Research Article

Endemic Freshwater molluscs of Cuba and their conservation status

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Abstract

Cuba is one of the richest places in malacological fauna in the world, especially in land snails, hosting a high degree of endemism. A study on the distribution of freshwater molluscs that occur within the limits of protected areas was carried out. The objective was to determine the status of the endemic species and the potential threats of introduced snails. It was found that the inclusion of freshwater molluscs is not a criterion for proposing protected areas no matter how ecologically important they actually can be. A total of 42 species of freshwater molluscs occur in Cuba, but only 24 exist in the National System of Protected Areas. More critical is the fact that of the 10 Cuban endemics, three are not protected and the distribution data on all of them are not abundant. Introduced species such as *Tarebia granifera* and *Melanoides tuberculata* are spread throughout the country and might be a threat for endemics and other native snails. Data on the distribution of endemic molluscs is presented and the role of some introduced/invasive species is discussed.

Keywords: Molluscs, Freshwater, Ecology, Conservation, Cuba

Resumen

Cuba es uno de los sitios de mayor riqueza de moluscos en el mundo, especialmente de moluscos terrestres en donde muestra un alto porciento de endemismo. Se realizó un estudio sobre la distribución de moluscos fluviales que existen dentro de los límites de las áreas protegidas con el objetivo de determinar el estado de las especies endémicas y las amenazas potenciales de algunas especies introducidas. Se encontró que la presencia de moluscos fluviales no es utilizada como criterio a la hora de proponer áreas protegidas independientemente de la importancia ecológica que presentan. Un total de 42 especies de moluscos fluviales existen en Cuba, pero solo 24 aparecen en el Sistema Nacional de Áreas Protegidas. Más crítico es el hecho de que de las diez especies endémicas (23.8%), tres no se encuentran protegidas y los datos sobre su distribución no son abundantes. Especies introducidas como *Tarebia granifera* y *Melanoides tuberculata* se han dispersado por todo el país y pueden ser una amenaza para especies endémicas y otras especies nativas. Se presentan datos sobre la distribución de moluscos endémicos y se discute sobre el papel de algunas especies introducidas / invasivas sobre los moluscos endémicos.

Palabras clave: Moluscos, Agua dulce, Ecología, Conservación, Cuba

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Introduction

The Cuban Archipelago hosts a wide variety of molluscs [1]. Most of its malacological diversity is found in marine and land molluscs, with nearly 3,000 species. This diversity is accompanied by a large degree of endemism in almost 94% of the species of land snails [2]. There are many works regarding taxonomic and systematic studies in marine and land molluscs [3,4] with a fewer number on ecology and distribution [1]. Freshwater molluscs, however, are scarcer and have received less attention. However, due to the role that some of species of molluscs play in the transmission of tropical diseases in Cuba [5], the Laboratory of Malacology, at the Tropical Medicine Institute (IPK), has developed a series of studies which have helped to complete the inventory of freshwater molluscs and the distribution of the different in the country [6-8]. The inventory to date shows the existence of 42 species of gastropods (Caenogastropoda, Neritomorpha, and Pulmonata) and bivalves. Although this may be the total number of species found in Cuba, new studies may indicate the presence of both local and introduced new species.

In Cuba a total of 253 protected areas of either national or local significance have been proposed in the National System of Protected Areas (SNAP) [10] and more than 200 are established. With the exception of some highly charismatic species of land snails, such as those of the genus *Polymita* and *Liguus*, no other species of molluscs are taken into consideration when selecting a protected area or delimiting its borders [11].

Biodiversity conservation and managing are key activities for the health and existence of many ecosystems [12]. However, mammals, birds or reptiles receive most of the attention, leaving molluscs and other taxa in a category that we might call neglected. Although the preservation of some habitats through the programs that consider these groups may indeed preserve mollusc populations as well, some threats are not considered, due to a lack of species´ monitoring. As an example, the introduction of exotic snails and the effect of some abiotic variables (e.g., pH, temperature, alkalinity, etc.) that don't necessarily affect major animal groups may threaten freshwater molluscs. This study attempts to update the information available on the distribution and status of the endemic species of molluscs and to provide a general assessment on the impact of introduced species of snails; possible interspecific competition among these species is also taken into consideration.

