation tool, underpinning a universal understanding of what it means for a species to be at risk or endangered. It is well known that the coverage of formal Red List assessments is taxonomically biased and systemically under-represents invertebrates and especially marine invertebrates. Right now, we have a single specialist group for all of Mollusca, whereas other phyla have specialist groups for much smaller clades (e.g. elephants, anguillid fishes), reflecting the number of available experts with relevant training and interests who volunteer to support these committees. In the marine realm, in fact, there are very few specialist groups covering only a tiny fraction of marine biodiversity. Beyond molluscs, there are current specialist groups only for corals, horseshoe crabs, crustaceans (nominally a group for freshwater taxa but taking on some marine work), and new groups for holothurians and "stars" (Asteroidea + Ophiuroidea). Meanwhile, these and other marine invertebrate groups are suffering significant threats and population declines, with many representing high value and over-exploited fisheries.

The use of the Red List assessment to communicate potential extinction risk would support important conservation measures. However, Red List assessments depend on expert input and peer review. This is challenging for clades for which there is no specialist group (and can even be challenging for marine molluscs).

Starting in December 2022 there is now a new Marine Invertebrate Red List Authority (MIRLA). The purpose of MIRLA is to focus on the Red List assessments of marine invertebrate species, to highlight threats and the level of extinction risk for these diverse taxa. There is already a group within the Species Survival Commission called the Terrestrial & Freshwater Red List Authority (TIRLA), which fulfills a similar role to support the assessments of "everything else" species not covered by taxon-specific specialist groups. This also fulfills a key mission of the new Senckenberg Ocean Species Alliance (SOSA), a major new project at Senckenberg to accelerate the taxonomic description of marine invertebrates.

It is not feasible at this time to embark on an endeavor to assess all marine invertebrate taxa, so the first task of the group will be to recommend priorities for assessments, following a similar process implemented for TIRLA that considered target groups based on species richness, assessment practicality, and the potential to act as conservation flagships (Gerlach *et al*., 2014). Focal projects for Red List assessments will be undertaken in collaboration with the Mollusc Specialist Group and other relevant specialist groups as well as supporting new specialist groups as they emerge.

For more information see the MIRLA website and the SOSA website.

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The mangrove inhabiting gastropods *Telescopium telescopium* (Linnaus, 1758), *Nerita albicilla* (Linnaeus, 1758), and *Lunella coronata* (Gmelin, 1791): species surviving under pollution stress are near to extinction at the coast of Karachi, Pakistan

By Malik Wajid H. Chan, Sadar Aslam & Shahnaz Rashid

Heavy metals and metalloids released by anthropogenic activities enter the marine environment via rivers and are eventually taken up by filter-feeding organisms such as mussels and snails. Since these metals/metalloids cannot be biodegraded, they accumulate in these animals. After bioaccumulation, the responses of these organisms under pollution stress, including their resistance responses, are of great interest. Pollutants (inorganic and organic) affect the immune responses of gastropods and unfortunately heavy metals/metalloids are abundantly distributed in marine

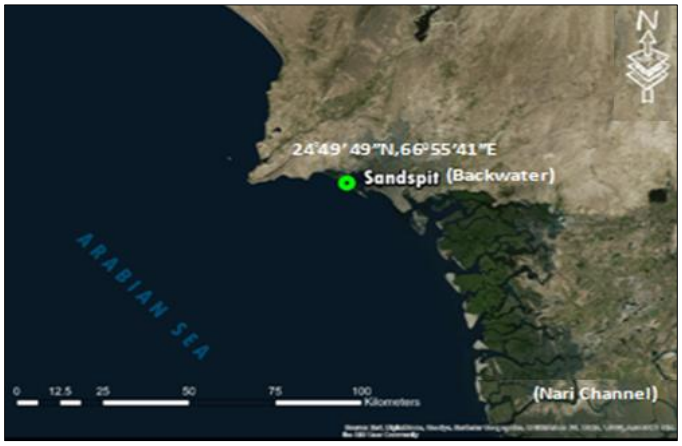

Fig. 1. Site location, Sandspit, a backwater mangrove area in the Southwestern part of Karachi, Pakistan.

ecosystems today (Aslam *et al*., 2020a, 2022; Chan *et al*., 2021a,b).

We studied an area known as Sandspit (24°50'59.62" N, 66°55'26.55" E), a backwater mangrove area in the southwestern part of Karachi, Pakistan (Fig. 1), where there is a dense mangrove forest with a single species, *Avicennia marina*. The other species cannot survive in this area because it receives untreated domestic and industrial wastewater from the Lyari River and is therefore considered highly polluted. In this area, three mangrove-inhabiting gastropod species, the Telescope shell *Telescopium telescopium* (Linnaeus, 1758), the Blotched/tubercular nerite *Nerita albicilla* (Linnaeus, 1758) and the Crowned turban shell *Lunella coronata* (Gmelin, 1791), were evaluated as potential bioindicator species for assessing pollution levels (Chan *et al*., 2021b-d).We assessed ten heavy metals/metalloids (Al, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb and Zn) in the water, sediment and tissue and shell samples of the above species. The bioaccumulation of heavy metal/metalloid pollutants in these mangrove-inhabiting gastropod species was assessed by estimating several pollution indices in seawater and sediment samples. The antibacterial and antifungal potential of n-hexane extracts obtained from these gastropod species was also determined (Chan *et al*., 2021d).

The study site at Sandspit supports a dense canopy of *Avicennia marina*. This mangrove area forms a wide belt behind the sandy beach of Sandspit (backwater area), extending from Manora Channel to Hawks Bay. The mangrove area has a rich benthic fauna (mainly gastropod species). It receives sea water through the Manora Channel and fresh water through the Lyari River, which is heavily polluted by domestic and industrial wastes, as well as port and shipping activities (Fig. 2). Recently, it has become the most polluted area along the entire Pakistani coast (Chan *et al*., 2021b, c).

Nine samples (replicates) were collected using 1 m^2 quadrats at low tide from the Sandspit mangrove area. Three species (*T. telescopium*, *N. albicilla* and *L. coronata*) were collected (Fig. 3). All specimens were taken to the laboratory to be sorted, identified and counted. The mean numbers of these specimens in the nine samples (Table 1) were used to determine the total population in the study area by extrapolation. Our previous

Fig. 2. The study site showing the untreated industrial and household wastes released in the mangrove area. (Photo: Shahnaz Rashid)

studies showed that the study area was heavily contaminated with heavy metals/metalloids to an extent that exceeded local limits, i.e. the National Environmental Quality Standards (Government of Pakistan, 2000) (Chan *et al*., 2021a-d).

After discharge of contaminants into the river, a settling process began in which metals and metalloids accumulated at the sediment surface where they could be ingested and bioaccumulated by filter feeders such as *T. telescopium*, *N. albicilla* and *L. coronata* (Chan *et al.*, 2021d). This accumulation of metals was based on gastropod size, so the order of bioaccumulation was *T. Telescopium* > *N. albicilla* > *L. coronata*. From this study, it was concluded that the ability of these three indigenous gastropod species (surviving under pollution stress) to produce bioactive compounds was based on the amount of heavy metals accumulated in their bodies. The tissue extracts of *T. telescopium* showed higher antibacterial and antifungal activities than those of the other two species (*N. albicilla* and *L. coronata*). The bioactive metabolites produced by organisms living under pollution stress also depend on the amount of pollutants accumulated in their bodies (Chan *et al*., 2021a; Aslam *et al*., 2022). However, in a detailed study (Chan *et al*., 2021d), we investigated only one aspect. We extracted (with n-hexane) only the metabolites of the gastropod species (*T. telescopium*, *N. albicilla*, and *L. coronata*) that survived under pollution stress. We did not focus on the pollution or

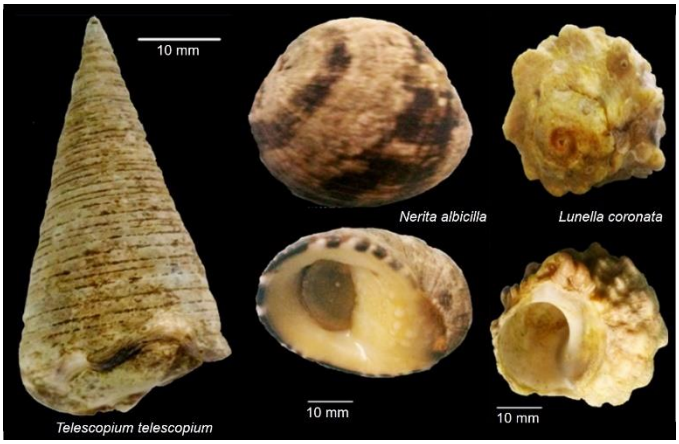

Fig. 3. The mangrove inhabiting gastropods *T. telescopium*, *N. albicilla* and *L. coronata*. (Photos: Sadar Aslam)

Table 1. Sampling from June to December 2021 and January to May 2022. Mean ± SD of numbers of individuals found in nine samples on each sampling occasion.

	T. telescopium	*N. albicilla*	*L. coronata*
January	3.40 ± 0.32	1.20 ± 0.08	1.10 ± 0.11
February	3.21 ± 0.40	-	-
March	4.19 ± 0.60	-	-
April	2.52 ± 0.40	-	-
May	1.50 ± 0.32	-	-
June	8.00 ± 0.70	16.60 ± 1.13	20.50 ± 1.75
July	8.50 ± 0.90	17.00 ± 1.50	19.90 ± 1.27
August	7.50 ± 0.90	16.10 ± 1.16	18.60 ± 1.22
September	7.00 ± 0.60	15.50 ± 1.22	18.20 ± 1.53
October	7.00 ± 0.50	13.20 ± 0.93	15.10 ± 1.31
November	6.50 ± 0.80	9.00 ± 0.77	7.00 ± 0.99
December	5.00 ± 0.50	3.00 ± 0.49	3.10 ± 0.29

examine the effects of pollution on their numbers. We continued our monthly visits to the study site for one year (June 2021 to May 2022). The objective of this study was to observe the biodiversity of the three species living under stress. During our study, we noticed a gradual decline in these species. From February to May 2022 we observed that *N. albicilla* and *L. coronata* had completely disappeared from the area, leaving *T. telescopium* as the only species in the area. The data (Table 1) show that the population of this species is declining. In this aquatic environment exposed to higher pollution, many mollusc species may be at risk of extirpation because of pollution exposure (Lewin & Smoliński, 2006). As a result, the diversity and population sizes of indigenous species in the Sandspit mangrove area have steadily declined and these species are now even close to complete extirpation. Pollution has increased the extinction rate of biodiversity globally to 1,000 to 10,000 times its natural rate (Suratissa & Rathnayake, 2017). In another study of an oyster reef in the Hab River Delta, Pakistan, Aslam *et al*. (2020b) recorded seasonal biodiversity, including species richness and abundance of these species, with notable related findings. The present report is based on our previous studies, showing the highest level of heavy metal pollution in seawater and sediments and the bioaccumulation of these pollutants in the tissues and shells of gastropod species (Chan *et al*., 2021d). The results are discussed in terms of the availability of pollutants in the environment and their uptake by gastropods, which are declining and even threatened with extirpation because of pollution. The current study monitoring gastropod species in coastal mangroves at Sandspit (Karachi, Pakistan) is important because it provides information on declines and local extirpations of indigenous gastropods, such that action by conservationists is required. Local extirpations of indigenous gastropods may indicate water quality problems or hydrological changes in the coastal area that explain their absence in certain locations. We invite the government and local community to curb marine pollution. The government should make strict rules so that all industrial and domestic wastes must be treated before discharge into the sea.