Methods

A gap study was carried out [13] in order to observe which protected areas included populations of freshwater molluscs. A total of 340 localities of freshwater habitats recorded by the Laboratory of Malacology (IPK) from 1985 to 2009 were used (Fig. 1). The studied localities ranged from the western to the eastern tips of Cuba and were considered independently of whether they were included within a protected area. The potential occurrence of false negatives of species in the gap analysis is due to the difficulty in accessing or totally exploring some areas. However, the number of sampled sites that are inside or outside protected areas may represent enough data to discuss the problem of freshwater mollusc conservation. The gap analysis shows which species are in or out of a protected area; how many populations are protected (at least passively because they are within a protected area); which areas with an important number of endemic species are sub-represented in the system of protected areas; and which are full of common species. Common species are those not currently threatened with extinction. By identifying their habitats, the gap analysis gives land managers and policy makers the information they need to make better decisions when identifying priority areas for conservation.

The selected localities had been studied to carry out ecological investigations in malacology, and data regarding species lists, environmental factors and GPS coordinates were recorded for each site. No literature or museum records were included in this study mainly because (1) literature records on freshwater snails previous to the foundation of the Laboratory of Malacology at the IPK needs a major revision and may include a high number of synonyms as well as unclear identification of localities, and (2) most museum records are based on old records and recent surveys have failed to detect the species reported.

Species were classified as endemic, local (those that normally occur in Cuba as well as in other nearby regions), and introduced (exotic species). Habitats were classified broadly as rivers, lakes, swamps, ponds, streams, springs, flooded terrains, and irrigation channels. A chart of protected areas provided by the CNAP [10] was used to plot the location of reported records. Each protected area is presented with its managing category according to the CNAP [14], homologous to those of the International Union for Conservation of Nature (IUCN) (see Appendix 1).

We used the software MapInfo 8.0 [15] for matching each species population with the protected area it inhabits.

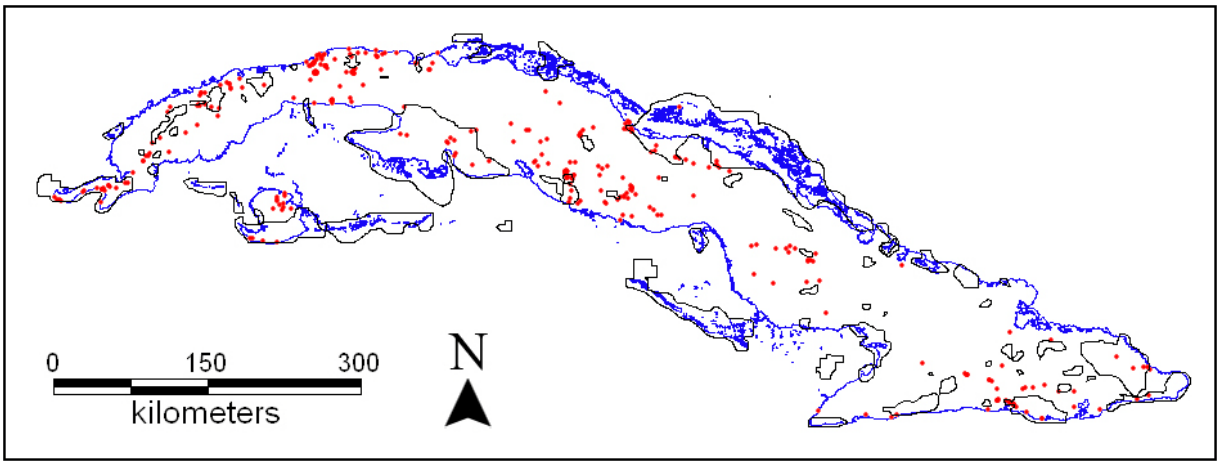

Fig. 1: Map of Cuba built for the study. (Red dots = Distribution of studied freshwater mollusc populations in Cuba; Black lines = Protected areas limits; Blue lines = Coastal line).