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Global abalone assessment reveals multiplicity of threats led by over-fishing but captive breeding offers hope

By Howard Peters, Laura Rogers-Bennett & Gina M. Ralph

A global assessment of the abalone genus (*Haliotis*) was completed in December 2022 with all assessments now published in the IUCN Red List. This groundbreaking study made headlines because of the number of abalones at risk and was publicised during COP15 in Montreal. Of the 54 abalone species from around the world, more than one third (20) are now classified as threatened. One common thread that many of these threatened species have is that they were once exploited. Of the 54 species, 21 (39 %) are (or once were) commercially fished, of which 15 (71 %) are now classified as threatened. Of the remaining 33 unexploited species, only five (15 %) are classified as threatened, underscoring the impact of fishing, both legal and illegal, on abalone populations.

The highest concentration of threatened species occurs along the North American Pacific coast. Here all seven species have been exploited, yet despite many years of fishery closures with exemptions only in Alaska and Mexico, six are categorised as Critically Endangered and one as Endangered. Poaching, the bane of abalone fisheries worldwide, has reached its apogee in South Africa, where gastronomic status and high prices, especially in East Asia, have attracted international criminal gangs tied to the narcotics trade, reducing the legal fishery of perlemoen (*Haliotis midae*) to a footnote, with widespread recruitment failure. Although in 2007 this species was listed by CITES, it was withdrawn three years later because of implementation challenges (De Greef & Raemaekers, 2014).

Abalones have been taken for thousands of years for food and have been important to native peoples as part of their culture, even showing up in indigenous lore. Wild caught animals in particular are prized as a marine delicacy fetching huge sums in the market. Unfortunately, even well-managed fisheries have not always accounted for the multiplicity of threats, including poaching, when setting total allowable catches. Marine heatwaves (MHWs), caused by a warming climate exacerbated by more frequent El Niño events, can result in widespread mortality in both abalones and their algal food source. This can be observed in the case of the red abalone (*H. rufescens*), once the mainstay of the abalone fishery in California. From 2014 to 2016 an intense MHW heavily impacted the bull kelp (*Nereocystis luetkeana*) forests, and sea urchins increased, dominating the system and leading to mass abalone mortalities. Rapid declines of more than 80 % of the red abalone (Rogers-Bennett & Catton, 2019) led to the closure of the last open abalone recreational fishery in the United States in 2018 with the exception of small-scale subsistence fisheries for pinto abalone (*H. kamtschatkana kamtschatkana*) in southeast Alaska.

MHWs exacerbate the virulence of diseases such as the abalone herpes-like virus, which causes viral ganglioneuritis that devastated blacklip abalone (*H. rubra rubra*) in 2005/6 in Victoria, Australia, where the pathogen escaped from an aquaculture facility when contaminated water was discharged into the ocean (Mayfield *et al*., 2011). Withering syndrome, a fatal bacterial disease first observed in 1985 in black abalone (*H. cacherodii*) of California (Friedman *et al*., 2000), spread to other species locally and through trade to other regions of the world, infecting both wild and cultured animals with up to 99 % mortality reported (Haaker *et al*., 1992).

Abalones are broadcast spawners with separate males and females, and to ensure reproductive success they need to be no more than two metres apart (Babcock & Keesing, 1999). As assemblages of abalones become dispersed and fragmented through overfishing, or through unavailability of algae or other causes, recruitment failure follows – the Allee Effect (Allee, 1931). Despite this plethora of threats there are some signs of

recovery thanks to the rapid expansion of the aquaculture industry. Abalone production is dominated by farm raised abalones. Today, wild caught abalones represent less than 5 % of total abalone production (Cook, 2019) and partnerships between industry and fisheries to replenish decimated wild stock through reseeding has led to some notable successes. In South Africa, along the Western Cape, abalone ranching is being developed, where hatchery-produced seeds of perlemoen are stocked into kelp beds outside their natural distribution (Troell *et al*., 2006) and includes spawning, larval development, seeding and harvest. In the Eastern Cape in 2011, the government fisheries department introduced a similar methodology using hatchery bred abalones along an 18 km section of coastline. Rightsholders were incentivised by means of 15-year investment rights, supported by anti-poaching measures using a private security team (Witte, 2016). By modelling data on confiscations, poachers and illegal boat encounters as a proxy, it is estimated that from 2013 to 2019 a significant reduction in poaching was recorded, with the illegal catch decreasing from around 300 tons per month in 2006 to less than 30 tons (Witte, 2021).

White abalone (*H. sorenseni*) (Fig. 1.), which occurs in southern California south to Baja California, Mexico, is on the very cusp of extinction. To inform restoration strategies for the species, a deterministic, density-dependent, size-based matrix model for the population was constructed, which showed that there is a 50 % probability that white abalone populations will reach 1,000 individuals (quasi-extinction threshold) by 2029 (Catton *et al*., 2016). A white abalone recovery programme, incorporating a captive breeding programme for restocking juveniles into suitable habitats, has been established in California (Rogers-Bennett *et al*., 2016) under the auspices of NOAA Fisheries. In addition to the captive breeding and outplanting programme, the plan includes monitoring to identify habitats best suited for future enhancement efforts and to track species status over time. The National Marine Fisheries Service oversees the programme with its partners in coordination with the California Department of Fish and Wildlife and the University of California Davis Bodega Marine Laboratory. The first stocking of captive-bred white abalones occurred in November 2019 and since then there have been six more releases.

Other major commercial abalone fishery nations, including Australia and Japan, also use captive breeding for restocking depleted populations. Ezo-awabi (*H. discus hannai*), which occurs in Japan and Korea, is the most extensively cultured species of abalone in the world, with major facilities in Japan, Korea and northern China, as well as outside its natural range in places such as Chile. However, populations are in steep decline as a result of over-fishing and the loss of habitat, in particular its preferred species of brown macroalgae with the disappearance of Laminariales and Sargassaceae (Serisawa *et al*., 2004; Hasegawa, 2005). Reintroductions have met with mixed success and while the general decline persists there is also a risk that repetitive restocking of hatchery bred abalones into the wild will result in inbreeding and a loss of genetic variability (Sekino *et al*., 2019). Its high retail value makes this species a target for poaching by organised crime

Fig. 1. White abalone (*Haliotis sorenseni*) on the cusp of extinction. (Photo: Athena Maguire)

syndicates and although enforcement has been strengthened in Japan with severe penalties, it remains a serious issue.

Captive breeding and outplanting is occurring in many countries where wild stocks have been ravaged by over-fishing. However, not all species under threat are considered suitable candidates, and although this offers some degree of optimism for some species, success has not been universal, and it comes at a high price. Even where a fishery may be classified as sustainable, failure in policing and enforcement can rapidly reverse any gains that may be made if there is aggressive and widespread poaching by criminal gangs. It may be the case that protecting large wild abalones at suitable densities will be far more successful and less costly than relying on stocking aquaculture produced abalones (Rogers-Bennett, in press).

Finally, acidification of the oceans, resulting from the combustion of fossil fuels and the absorption of CO_2 from the atmosphere, has a deleterious effect not only on the development of larval shells but also on the crustose coralline algae on which larval settlement depends (Byrne *et al*., 2011; Kuffner *et al*., 2007; Tahil & Dy, 2015). Over future decades, abalones, in common with most, if not all calcareous marine taxa, will become increasingly vulnerable to these changes in ocean chemistry. In addition to the impact on calcification, fertilisation, embryonic larval development and settlement could be compromised (Parker *et al*., 2013), but see O'Leary *et al*. (2017). Unless the combustion of fossil fuels driving marine heatwaves and acidification can be halted, the long-term future of abalones and kelp forests together with many marine molluscs remains uncertain.

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RECENT PUBLICATIONS RELEVANT TO MOLLUSC CONSERVATION

2022 World Congress of Malacology, Munich – Book of Abstracts and Book of Posters

The book of abstracts of the oral presentations at the WCM is available online as Supplement 30A of the journal *Spixiana*. This includes presentations in the American Malacological Society President's Symposium on Molluscan Conservation. In addition, the book of posters, in all their glorious colour, is available as Supplement 30B of the same journal.

Journal of Threatened Taxa

All issues for 2022 (volume 14), and the first three for 2023 (volume 15, numbers 1–3), of the *Journal of Threatened Taxa* are available online now. The journal occasionally has articles about molluscs.

Freshwater Mollusk Biology and Conservation

Freshwater Mollusk Biology and Conservation, formerly *Walkerana* is the on-line journal of the Freshwater Mollusk Conservation Society, based in North America. In 2022, it published two issues: volume 25, numbers 1 and 2, each with five papers. All issues are available on-line at the journal's website, with open access.

Volume 25, number 1

Ortiz, K., Jones, J.W. & Hallerman, E.M. 2022. Development and characterization of microsatellite loci in the endangered catspaw, *Epioblasma obliquata* (Bivalvia: Unionidae). *Freshwater Mollusk Biology and Conservation* 25: 1-6.
Williams, C.E. 2022. Potential recovery of the mussel fauna of the Clarion River, Pennsylvania. *Freshwater Mollusk Biology and Conservation* 25: 7-14.
Newton, T.J., Schrank, P.R., Zigler, S.J., Gritters, S., Kenney, A. & Skrabis, K. 2022. *Freshwater Mollusk Biology and Conservation* 25: 15-26.
Prezant, R.S., Dickinson, G.H., Chapman, E.J., Mugno, R., Rosen, M.N. & Cadmus, M.B. 2022. Comparative assessment of shell properties in eight species of cohabiting unionid bivalves. *Freshwater Mollusk Biology and Conservation* 25: 27-36.
Layer, M.R., Minton, R.L., Morris, T.J. & Zanatta, D.T. 2022. Utility of shell-valve outlines for distinguishing among four lampsiline

mussel species (Bivalvia: Unionidae) in the Great Lakes region. *Freshwater Mollusk Biology and Conservation* 25: 37-53.

Volume 25, number 2

Barnes, M.C., Mabey, L. & Billman, E.J. 2022. Relocation of Western Pearlshell before and after stream restoration in Tincup Creek, Idaho. *Freshwater Mollusk Biology and Conservation* 25: 54-61.

Ellwanger, R.J. & Wagner, M.D. 2022. Distribution and status of freshwater mussels in the Bear Creek watershed, Mississippi. *Freshwater Mollusk Biology and Conservation* 25: 62-73.

Ford, D.F., Plants-Paris, E.D. & Ford, N.B. 2022. Density, apparent survival, and local population size of Louisiana Pigtoe (*Pleurobema riddellii*) in the Neches River, Texas. *Freshwater Mollusk Biology and Conservation* 25: 74-81.

Perez, K.E., Noreika, N., Norris, C., Kelly, M., Lopez, M., Ortega, C., Sandoval, S.R., Gonzalez, S. & Nowlin, W. 2022. Population density and reproductive seasonality of *Tryonia cheatumi* (Gastropoda: Cochliopidae), the Phantom Tryonia. *Freshwater Mollusk Biology and Conservation* 25: 82-90.

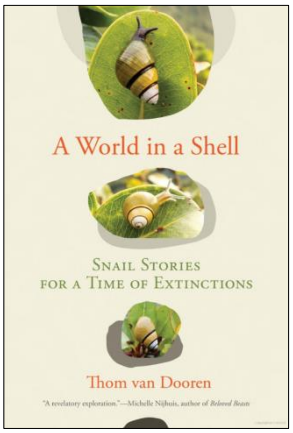
Skorupa, A.J., Roy, A.H., Hazelton, P.D., Perkins, D. & Warren, T. 2022. Evaluation of host fishes for the Brook Floater (*Alasmidonta varicosa*) from populations in Massachusetts and Maine, USA. *Freshwater Mollusk Biology and Conservation* 25: 91-102.

A World in a Shell – Snail Stories for a Time of Extinction

Thom van Dooren, 2022. MIT Press, Cambridge, USA.

From the publisher's website:

Following the trails of Hawai'i's snails to explore the simultaneously biological and cultural significance of extinction.



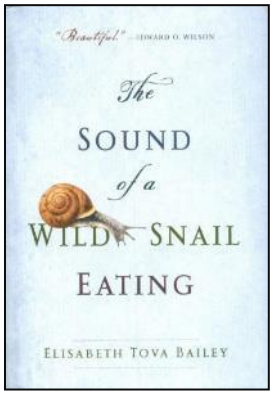
In this time of extinctions, the humble snail rarely gets a mention. And yet snails are disappearing faster than any other species. In *A World in a Shell*, Thom van Dooren offers a collection of snail stories from Hawai'i—once home to more than 750 species of land snails, almost two-thirds of which are now gone. Following snail trails through forests, laboratories, museums, and even a military training facility, and meeting with scientists and Native Hawaiians, van Dooren explores ongoing processes of ecological and cultural loss as they are woven through with possibilities for hope, care, mourning, and resilience.

Van Dooren recounts the fascinating history of snail decline in the Hawaiian Islands: from deforestation for agriculture, timber, and more, through the nineteenth century shell collecting mania of missionary settlers, and on to the contemporary impacts of introduced predators. Along the way he asks how both snail loss and conservation efforts have been tangled up with larger processes of colonization, militarization, and globalization. These snail stories provide a potent window into ongoing global process of environmental and cultural change, including the largely unnoticed disappearance of countless snails, insects, and other less charismatic species. Ultimately, van Dooren seeks to cultivate a sense of wonder and appreciation for our damaged planet, revealing the world of possibilities and relationships that lies coiled within a snail's shell.

Editor's note – Various people well known to readers of *Tentacle*, including Mollusc Specialist Group members, appear in the book.

The Sound of a Wild Snail Eating

Elisabeth Tova Bailey, original edition 2010. Algonquin Books of Chapel Hill, Chapel Hill, North Carolina, USA.



Here is my usual notice of this delightful book, which I continue to thoroughly recommend. It was originally reviewed in *Tentacle* 19 (2011). The memoir recounts the author's year-long observation of a forest snail, *Neohelix albolabris*. The original book was published in the USA in 2010, but it has been translated into various languages. For links to the publishers of these editions please see the author's website. An audiobook edition is available as a Kindle or hard CD. And there is an award winning short film adapted from it (see wildsnailfilm.org for upcoming screenings).

Film of the book available

The author informs me that the film of the book (around 15 minutes) is available for screenings to malacology and other groups and departments. Anyone interested in such a group screening for their lab or department should send an e-mail to info@wildsnailfilm.org. I have seen the film and can recommend it highly – it is as delightful and thought provoking as the book.

Other publications of interest

This is by no means a comprehensive list but simply a list of publications that I have happened to come across, additional to those mentioned elsewhere in this section. If you want to have your publications listed in the next issue of *Tentacle*, please send details to me, Robert Cowie, the editor.

Barman, H., Paul, P., Shee, A., Mazumdar, S.M., Mudi, S.D. & Aditya, G. 2022. Distribution of an arboreal snail, *Rhachistia bengalensis* (Lamarck, 1822) in managed and unmanaged habitats: implications for conservation. *Tropical Ecology* 63: 485-493.

Brian, J.I. & Aldridge, D.C. 2022. Mussel parasite richness and risk of extinction. *Conservation Biology* 36(6): e13979.

Coelho, P.R.S., Ker, F.T., Araujo, A.D., Pinto, H.A., Negrão-Corrêa, D.A., Caldeira, R.L. & Geiger, S.M. 2022. Survey on limnic gastropods: relationships between human health and conservation. *Pathogens* 11: 1533.

Cooper, A.R., Wehrly, K.E., Yeh, S.-K. & Infante, D.M. 2022. Influence of spatial extent on contemporary and future threat evaluation for imperiled fluvial fishes and mussels. *Water* 14(21): 3464.

Copeland, A. & Hesselberg, T. 2022. Habitat preferences of the Critically Endangered greater Bermuda land snail *Poecilozonites bermudensis* in the wild. *Oryx* 56(1): 34-37.

Cordero-Rivera, A., Ondina, P., Outeiro, A., Amaro, R. & San Miguel, E. 2022. Allometry in the freshwater pearl mussel (*Margaritifera margaritifera* L.): mussels tend to grow flatter at higher water speed. *Malacologia* 64(2): 257-267.

Cosgrove, P., Shields, D., Anderson, D., Massey, K., Cosgrove C. & Sime, I. 2022. The impact of a drought on key freshwater pearl mussel *Margaritifera margaritifera* populations in Scotland. *Journal of Conchology* 44(3): 241-255.

Cowie, R.H. 2022. Evolution, extinction and conservation of native Pacific island land snails. In: *Imperiled: The Encyclopedia of Conservation*, vol. 1 (ed. DellaSala, D.A. & Goldstein, M.I.), p. 395-404. Elsevier.

Cowie, R.H., Bouchet, P. & Fontaine, B. 2022. The Sixth Extinction: fact, fiction or speculation? *Biological Reviews* 97: 640-663.

Dance, S.P., Hancock, E.G. & Sutcliffe, R. 2022. Obituary of Frederick Richard Woodward (1939-2020). *Journal of Conchology* 44(3): 311-315. [see Kabat, 2022, below; Woodward published on Margaritiferidae and mollusc conservation]

Gladstone, N.S., Niemiller, M.L., Hutchins, B., Schwartz, B., Czaja, A., Slay, M.E. & Whelan, N.V. 2022. Subterranean freshwater gastropod biodiversity and conservation in the United States and Mexico. *Conservation Biology* 36(1): e13722.

Goncalves, A., Zieritz, A., Lopes-Lima, M., Deein, G. & Pfeiffer, J. 2022. Taxonomic revision and conservation assessment of the Southeast Asian freshwater mussel genus *Chamberlainia* Simpson, 1900. *Journal of Molluscan Studies* 88(2): eyac008.

Gross, M. 2022. Extinction in progress. *Current Biology* 32: R721-R723. [Review of Cowie *et al*. 2022. The Sixth Mass Extinction: fact, fiction or speculation. *Biological Reviews* 97: 640-663.]

Hayward, E.E., Gillis, P.L., Bennett, C.J., Prosser, R.S. Salerno, J., Liang, T., Robertson, S. & Metcalfe, C.D. 2022. Freshwater mussels in an impacted watershed: influences of pollution from point and non-point sources. *Chemosphere* 307(3): 135966.

Hyvärinen, H.S.H., Sjönberg, T., Marjomäki, T.J. and Taskinen, J. 2022. Effect of low dissolved oxygen on the viability of juvenile *Margaritifera margaritifera*: hypoxia tolerance ex situ. *Aquatic Conservation: Marine and Freshwater Ecosystems* 32(8): 1393-1400.

Inoue, K., Yahagi, T., Kimura, T. & Kano, Y. 2022. Population differentiation of the endangered salt-marsh snail *Ellobium chinense* in Japan (Gastropoda: Ellobiidae). *Plankton and Benthos Research* 17(1): 66-75.

Kabat, A.R. 2022. Frederick Richard Woodward – additions to bibliography and new taxa. *Journal of Conchology* 44(4): 407-411. [see Dance *et al*., 2022, above]

Kaji, N. & Yadav, S. 2023. A note on the occurrence of *Cremnochonchus conicus* (Blanford, 1870) in Mumbai, India. *Journal of Threatened Taxa* 15(3): 22908-22910.

Klunzinger, M.W., Whisson, C., Zieritz, A., Benson, J.A., Stewart, B.A. & Kirkendale, L. 2022. Integrated taxonomy reveals new threatened freshwater mussels (Bivalvia: Hyriidae: *Westralunio*) from southwestern Australia. *Scientific Reports* 12: 20385.

Lawrence, A.J., Matuch, C., Hancock, J.J., Rypel, A.L. & Eliassen, L.A. 2022. Potential local extirpation of an imperiled freshwater mussel population from wildfire runoff. *Western North American Naturalist* 82(4): 695-703.