Results

A total of 10 (23.8%) out of 42 described freshwater snails and mussels are endemic in Cuba. Only one endemic species exhibits a wide distribution range throughout the country while the others have small populations in a few or only one locality (Table 1).

At least three species of endemic molluscs are not included within the limits of any protected area and thus poor data of their status are presented. These species are *Nanivitrea alcaldei* and *N. helicoides*, which are hydrobiids, and *Pachychilus nigratus* (Fam. Pachychilidae). Of the 42 freshwater molluscs of Cuba, 24 species occur within the limits of protected areas (Fig. 2A). Of

these, *Tarebia granifera* and *Physa acuta* seem to be the most common snails while the endemics of the genus *Hemisinus*, *Nephronaias,* and *Viviparus* are quite rare in the protected areas, and have scarce populations in Cuba. Of the 253 protected areas in Cuba, only 35 have populations of freshwater molluscs (endemic and non-endemic species). Eleven of these areas have populations of endemic molluscs and nine are lacking administration and/or do not have sufficient staff for monitoring and protecting the extant biodiversity. In these estimates, we excluded those protected areas harboring only *Pomacea poeyana* which is well distributed in Cuba (Fig. 2B). A remarkable point is that 54% of protected areas host introduced species.

Table 1: Endemic species of Cuba and population distributions. (*these species have not been currently found and have perhaps disappeared).

Family	Species	Population distribution
AMPULLARIIDAE	*Pomacea poeyana* (Pilsbry, 1927)	Cuba (widely distributed)
VIVIPARIDAE	*Viviparus bermondianus* (d´Orbigny, 1842)	Zapata Peninsula*
HYDROBIIDAE	*Nanivitrea alcaldei* (Jaume & Abbot, 1947)	Cárdenas (1 population)*
	N. helicoides (Gundlach, 1865)	Trinidad (1 population)*
THIARIDAE	*Hemisinus cubanianus* (d´Orbigny, 1841)	Pinar del Río (scarce)
	H. brevis (d´Orbigny, 1841)	Pinar del Río (scarce)
PACHYCHILIDAE	*Pachychilus nigratus* (Poey, 1858)	Villa Clara
	P. violaceus (Preston, 1911)	Santiago de Cuba – Baracoa
UNIONIDAE	*Nephronaias gundlachi* (Dunker, 1858)	Pinar del Río (scarce)
	N. scammata (Morelet, 1849)	Pinar del Río (scarce)

Five species of introduced freshwater molluscs occur in Cuba. The main species are the thiarids *Tarebia granifera* and *Melanoides tuberculata* (family Thiaridae). Other species are *Pomacea diffusa* and *Marisa cornuarietis* (family Ampullariidae), and *Corbicula fluminea* (family Corbiculidae) (Appendix 1).

Introduced species of freshwater snails, such as the thiarids *Tarebia granifera* and *Melanoides tuberculata,* are widespread in the freshwater bodies of Cuba with a total of 213 and 78 known localities, respectively. However, the ampullariids *Pomacea diffusa* and *Marisa cornuarietis* are an exception with only scarce populations in the western region. These ampullariids do not show large populations and no record of their occurrence in protected areas has been proved. The thiarids, however, can be found occurring in almost every type of ecosystem ranging from natural to anthropic habitats. These introduced species are usually found in many protected areas sharing habitats with local species, especially with the endemic thiarids in Pinar del Río province. Recent surveys of these sites report population densities of *Tarebia granifera* of 85 individuals/m^2, well above those of its endemic relatives (5 individuals/m^2). This scenario seems to repeat itself in many sites harboring other endemics like *Pachychilus nigratus*, *P. violaceus,* and *Viviparus bermondianus*.

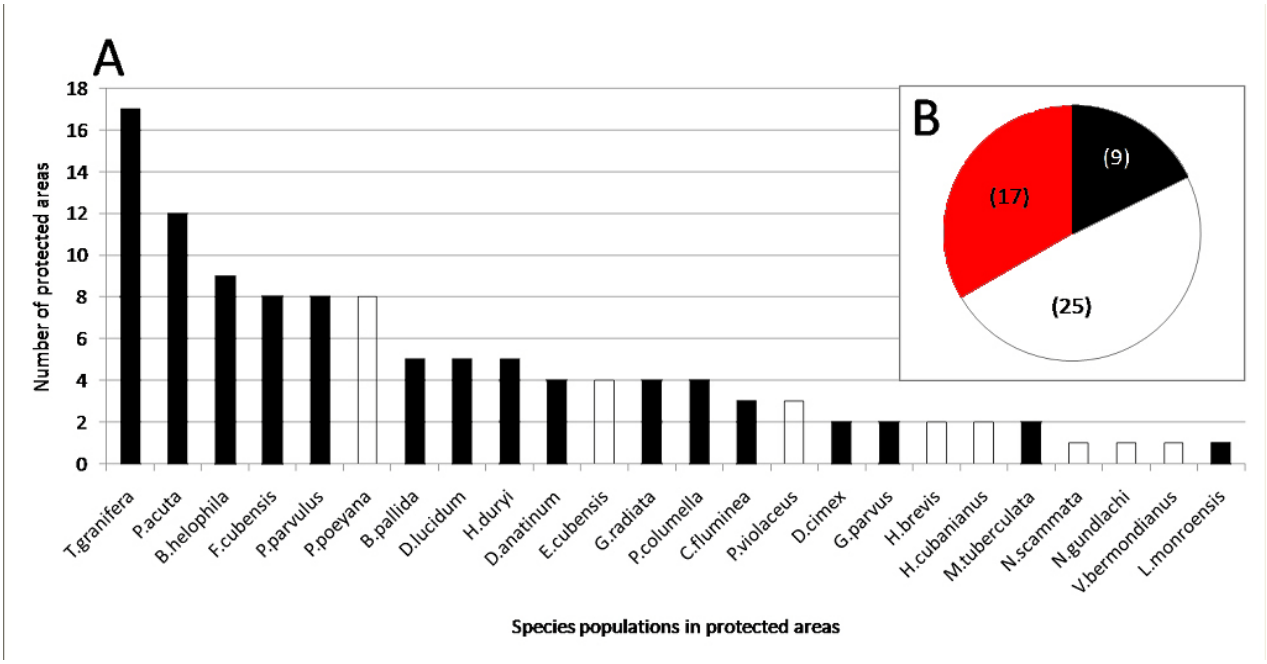

Fig. 2: Mollusc species by protected areas. (A)= Number of protected areas that host a particular species of freshwater mollusc (endemic species are in white bars); (B)= Number of protected areas with a particular type of species (black=endemics, red=introduced, white=local).

Discussion

The percentage of endemism shown in Cuban freshwater molluscs (23.8%) is characteristic of the fauna of islands [16]. More species are yet to be found and described, especially in heterogeneous island habitats. These species are expected not only to be endemics, but also other introduced and locally occurring species in the Caribbean area. Surveying the whole Cuban territory is nearly impossible, but the number of sampled sites in this study and their locations give a wide coverage of the country. The small percentage of endemism of freshwater molluscs may have its cause in the number of introduced species in Cuba, which are highly invasive like the thiarids. Local species occurring in the region but not considered as invasive, have probably been introduced as a result of the plant trade for aquariums [6]. One of the well-established endemic species is the ampullariid *Pomacea poeyana*. This species has a wide distribution range and ecological tolerance to environmental factors [6].

The fact that not all protected areas show populations of freshwater molluscs may be due to two main factors: (a) most of the protected areas are found in marine or coastal zones (43%), or high mountains (34%) [10]; (b) data of freshwater snails are often unavailable. Unavailability of data is usually the result of the absence of monitoring of these species and/or difficult accessibility to the localities in which they are found. Some of the protected areas in Cuba are not adequately

supervised [10] and thus data on many species, including snails, are not well recorded or simply not taken.