Linscott, T.M., González-González, A., Hirano, T. & Parent, C.E. 2022. De novo genome assembly and genome skims reveal LTRs dominate the genome of a limestone endemic Mountainsnail (*Oreohelix idahoensis*). *BMC Genomics* 23: 796.

Maine, A.N. & O'Brien, C. 2022. Use of Native and nonnative fish hosts by the freshwater mussel *Anodonta californiensis* (California Floater) in the Columbia River Basin. *Malacologia* 64(2): 203-213.

Meyer, W.M., III, Evans, L.M., Kalahiki, C.J.K., Slapcinsky, J., Goulding, T.C., Robinson, D.G., Kaniaupo-Crozier, D.P., Kim, J.R., Hayes, K.A. & Yeung, N.W. 2022. Plants critical for Hawaiian land snail conservation: arboreal snail plant preferences in Pu'u Kukui watershed, Maui. *Oryx* 56(1): 38-43.

Miyahira, I.C., Clavijo, C., Callil, C.T., Cuezzo, M.G., Darrigran, G., Gomes, S.R., Lasso, C.A., Mansur, M.C.D., Pena, M.S., Ramírez, R., Santos, R.C.L., Santos, S.B., Scarabino, F., Torres, S.H., Vogler, R.E. & Cowie, R.H. 2022. The conservation of non-marine molluscs in South America: where we are and how to move forward. *Biodiversity and Conservation* 31(11): 2543-2574.

Miyahira, I.C., Mansur, M.C.D. Macedo de Lacerda, L.E., Gonçalves, I.C.B., Sant'Anna, G.G. & dos Santos, S.B. 2023. Protected areas and native freshwater bivalves are not in the same place in south-east Brazil. *Aquatic Conservation: Marine and Freshwater Ecosystems* 33(1): 102-114.

Nishida, S., Mimura, K., Mori, H. & Chiba, S. 2022. Characterization of polymorphic microsatellite markers for the Japanese endangered land snail *Mandarina*. *BMC Research Notes* 15: 255.

Perez, M.C.R. & Hausdorf, B. 2022. Low abundance but high land snail diversity in montane rainforest on the western slope of the Andes in Ecuador. *Journal of Molluscan Studies* 88(1): eyab048.

Psonis, N., Vardinoyannis, K. & Poulakakis, N. 2022. High-throughput degraded DNA sequencing of subfossil shells of a critically endangered stenoendemic land snail in the Aegean. *Molecular Phylogenetics and Evolution* 175: 107561.

Richards, K., Macfarlane, K.R. & Green, E. 2022. A unique survey method for freshwater limpets leads to the rediscovery of *Beddomeia tumida* Petterd, 1889 (Mollusca: Tateidae) in *yingina*/Great Lake, Tasmania. *The Tasmanian Naturalist* 144: 1-11.

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Rodgers, T.W., Tronstad, L.M., Gonzalez, B.R., Crawford, M. & Mock. K.E. 2022. Distribution of the native freshwater mussels *Anodonta nuttalliana* and *Margaritifera falcata* in Utah and Western Wyoming using environmental DNA. *Western North American Naturalist*, 82(3): 439-450.

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& Szabo, K. 2022. A strategy for conservation of springsnails in Nevada and Utah, USA. *Sustainability* 14, 9546.
Tamario, C., Tibblin, P. & Degerman, E. 2022. Ecological marginality and recruitment loss in the globally endangered freshwater pearl mussel. *Journal of Biogeography* 49(10): 1793-1804.
Teixeira, D., Groh, K., Yanes, Y., Pokryszko, B.M., Silva, S. & Cameron, R.A.D. 2022. Late Quaternary land snail faunas of the Desertas Islands (Madeira): high diversity and endemism followed by recent impoverishment and extinction. *Journal of Molluscan Studies* 88(2): eyac010.
Teles, W.S., Silva, D. de P., Vilela, B., Lima-Junior, D.M., Pires-Oliveira, J.C. & Miranda, M.S. 2022. How will the distributions of native and invasive species be affected by climate change? Insights from giant South American land snails. *Diversity* 14(6): 467.
Thomas, E.A., Böhm, M., Pollock, C., Seddon, M. & Sigwart, J.D. 2022. Assessing the extinction risk of insular, understudied marine species. *Conservation Biology* 36(2): e13854.
Thompson, K.J., Fenwick, M.C. & Clearwater, S.J. 2022. In vitro larvae metamorphosis of a New Zealand native freshwater mussel (Bivalvia: Unionida: Hyriidae) *Echyridella menziesii*. *Molluscan Research* 42(2): 99-109.
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IUCN/SSC AND MOLLUSC SPECIALIST GROUP NEWS AND ANNOUNCEMENTS

www.iucn.org/

News and information provided by Mary Seddon, chair of the Mollusc Specialist Group (MSG) of the IUCN Species Survival Commission (SSC).

IUCN Red List updates 2023

This year the Red List database will be updated twice during the year. Submission of a Red List assessment by the dates listed does not guarantee whether it will be published by the first proposed date. These schedules may change but at present the submission and target publication dates are:

Submission	Target publication
21 April 2023	20 July 2023
8 September 2023	7 December 2023

Milestone of a high seas treaty achieved

This treaty has been decades in the making, so in March 2023, the completion of the United Nations (UN) agreement on the conservation and sustainable use of marine biodiversity of areas beyond national jurisdiction (BBNJ Agreement) is a fantastic step forward in biodiversity conservation for much of the oceans across our planet. IUCN has been providing advice to the treaty discussions for the last five years, at each of five major meetings of the parties.

This treaty means that there will now be a governance body that can review cumulative impacts of human activities and climate stressors such as ocean warming, acidification, deoxygenation and marine heatwaves, which can occur in concert and further exacerbate other existing anthropogenic pressures, undermining ocean resilience.

There are four main activity areas:

- Development of a well-managed network of Marine Protected Areas (MPAs), which are fully protected, as well as other Area-Based Management Tools (ABMTs), through a transparent, science-based process.
- Improved environmental impact assessment, management and monitoring of the effects of human activities and climate change (including ocean acidification, deoxygenation and marine heat waves) on marine biological diversity.
- Advancing marine science through scientific initiatives and partnerships such as the UN Decade of Ocean Science to inform ecosystem-based management.
- Capacity building partnerships and benefits sharing mechanisms.

New Convention on Biological Diversity 2022-2030

We have now entered the fourth decade of countries working together to conserve biological diversity. After four years of negotiation, the latest plan, with 23 targets, was signed by 186 countries in December 2022 and is known as the *Kunming-Montreal Global Biodiversity Framework*. This replaces the Aichi targets that were operational between 2012 and 2022 and has been amended slightly from the proposed targets listed in 2022. Each country will be required to submit their next 5 year progress report in 2026. Some of the notable targets are as follows (paraphrased or abbreviated in some cases), with related IUCN/MSG activities following each target statement.

- **Target 1** By 2030 reduce to near zero, the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity.

IUCN will be monitoring the extinctions of species over the next decade using the Red List as one tool to measure change. It is disappointing that the Target was reduced to "reduce to near zero" as originally it was no loss in the first drafts of the targets.

An example of progress reporting for 2026, will be delivered by the European Union (EU) Pulse project, which is still ongoing and will produce the first Red List Index for a regional mollusc fauna.

New initiatives include the Greek National Red List project, which is currently ongoing, led by Kostas Triantis, and this has an ambitious target of assessing the complete national fauna, includingan update to the land and freshwater molluscs listed in 2010 and 2017 by the regional projects. It will also include all marine species, so a welcome addition to knowledge of threats to molluscs.

- **Target 2** Ensure that by 2030 at least 30% of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration.

IUCN will be looking at this target to track habitat restoration and monitor impact on species in these habitats. Many molluscs, especially freshwater molluscs, could benefit, but there is insufficient information in the Red List at present.

The CONFREMUS mussel project hopes to include some proposed targets for restoration in the final European conservation plan.

- **Target 3** Ensure and enable that by 2030 at least 30 % of terrestrial, inland water, and coastal and marine areas are effectively conserved and managed through systems of protected areas and other effective area-based conservation measures.

This revised target will track the changes in protected areas and monitor impact on threatened species in these areas. Many molluscs, especially freshwater molluscs could benefit, but there is insufficient information about protected areas in the conservation actions section on the Red List at present and few threatened species are listed on the national protected areas plans. Countries are setting their own 30 x 30 (30 % by 2030) targets for creation of protected areas, so it is worth checking if a mollusc that you are monitoring is named in the management plan for the protected area.

There is now a system in place to add new Key Biodiversity Areas to the IUCN database and members are invited to view the webinars about the KBA process (see below).

- **Target 4** Ensure urgent management actions, to halt human induced extinction of known threatened species and for the recovery and conservation of species.

IUCN will be a key partner in monitoring progress towards this target as it will track species specific conservation actions to prevent extinctions. At present for freshwater molluscs if the Red List were used to monitor the species that this target applied to it would mean that countries should be tracking 60 molluscs for which species management is a conservation action on the Red List. See the webinars on how to use Conservation Planning tools to increase Action 2 Plan work. The first pilot project for the Conservation Planning Specialist Group using the new framework on Molluscs is working with the CONFREMUS project in Europe to develop a full conservation plan for all freshwater bivalves. This will include policy recommendations that the IUCN EU policy officers can use to lobby for conservation actions at regional levels.

- **Target 5** Ensure that the use, harvesting and trade of wild species is sustainable, safe and legal, preventing overexploitation, minimizing impacts on non-target species.

This applies to any species that is harvested, and as such will apply to some molluscs, including those impacted as bycatch. This will be worth reviewing for exploited species of marine molluscs in the next five years.

- **Target 6** Eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services.

Invasive alien species are an escalating threat to molluscs, as increasingly non-native molluscs are impacting native species, as well as the more traditional threats such as introduced rodents that prey on molluscs and invasive plant species changing habitats. However, molluscs may also be impacted by eradication actions that can adversely impact non-target species.

- **Target 7** Reduce pollution risks and the negative impact of pollution (including plastic pollution) from all sources, by 2030, to levels that are not harmful to biodiversity and ecosystem functions and services.

Already considered the major threat to freshwater molluscs, this target might be useful to follow for conservation actions in individual countries as pollution has caused decline in many species across all regions.

Other relevant targets:

- **Target 8** Minimize the impact of climate change and ocean acidification on biodiversity.
- **Target 9** Ensure that the management and use of wild species are sustainable, thereby providing social, economic and environmental benefits for people.
- **Target 10** Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably, in particular through the sustainable use of biodiversity.
- **Target 11** Restore, maintain and enhance nature's contributions to people, including ecosystem functions and services.
- **Target 12** Significantly increase the area and quality of green and blue spaces in urban and densely populated areas.
- **Target 13** Ensure the fair and equitable sharing of benefits that arise from the utilization of genetic resources in accordance with international access and benefit-sharing instruments.
- **Target 14** Ensure the full integration of biodiversity into policies, planning and development processes, environmental impact assessments within and across all levels of government and across all sectors.

MIRLA: a new marine invertebrate initiative

A new group has been established to create Red List assessments of marine invertebrate species, which will shed light on threats and the level of extinction risk for these diverse taxa. Julia Sigwart is one of the co-chairs of this new group (see her article starting on page 54 of this issue of *Tentacle*). It will be supported by a new funding initiative, the Senkenberg Ocean Species Alliance (SOSA) based at the Senckenberg Museum in Frankfurt.

A prioritisation exercise will be undertaken similar to that for terrestrial invertebrates led by Justin Gerlach in 2014. Focal projects for Red List assessments in the current quadrennium will be undertaken in collaboration with the relevant specialist groups, including the Mollusc Specialist Group and supporting new taxon specialist groups as they emerge. Direct threats include overfishing and bycatch. Indirect effects include ecosystem degradation through overfishing or habitat destruction, particularly as a result of bottom trawling. Climate change and rising ocean temperatures also affect many marine invertebrates, particularly hard corals. Ocean acidification can have detrimental impacts, particularly for species with shells or hard carapaces made of calcium carbonate.

One of the first proposed projects includes reassessment of the cone species, last assessed in 2010, which will produce a Red List Index for this family of gastropods, led by Julia Sigwart, Nicolas Puillandre and Philippe Bouchet, assisted by Howard Peters, the previous project leader. For more information, including job opportunities see the SOSA website or follow them on Twitter.

New centre established for freshwater species conservation

The Shedd Aquarium in Chicago has entered a partnership with IUCN/SSC to create a centre supporting the conservation of freshwater species. Dr. Chuck Knapp, its lead scientist on the project, has secured funding to support capacity building projects in Meso-America and South America focussing on freshwater fish and freshwater mussels. These same vital freshwater systems are the most imperiled ecosystems on the planet and face a growing list of challenges like pollution, habitat loss, overexploitation, fragmentation (e.g. dams and culverts) and the climate crisis. The Shedd Aquarium's Center for Species Survival: Freshwater will elevate awareness of threats to freshwater habitats across the globe to help combat the current trend of freshwater biodiversity loss, which will benefit animals, plants and people alike. The new projects will use tools produced by IUCN, and the Shedd team will work alongside local collaborators and IUCN SSC Specialist Groups to assess potential extinction threats, identify key biodiversity areas and train local partners to build capacity for this work so that it can be sustained within the region.

Conservation Planning Specialist Group

The Conservation Planning Specialist Group has put together a series of webinars covering different approaches to developing Species Conservation Plans, from single species through to multi-taxon approaches. These webinars are accessible to anyone and may provide some useful advice for those starting on the ground actions for species conservation. It would also be useful viewing for those considering making a grant application to one of the SSC/IUCN types of funding sources (see below). The content includes the following modules:

Module 1: Principles of species conservation planning—This video covers the seven main principles of developing species conservation plans. There is a conservation planning handbook that summarises these principles along with providing case-studies that demonstrate principles in real life. Video presenters: Jamie-Lee Copsey and Caroline Lees.

Module 3: Assessing to plan – multi-species planning pathways—This video provides three examples of developing multi-species conservation plans. These examples include trees, reptiles and amphibians, and freshwater fishes. Video presenter: Caroline Lees

Module 5: Wildlife disease risk analysis: a 'One Health' approach—This video provides an overview of the IUCN approach to wildlife disease risk analysis, something we have all become more aware of since COVID-19. There has been an increase in the number of diseases that have been impacting wild species, including molluscs. A handbook, *Guidelines for Wildlife Disease Risk Analysis*, is also provided. Video lead presenter: Phil Miller.

New IUCN Red List webinar series from 2022

There is a series of webinars covering various aspects of creating a Red List assessment for publication on the IUCN Red List. These were broadcast over several months in 2022 and were recorded so that they can be replayed. They cover many of the "Frequently Asked Questions" about the categories and criteria as well as creating maps. To find out more go to the IUCN Red List webinars page.

IUCN Key Biodiversity Areas: new webinar series for 2023

There is a series of Webinars covering an introduction to the concept of Key Biodiversity Areas (KBAs) and their value for species and ecosystem conservation. These are being broadcast over several months in 2023 and have been recorded so that they can be replayed. They cover many of the "Frequently Asked Questions" about Key Biodiversity Areas.

Webinar 1: Key Biodiversity Areas (KBAs)—What are Key Biodiversity Areas (KBAs), how are they used and why should IUCN SSC members engage with them? In 2004, the World Conservation Congress in Bangkok recognised that to deal with the threats to biodiversity and ecosystems, we need a single framework that identifies important sites across taxonomy. This recognition resulted in the creation of the KBA Global Standard, an umbrella framework that was designed to identify areas of importance across all biodiversity. Speaker: Andrew Plumptre, Head of the KBA Secretariat, IUCN.

Webinar 2: Key Biodiversity Areas (KBAs)—An overview of the KBA criteria for identifying sites contributing significantly to the global persistence of biodiversity. Key Biodiversity Areas are identified using a set of science-based criteria that are defined in the KBA Global Standard. These 11 KBA criteria have been categorised into five groups: A – Threatened biodiversity, B – Geographically restricted biodiversity, C – Ecological integrity, D – Biological processes, and E – Irreplaceability through quantitative analysis. Speaker: Charlotte Boyd, Africa Oceans Fellow, Conservation International.

Webinar 3: Monitoring the status of Key Biodiversity Areas—Key Biodiversity Areas can be gazetted as protected areas because of their global significance, but this is not always necessary. At a minimum KBAs need to be monitored and a monitoring platform is being developed to enable this and build on Bird Life's Important Bird Areas monitoring programme. One aim of the KBA monitoring is to develop a measure of the proportion of KBAs in favourable condition, which would be used as an indicator for Convention of Biological Diversity and the United Nations Sustainable Development Goals.

Grants 2023

There are several small grant opportunities that run through SSC and members may apply for these. Competition is strong and preference is given to applications that cover all areas from the 'Assess, Plan, Action' cycle that SSC has been promoting, as its approach to species conservation. Examples of projects previously funded can be found in the previous issue of *Tentacle*, issue 30 (page 54).

Mohamed bin Zayed (MBZ) grants 2023

Two main opportunities remain in 2023, closing dates 30 June and 30 November.

The main application form is online. The majority of successful grants receive between $5,000 and $10,000 although grants of up to $25,000 are occasionally given. If possible, there should be a named focal species, although projects that look at a group of species in similar habitats are also funded. Soil invertebrate projects have a special funding allocation in 2023 and therefore will technically be available to projects including those land snails that are soil dwellers.

SSC Internal Grant 2023

One further opportunity remains in 2023. The main application form is online and the applicant must obtain endorsement from one of the Specialist Groups. The successful grants receive between $2,000 and $3,000. There should be a named focal species although projects that look at a group of species in similar habitats are also funded. The project must be in the SSC main plan for an 'Assess, Plan, Action' activity in 2023/2024.

SSC Edge of Extinction Grant 2023

There is one opportunity a year, usually in October/November, but the closing date has not yet been announced. The main application form is online and the applicant must obtain endorsement from one of the Specialist Groups. The successful grants receive up to $10,000. There should be a named focal species that is in a taxon group that is isolated and evolutionary distinct. The project also must be in the SSC main plan for a conservation activity in 2023/2024. In the last round in 2022, there was a successful application that was endorsed by MSG to work on the *Cremnoconchus* group of freshwater littorinid gastropods that live on waterfalls in India (see the article on this work by Aravind starting on page 26 of this issue of *Tentacle*).

MEETINGS 2023

This is not a comprehensive list of mollusc and conservation related meetings but includes those for which people have sent me details and the major ones that I am generally aware of without doing a thorough search. Robert Cowie, *Tentacle* editor.

American Malacological Society annual meeting

The 2023 annual meeting of the American Malacological Society will take place on 1-5 August in Tuscaloosa, hosted by the University of Alabama and the Alabama Museum of Natural History. For more information, check the meeting website, or contact AMS President Kevin Kokot by email: kmkocot@ua.edu

Bivalves – Where Are We Going

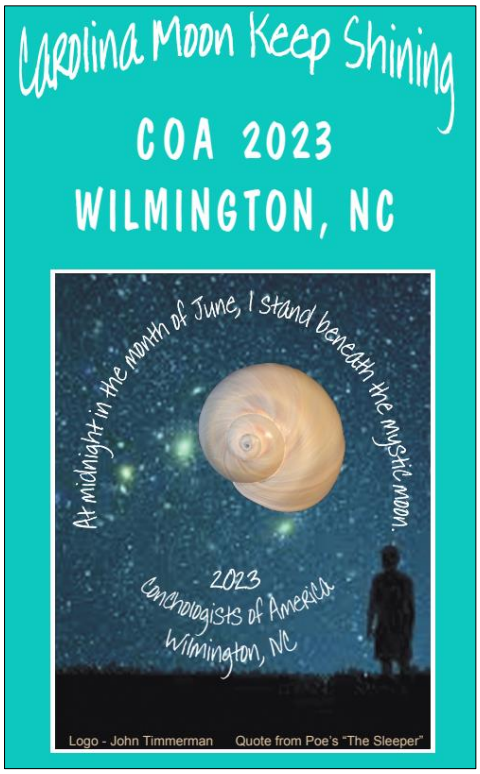
Meeting dates: 5-8 September 2023
Location: University of Cambridge (UK)
Organisers: Liz Harper (University of Cambridge), John Taylor, Emily Glover and Katie Collins (Natural History Museum, London

The Palaeontological Association
Reg. Charity No. 1168330

Contact email: emh21@cam.ac.uk

From the organisers:
We are pleased to announce the forthcoming conference focused soley on bivalved molluscs. This is intended as a successor to the previous bivalve meetings that took place in London (1977), Drumheller (1995), Cambridge (1999) and Barcelona (2006). Our aim is to host a relaxed, open in-person meeting to carry on this tradiaion of convivial review of all aspects of current bivalve research (living and fossil).

Conchologists of America 2023 convention



Conchologists of America will celebrate the 50th anniversary of the society at its 2023 Convention, which is to be held in Wilmington, North Carolina from 31 May to 4 June 2023, with field trips on 29 and 30 May. For more information, please see the Convention website.

Brasilian Malacological Meeting (XXVIII EBRAM) and Latin American Congress of Malacology (XII CLAMA), 2023

The Brasilian Society of Malacology (SBMa – Sociedade Brasileira de Malacologia) will jointly hold the XXVIII Encontro Brasileiro de Malacologia (XXVIII EBRAM) and the XII Congreso Latinoamericano de Malacología (XII CLAMA), during 2-6 October 2023; the meeting will be online only. The theme of the event was inspired by the United Nations (UN) and its agency for education, UNESCO (United Nations Educational, Scientific and Cultural Organization), which designated 2023 as the International Year of Basic Sciences for Sustainable Development. The objective is to highlight the possible impacts of basic sciences on the 17 Sustainable Development Goals (SDGs). Several, if not all, of these objectives are explicitly linked to scientific advances, making it necessary to convince economic and political leaders, as well as the general public, of the importance of this type of science for our future. Quality Education is the fourth SDG and aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". In recent years, we have observed the phenomenon of scientific denialism, in which basic concepts, often already largely established by scientific endeavour, have increasingly been questioned. How can we achieve an inclusive education with sustainable development in a world continually haunted by denialist beliefs? Science education is therefore a key element in achieving several SDGs. As malacologists and educators, what would be our role in building science education for now and future generations? Thus, the theme of this meeting will be **Malacology, Scientific Education and Sustainable Development**, reinforcing: 1) the relevance of guaranteeing a sustainable future for the next generations by preserving the environment, and 2) the urgency of strengthening scientific education in schools and in informal education spaces, for people of all ages. Short courses, a Symposium of Young Latin American Taxonomists, special sessions of contributed papers, oral presentations and a virtual poster session are being organised and will be open to all aspects of malacology, including taxonomy, ecology, basic biology, evolution, education, ecotoxicology, distribution and conservation of terrestrial, marine and freshwater molluscs, fisheries and other topics. Our established prizes will be awarded as usual, despite the meeting being online: the "Prof. Maury Pinto de Oliveira Award for Advancement of Malacological Studies" (general Malacology) and the "Dr. Wladimir Lobato Paraense Award (medical malacology). More detailed information will be uploaded soon on the website and questions can be sent to ebramsecretaria@gmail.com

Best wishes, and we hope to see many of you at the meeting.

Dra Lenita de Freitas Tallarico, President of the Sociedade Brasileira de Malacologia
Dr Alvar Carranza, President of the Asociación Latinoamericana de Malacología

INTERNET RESOURCES

These are just a few of the many websites dealing with mollusc conservation, with molluscs and conservation in general, and available collection databases. If you would like me to include any new ones or to update any of the current ones, please send details to me, Robert Cowie, editor of *Tentacle*.

IUCN Red List

The entire *IUCN Red List of Threatened Animals* can be searched at the following address: www.iucnredlist.org

Unitas Malacologica

Unitas Malacologica (UM) is the worldwide society for malacologists and malacology. Its aim is to further the study of Mollusca by individuals, societies and institutions

worldwide. UM has provided financial support for the production of *Tentacle* in the past and I urge all readers to become members. The UM website has links to many interesting and useful sources of malacological information, including all the UM newsletters, which have a lot of information complementing information in *Tentacle*. UM also makes small grants available to students for both research and travel to the triennial UM World Congress of Malacology. To become a member of UNITAS, go to its website and follow the links to the application.

IUCN Invasive Species Specialist Group

The ISSG website includes details of the Aliens-L listserver and the ISSG newsletter, *Aliens*, published up to 2013.

Mollusca list

The MOLLUSCA listserver is an informal forum for discussions of molluscan biology. There are over 700 subscribers. You can subscribe to the list here. Once your subscription is approved, you will receive anything that is posted to the list, and be able to post to the list. To post to the list, send email to molluscalist@listserv.dfn.de. The list is now managed by Julia Sigwart of the Senckenberg Museum, Frankfurt, with David Lindberg and Gerhard Haszprunar.

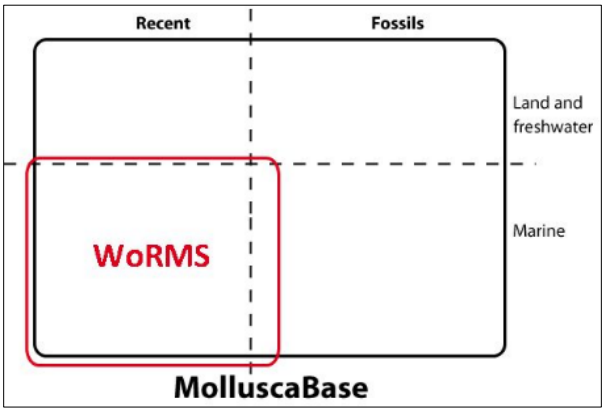
MolluscaBase

MolluscaBase is a taxonomically oriented database that aims to provide an authoritative, permanently updated account of all molluscan species.

Subject to availability, the following information is provided for taxa included in MolluscaBase:

- Accepted (valid) name
- Classification (presented with a parent/child hierarchy)
- Synonyms
- Reference of original description and other relevant literature sources
- Type locality and distribution
- Stratigraphic range
- Traits (environment, feeding type, host/parasite relationship) and notes
- Images

The recent, marine component coincides with the Mollusca entries in the World Register of Marine Species (WoRMS),



whereas the non-marine and fossil components are not displayed in the WoRMS interface, although the former are increasingly being added.

American Malacological Society

The homepage of the American Malacological Society carries a link to its Conservation Policy. and Imperiled Species Newsletter. Student research grants are available (scroll down on the homepage). Many useful links are provided on the Resources page, including links to malacological museum collection databases.

Freshwater Mollusk Conservation Society

The Freshwater Mollusk Conservation Society (FMCS) is devoted to the advocacy for, public education about and conservation science of freshwater molluscs, North America's most imperiled fauna. Its website has an excellent page of links. The FMCS now publishes the journal *Freshwater Mollusk Biology and Conservation* (formerly *Walkerana*) and has all issues on-line and available, including volume 1, which includes Jack Burch's *Identification of Eastern North American Land Snails* and two-part *North American Freshwater Snails*.

Malacological Society of Australasia

The Malacological Society of Australasia is networked with the leading conservation organisations and is working with the IUCN Mollusc Specialist Group to list Australia's threatened and endangered species of molluscs. The society publishes the journal *Molluscan Research*.

Brasilian Society of Malacology

The Sociedade Brasileira de Malacologia (SBMa) welcomes malacological researchers, professionals and students, Brasilian and foreign, as well as aficionados of molluscs, having as its main objective to encourage the study of malacology, promoting knowledge of molluscs and its dissemination at all cultural levels, and taking reasonable measures to preserve the Brasilian mollusc fauna.

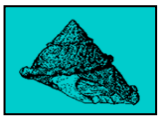
Haus der Natur – Cismar

The Haus der Natur homepage carries a link to a page on mollusc conservation and responsible collecting, as well as other links.

Conchologists of America

The homepage of the COA carries a link to a number of pages dealing with its conservation policy and conservation issues. Research grants are available.

Western Society of Malacologists



The WSM home page carries links to membership, conferences, grants, and other news.

The Malacological Society of London

The Malacological Society of London is dedicated to the advancement of research and education on molluscs. It is an international organization based in London, UK, and welcomes as members all who are interested in the scientific study of molluscs.

The Society was founded in 1893, with the objectives "to advance education, research and learning for the public benefit in the study of Mollusca from both pure and applied aspects".

The main activities of The Society are to:

Publish the *Journal of Molluscan Studies*.
Distribute a bulletin, *The Malacologist*, to Society members (also freely available online).
Make awards for research and travel to students of malacology and non-salaried applicants.
Award prizes for outstanding contributions in the field of molluscan biology.
Organise meetings and symposia.
Promote education and awareness about molluscs.
In 2022, a new initiative was launched to help support more students from across the world in their malacological studies. More information on this here.

The Natural History Museum, London

The collections database of the Natural History Museum can be searched via the Museum's Data Portal.

The Smithsonian Institution National Museum of Natural History, Washington

The Invertebrate Zoology collections, including Mollusca, can be searched online.

Florida Museum of Natural History Invertebrate Zoology Collection

The collection database, including Mollusca, can be searched online.

The National Museum of Wales – Mollusca

The Mollusca page of the National Museum of Wales provides information on the global projects on molluscs underway based in Cardiff. The museum's Mollusca collection database is searchable.

Illinois Natural History Survey

The Illinois Natural History Survey's mollusc page has much information on the mussels of North America, with links to other mussel sites.

National Zoological Collection of India type specimens illustrated online

The Zoological Survey of India now has online information, including illustrations, for the type collections of the National Zoological Collection of India, including molluscs.

Field Museum land snails

The online database of Chicago's Field Museum mollusc collections contains information for most of its 143,000 land snail lots, including over 2,500 type lots. Freshwater lots (45,000) and most marine lots (90,000) are yet to be fully databased.

Museum of Comparative Zoology (MCZ) collections, Harvard University

The MCZ has migrated its legacy specimen records from multiple independent sources, including the Malacology Collection, to a single centralised database, MCZbase.

Academy of Natural Sciences, Philadelphia, Malacology Collection

The Malacology Collection database contains records related to 460,000 lots maintained in the Malacology Department.

CLEMAM: Check List of European Marine Mollusca

The Check List of European Marine Mollusca database provides a list of taxonomic references concerning all molluscan taxa living in marine waters of Europe.

MUSSEL database project

The MUSSEL Project is an on-going study aimed at the global revision of the classification of the Unionoida, otherwise known as freshwater mussels. The two principle investigators, Daniel L. Graf and Kevin S. Cummings, combine their efforts to maintain an efficient malacological strike force equally capable of working in remote collection localities or urban mollusc collections. Toward this end, they are compiling an exhaustive database of all Recent described unionoid species and genera. This database will eventually serve as the basis for a universal synthesis and revision of freshwater mussel taxonomy.

Unio listserver

Unio is an unmoderated internet listserver focusing on the biology, ecology and evolution of freshwater unionid mussels. The list is sponsored by the Florida Institute of Technology and administered and managed by Rick Tankersley (rtank@fit.edu).

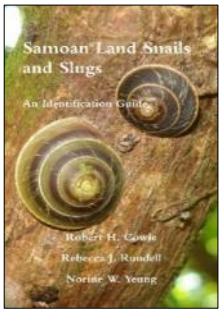
Caucasian Snail Project

The Caucasian Land Snails Project is a major collaborative effort. The website is maintained by Bernhard Hausdorf, mollusc curator at the Zoological Museum, Hamburg University.

Tropical land snail project at the Natural History Museum, London

The Tropical Land Snail Diversity site provides access to the Sri Lankan and South and South-east Asian snail projects of Fred Naggs, Dinarzarde Raheem and colleagues. There are some marvellous photos of brightly coloured snails.

Samoan Snail Project



The Samoan Snail Project had as its goals assessing the diversity and historical decline of the native Samoan non-marine snail fauna, as a first step in its conservation. It is part of the Bishop Museum's Pacific Biological Survey. In 2017 an inexpensive illustrated paperback guide to the Samoan Islands land snail fauna was published (see *Tentacle* 26).

Hawaii Biological Survey

The Hawaii Biological Survey (based at the Bishop Museum, Honolulu) web site has searchable databases and much additional information on most Hawaiian organisms, including both indigenous (99 % endemic) and non-indigenous land and freshwater snails, endangered species, and so on.

CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The majority of information relates to mammal and bird trade, but a number of molluscs are listed in the Appendices.

Other useful links

www.manandmollusc.net/
https://www.molluscs.at/
https://australian.museum/learn/animals/molluscs/
https://kids.kiddle.co/Mollusc

TENTACLE – PUBLICATION GUIDELINES AND INFORMATION

Disclaimer 1: *Tentacle* is not issued for purposes of zoological nomenclature. All or any names or nomenclatural acts in it are disclaimed for nomenclatural purposes. See the *International Code of Zoological Nomenclature*, Fourth Edition, Article 8.

Disclaimer 2: Views expressed in *Tentacle* are those of the authors of individual articles. They do not necessarily reflect the views of the Editor, nor of the Mollusc Specialist Group, the Species Survival Commission or IUCN.

Tentacle is a web-based newsletter, accessed at www.hawaii.edu/cowielab/Tentacle.htm, where all issues are available. Guidelines for submission of articles to *Tentacle*, and other related IUCN links are also on this website.

If you plan to submit something to *Tentacle*, please read the following guidelines. Carefully following the guidelines will make the life of the editor a lot easier! And please look at recent issues to help guide you.

Your submission **must** be **explicitly** relevant to **mollusc conservation** and the conservation relevance must be **specific to the study you are reporting**.

I usually make only editorial changes to submitted articles and in the past have accepted almost everything sent to me. However, before I accept an article I will assess whether it really includes anything **explicitly and specifically relevant to mollusc conservation** and whether any conclusions drawn are supported by the information presented. For example, **new records of non-native species and lists of non-native species will not be accepted unless there is a clear and significant relevance to mollusc conservation**. Also **reports of surveys will not be accepted unless there is a clear and specific conservation significance of the survey**. So, fully explain the specific conservation relevance in your article and be sure not to speculate too wildly. Unjustified statements (even if probably true) do a disservice to conservation as they permit our critics to undermine our overall arguments. *Tentacle*, however, is not a peer-reviewed publication and statements made in *Tentacle* remain the authors' responsibilities.

I stress that *Tentacle* is not a peer-reviewed publication. Please do not see *Tentacle* as an easy way to get your original data published without going through the rigours of peer review. ***Tentacle* is a NEWSLETTER** and so it is primarily **news items** that I want, including summaries of your ongoing studies, rather than full, data-rich reports of your research. Those reports should be submitted to peer reviewed journals. I will increasingly decline to publish articles that I feel should be in the peer-reviewed literature, especially if they are long.

There is, therefore, a **limit of three published pages**, including all text, illustrations, references, etc., for all articles that I accept for publication in *Tentacle* (though I reserve the right to make rare exceptions if I consider it appropriate).

Please make every effort to FORMAT YOUR ARTICLE, including fonts (Times New Roman), paragraphing styles, heading styles, and especially citations, in a way that makes it easy for me simply to paste your article into *Tentacle*, which is created in Microsoft Word. Please pay special attention to the format (paragraphing, fonts, font sizes, etc.) in past issues. TEMPLATES FOR ARTICLES ARE AVAILABLE – ASK ME IF YOU HAVE NOT RECEIVED ONE.

Conformance to the guidelines has improved – perhaps because of my many many reminders! But it still takes untold hours to format your submissions – please do it for me! Especially, please pay very careful attention to the format of references in the reference lists, especially punctuation – it still takes enormous amounts of time deleting commas, inserting colons, changing journal titles to italics, putting initials after not before names, deleting parentheses around dates and so on. Here are examples of how it should be done – please follow them very carefully:

Cowie, R.H., Bouchet, P. & Fontaine, B. 2022. The Sixth Mass Extinction: fact, fiction or speculation? *Biological Reviews* 97: 640-663.

Cowie, R.H., Evenhuis, N.L. & Christensen, C.C. 1995. *Catalog of the Native Land and Freshwater Molluscs of the Hawaiian Islands.* Backhuys Publishers, Leiden. vi + 248 p.

Cowie, R.H. 2011. Snails and slugs. In: *Encyclopedia of Invasive Introduced Species* (ed. Simberloff, D. & Rejmánek, M.), p. 634-643. University of California Press, Berkeley.

Please provide links to references if available.

Also note that **illustrations and tables must fit in a single column**, so make sure your maps, diagrams and tables are readable and show what you intend when they are reduced to this size. **Any text on a figure must be large enough to read**.

Metric Système International units are used throughout *Tentacle*. Please do not use miles, inches, gallons, acres, etc.

Tentacle is published using **British English** not American English, e.g. mollusc not mollusk, centre not center, favour not favor, realise not realize, etc.

Membership of the Mollusc Specialist Group is by invitation. However, everyone is welcome to submit articles to *Tentacle* and to promote its distribution as widely as possible. Since I announce the publication of each new issue to all who are on my *Tentacle* e-mail distribution list, please keep me updated with your current e-mail address so that you do not drop off the list. I also announce the availability of each issue on the MOLLUSCA listserver (for details, see page 67 of this issue) and the Unitas Malacologica members e-mail list.

As always, I reiterate that the content of *Tentacle* depends on what you send me. So I encourage anyone with anything relevant to mollusc conservation to send me something now, and it will be included in the next issue (published once a year, usually in January-March).

IUCN SSC MOLLUSC SPECIALIST GROUP

This membership list includes taxonomic and conservation expertises, to the extent they are known. In order to keep your details up to date, please inform the chair of the IUCN SSC Mollusc Specialist Group, Mary Seddon, and the editor of *Tentacle*, Robert Cowie, of any changes or corrections, especially regarding expertises. If there is any information you do not want to be public, please also inform us.

The list is in two parts: Official Members and Other Contributors. The former are currently listed on the IUCN official register of members of the IUCN SSC Mollusc Specialist Group. The latter are people who may have served on the Mollusc Specialist Group in the past or have provided assistance on enquiries, all of whom we acknowledge for their continued support of the work of the Group, although they are not currently listed on the IUCN official register of members.

Chair
Mary B. Seddon, Okehampton, UK. mary.molluscsg@gmail.com

Editor (*Tentacle*)
Robert H. Cowie, University of Hawaii, Honolulu, USA. cowie@hawaii.edu www.hawaii.edu/cowielab/

Name	Country	Taxonomic Expertise			Conservation Expertise								
		Marine molluscs	Freshwater molluscs	Land snails	Assessment	Survey & monitoring	Red List trainer	Habitat status & restoration	Conservation breeding	Conservation genetics	Environmental legislation	Invasive species	Wildlife trade
Official Members													
Christian Albrecht Justus Liebig University, Giessen	Germany		X		X	X				X			
David Aldridge University of Cambridge, Cambridge	UK		X			X				X		X	
Louise Allcock National University of Ireland, Galway	Ireland	X			X								
Maria Rosario Alonso Universidad de la Laguna, Tenerife	Spain			X	X								
Jose Arrebola Burgos Universidad de Sevilla, Sevilla	Spain			X	X				X				X
Thierry Backeljau Royal Belgian Institute of Natural Sciences, Brussels	Belgium	X		X	X					X		X	
Igor Balashov Schmalhausen Institute of Zoology, Kiev	Ukraine			X	X	X							
Gary Barker Landcare Research, Hamilton	Australia / New Zealand			X	X								
Gregory Barord Des Moines, Iowa	USA	X			X								
Arthur Bogan North Carolina State Museum of Natural History, Raleigh	USA		X		X	X			X				
Monika Böhm Global Center for Species Survival, Indianapolis Zoo	USA	X	X		X		X						

Name	Country	Taxonomic Expertise			Conservation Expertise								
		Marine molluscs	Freshwater molluscs	Land snails	Assessment	Survey & monitoring	Red List trainer	Habitat status & restoration	Conservation breeding	Conservation genetics	Environmental legislation	Invasive species	Wildlife trade
Official Members (continued)													
Ivan Bolotov Northern Arctic Federal University, Arkhangelsk	Russian Federation		X		X			X					
Khadija Boulaassafer Cadi Ayyad University, Marrakech	Morocco		X		X				X				
Prem Budha Tribhuvan University, Kathmandu	Nepal		X	X	X	X							
Viviana Castillo Servicio Agrícola y Ganadero, Santiago	Chile			X		X						X	
Chong Chen Japan Agency for Marine-Earth Science and Technology, Yokosuka	Japan	X			X	X							
Satoshi Chiba Tohoku University, Sendai	Japan			X		X			X				
Simone Cianfanelli Museo di Storia Naturale dell'Università degli Studi di Firenze	Italy		X	X	X	X			X			X	
Stephanie Clark Invertebrate Identification Australasia, Chicago, Illinois	USA		X		X	X							
Cristhian Clavijo Museo Nacional de Historia Natural, Montevideo	Uruguay		X		X	X							
Mary Cole East London Museum	South Africa			X	X	X							
Robert H. Cowie University of Hawaii, Honolulu, Hawaii	USA		X	X	X	X						X	
Kevin Cummings Illinois Natural History Survey, Champaign, Illinois	USA		X		X	X							
Gustavo Darrigran Museo de La Plata	Argentina	X	X		X							X	
Ivaylo Dedov Institute of Biodiversity and Ecosystem Research, Sofia	Bulgaria		X	X	X	X							
Zoltán Fehér Hungarian Natural History Museum, Budapest	Hungary		X	X	X	X		X					
Junn Kitt Foon Australian Museum, Sydney	Australia / Malaysia			X	X	X							
António Frias Martins Universidade dos Açores, Ponta Delgada	Portugal (Azores)	X		X	X	X							
Gerardo Garcia Chester Zoo	UK			X					X				
Olivier Gargominy Muséum national d'Histoire naturelle, Paris	France			X	X	X							
Daniel Geiger Santa Barbara Museum of Natural History, California	USA	X			X	X							

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		Marine molluscs	Freshwater molluscs	Land snails	Assessment	Survey & monitoring	Red List trainer	Habitat status & restoration	Conservation breeding	Conservation genetics	Environmental legislation	Invasive species	Wildlife trade
Official Members (continued)													
Jürgen Geist Technische Universität München, Freising	Germany		X		X	X			X				
Dilian Georgiev University of Plovdiv	Bulgaria		X	X	X	X							
Justin Gerlach, University of Cambridge	UK/Seychelles			X	X	X							
Mohammed Ghamizi Muséum d'Histoire Naturelle de Marrakech, Marrakech	Morocco		X	X	X	X		X	X				
Ronaldo Gomes de Sousa University of Minho, Braga	Portugal		X		X	X		X	X	X		X	
Benjamin Gomez-Moliner Universidad de Pais Vasco, Vitoria	Spain			X	X	X							
Daniel Graf University of Wisconsin, Wisconsin	USA		X		X	X			X				
Klaus Groh Büro Groh, Bad Dürkheim	Germany	X	X	X	X	X							
Diego Gutierrez Gregoric Museo de La Plata	Argentina		X		X	X			X				
Michael G. Hadfield University of Hawaii, Honolulu, Hawaii	USA			X									
Jason Hall-Spencer University of Plymouth	UK	X						X					
Kenneth A. Hayes Bishop Museum, Honolulu, Hawaii	USA		X	X	X	X							
Dai Herbert National Museum of Wales, Cardiff	UK / South Africa	X		X	X	X							
Auke-Florian Hiemstra Naturalis Biodiversity Center, Leiden	Netherlands	X				X							X
Isabel Hyman Australian Museum, Sydney	Australia			X	X	X			X				
Mayu Inada Ministry of the Environment, Chichijima	Japan			X		X			X				
Paul Johnson Alabama Aquatic Biodiversity Center, Marion, Alabama	USA		X		X				X				
Umit Kepabci Mehmet Akif Ersoy University, Burdur	Turkey		X	X	X	X							
Michael Klunzinger North Lakes, Queensland	Australia		X		X								
Frank Köhler Australian Museum, Sydney	Australia		X	X	X	X							
Andrew Kough John G. Shedd Aquarium, Chicago	USA	X				X			X				X
Charles Lange National Museums of Kenya, Nairobi	Kenya		X	X	X								
Dwayne Lepitzki Wildlife Systems Research, Banff	Canada		X		X	X		X					

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Official members (continued)													
Katrin Linse British Antarctic Survey, Cambridge	UK			X	X								
Jon Mageroy Norwegian Institute for Nature Research	Norway		X		X			X	X				
Marco Neiber Universität Hamburg	Germany		X	X	X	X							
Jeff Nekola Masaryk University, Brno	Czech Republic / USA			X		X							
Eike Neubert Naturhistorisches Museum, Bern	Switzerland			X	X	X							
Christine Ngereza National Museums of Tanzania, Dar es Salaam	Tanzania			X	X	X							
Vincent Nijman Oxford Brookes University, Oxford	UK	X											X
Ayu Nurinsiyah Museum Zoologicum Bogoriense, Bogor	Indonesia			X	X	X							
Mac Elikem Nutsaokor Kwame Nkrumah University of Science and Technology, Kumasi	Ghana			X	X	X							
Kristiina Ovaska Royal British Columbia Museum and Biolinx Environmental Research Ltd., Victoria	Canada			X	X	X		X	X				
Barna Páll-Gergely Centre for Agricultural Research, Budapest	Hungary			X	X	X							
Somsak Panha Chulalongkorn University, Bangkok	Thailand			X	X	X							
Martina Panisi Associação BIOPOLIS, Porto	Portugal			X	X	X			X				
Christine Parent University of Idaho, Moscow, Idaho	USA/Galapagos			X	X	X							
Paul Pearce-Kelly Zoological Society of London	UK			X		X			X				X
Kathryn Perez University of Texas Rio Grande Valley, Edinburgh, Texas	USA		X	X	X	X		X					
Howard Peters University of York	UK	X			X								X
John Pfeiffer Smithsonian National Museum of Natural History, Washington, DC	USA		X		X	X				X			
Winston F. Ponder Australian Museum, Sydney	Australia												
Vincent Prié Muséum national d'Histoire naturelle, Paris	France		X		X	X		X		X	X		
Nicolas Puillandre Muséum National d'Histoire Naturelle, Paris	France	X			X								

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Official members (continued)													
Canella Radea National and Kapodistrian University of Athens	Greece		X		X	X							
Nicoletta Riccardi Institute of Ecosystem Study, Verbania Pallanza	Italy		X		X	X		X	X		X		
Ira Richling Staatliches Museum für Naturkunde Stuttgart	Germany		X	X	X	X				X			
Rodrigo Salvador Museum of New Zealand Te Papa Tongarewa, Wellington	New Zealand / Brasil		X	X	X	X			X				
Sonia B. dos Santos Universidade do Estado do Rio de Janeiro, Rio de Janeiro	Brasil		X			X							
Menno Schuilthuizen Naturalis Biodiversity Center, Leiden	Netherlands			X		X				X			
Mary B. Seddon Okehampton	UK	X	X	X	X	X	X				X		
Julia Sigwart Senckenberg Research Institute and Natural History Museum, Frankfurt am Main	Germany	X			X	X					X		
Ioan Sîrbu Lucian Blaga University of Sibiu	Romania		X		X	X		X				X	
David Sischo Department of Land and Natural Resources, State of Hawaii, Honolulu, Hawaii	USA			X				X	X				
Rajko Slapnik Agencija Republike Slovenije Okolje, Ljubljana	Slovenia		X	X	X								
Peter Tattersfield Bakewell, Derbyshire.	UK			X	X	X		X			X		
Dinarte Teixeria Instituto das Florestas e Conservação da Natureza, Madeira	Portugal (Madeira)			X	X	X	X						
Frankie Thielen, Fondation Hëllef fur d'Natur, Heinerscheid	Luxembourg		X		X			X	X				
Elin Thomas Queen's University Belfast, Portaferry	UK	X			X	X					X		
Kostas Triantis National and Kapodistrian University of Athens	Greece			X	X	X							
Do Van Tu Institute of Ecology and Biological Resources, Hanoi	Viet Nam		X		X	X							
Dirk Van Damme Destelbergen	Belgium		X		X	X							
Jackie Van Goethem Royal Belgian Institute of Natural Sciences, Brussels	Belgium	X		X		X							
Ilya Vikhrev N. Laverov Federal Center for Integrated Arctic Research, Arkhangelsk	Russian Federation		X		X	X				X			

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Maxim Vinarksi Saint Petersburg State University	Russian Federation		X		X	X				X			
Ted von Proschwitz Göteborg Natural History Museum	Sweden		X	X	X	X							
Thomas von Rintelen Museum für Naturkunde, Berlin	Germany		X		X	X							
Norine Yeung Bishop Museum, Honolulu, Hawaii	USA			X	X	X		X	X				
Tadeusz Zajac Institute of Nature Conservation, Krakow	Poland		X		X	X			X				
Alexandra Zieritz University of Nottingham	UK		X		X	X			X				
Other contributors													
Jonathan Ablett, Natural History Museum, London	UK	X		X									
Takahiro Asami Shinshu University, Matsumoto	Japan			X									
Ruud Bank, University of Groningen	Netherlands		X	X									
Rudiger Bieler Field Museum, Chicago	USA	X											
Philippe Bouchet Muséum national d'Histoire naturelle	France	X	X	X									
Bram Breure Naturalis Biodiversity Center, Leiden	Netherlands			X									
Gilianne Brodie University of the South Pacific	Fiji			X	X								
David Clarke Zoological Society of London	UK			X					X				
Robert Cameron University of Sheffield	UK			X	X	X							
Jay Cordeiro Boston	USA		X		X								
Willy De Mattia Natural History Museum Vienna	Austria			X	X								
Mark Etherbirdge Environment and Natural Resources	Bermuda			X					X				
Hiroshi Fukuda Okayama University	Japan	X											
Terrence Gosliner California Academy of Sciences, San Francisco, California	USA	X											
Owen Griffiths BioCulture Mauritius	Mauritus			X	X								
Nova Hanson Memorial University of Newfoundland	Canada	X			X								
Joseph Heller Hebrew University, Jerusalem	Israel		X	X	X	X							

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Other contributors (continued)													
Jasna Lajtner University of Zagreb	Croatia		X		X	X							
Charles (Chuck) Lydeard Morehead State University, Morehead	USA		X	X									
Maria Cristina Dreher Mansur Museu de Ciências e Tecnolo, Porto Alegre	Brasil		X	X									
Ristiyanti M. Marwoto Research and Development Centre for Biology, Bogor	Indonesia		X	X									
Paula M. Mikkelsen Paleontological Research Institution, Ithaca	USA	X											
Hugh Morrison Australian Sea Shells P/L	Australia	X			X								X
Richard Neves Virginia Tech, Blacksburg, Virginia	USA		X						X				
Diarmaid Ó Foighil University of Michigan	USA		X	X	X					X			
Timothy A. Pearce Carnegie Museum, Pittsburg	USA		X	X									
Shane Penny Fisheries, Department of Industry, Tourism and Trade, Northern Territories	Australia	X	X										
Vladimir Pešić University of Montenegro	Montenegro		X	X	X								
Guido Poppe Conchology Inc, Cebu	Philipinnes	X			X								X
Barry Roth San Francisco, California	USA			X									
David Robinson USDA/APHIS/PPQ, Academy of Natural Sciences, Philadelphia	USA			X									
Rebecca J. Rundell State University of New York, Syracuse	USA			X									
John Stanisic Queensland Museum, South Brisbane	Australia			X									
Jaap J. Vermeulen National Botanic Garden, Singapore	Singapore			X									
Peter Ward University of Washington, Seattle	USA	X											
Anton (Ton) J. de Winter Nationaal Natuurhistorisch Museum, Leiden	Netherlands			X									
Min Wu Nanjing University	China			X									
Xiaoping Wu Nanchang University	China		X										
Nicolas Zuël, Ebony Forest Ltd	Mauritius			X	X	X		X