Introduced species are always a major threat to local species, especially endemics [18]. Causes of introductions of freshwater snails can be considered natural or human. Natural introductions are usually provoked by the role some aquatic birds have in the translocation of snails [17]. At least two main bird migration routes pass through Cuba, going to and from North and South America [19]. Within Cuba, the spread of snails can be the result of the flight of local birds through the different provinces. The main species of birds associated with freshwater bodies where these molluscs occur are the cattle egret (*Bubulcus ibis*), the common moorhen (*Gallinula chloropus*), the American coot (*Fulica Americana*) and the limpkin (*Aramus guarauna*), among others [6].

Introductions that have been directly linked with human activities are generally associated with the pet trade for aquariums [20]. Several species of freshwater snails are commonly sold to aquarists. These include *Marisa cornuarietis* and *Pomacea diffusa*, the latter being the most commonly traded ampullariid [21]. Also, the trade of aquatic plants for aquariums may be a source of introduction of species [22,23]. We do not disregard the possibility that thiarids (*T. granifera* and *M. tuberculata*) were once introduced in Cuba in this way. These species originated in Asia and recently invaded several islands in the Caribbean [21]. These species can reach high densities (more than 500 individuals/m^2) in sites where aquatic vegetation is abundant [24]. Although adult snails can be removed from the aquatic vegetation, juveniles are often hard to see and to remove from the plants.

Interspecific competition in species assemblages is common as a result of ecological niche overlap among different species populations [25]. Some authors have tried to explain species interactions and differences in abundance distributions by this ecological relationship. For example, a study reports a possible interaction in a community of freshwater snails in the central region of Cuba, which competes for the nearest space to the shore in a lake [26]. Another report documents a possible competitive interaction for food and space between two thiarids in a lake ecosystem, reducing the availability in space for the establishment of other species [27].

Of the three endemic species that are not included in protected areas, two have not been recorded in recent surveys [8]. These are small hydrobiids (*N. alcaldei* and *N. helicoides*) of less than 3 mm that live in aquatic plants or stones, and their populations might have gone extinct.

Another endemic lacking protection, *Pachychilus nigratus*, was described in Cárdenas (type locality), in the central region of Cuba, but no individuals have been recovered from that site. This species has suffered a dramatic decrease in its populations and recently has been found only in a small river near Santa Clara City. This species has experienced a drop in the effective number of its populations probably because of habitat transformation, which may indeed favor the establishment of opportunistic introduced molluscs such as the thiarids.

Main habitat transformations are the result of construction of buildings and recreational installations like camping sites. These transformations usually bring both organic and non-organic contaminants to the ecosystems. It is important to note that the two species of *Nanivitrea* mentioned earlier as well as *Viviparus bermondianus* have an unknown distribution. The latter is described for the Zapata swamp area but has not been found again since decades ago. This fact evidently raises the question if these three species still actually occur in Cuba.

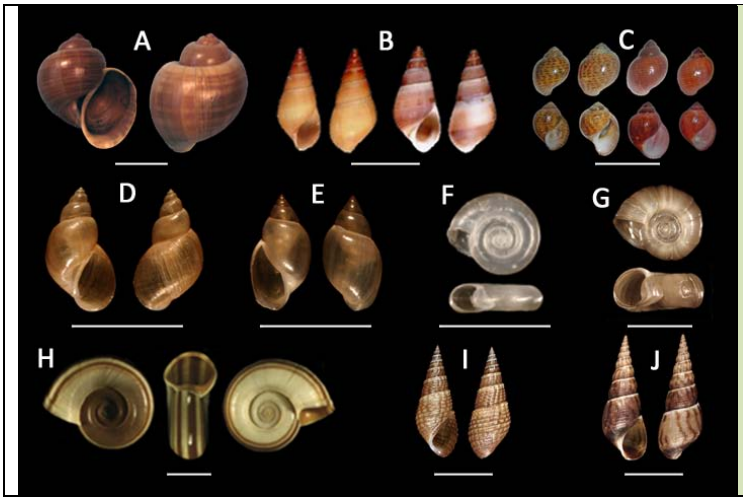

Fig. 3: Examples of freshwater molluscs of Cuba. Endemic species are in the upper line, local species in middle line, and introduced species in the bottom line. (Mollusc species: A=Pomacea poeyana, B=Hemisinus cubanianus, C=Hemisinus brevis, D=Fossaria cubensis, E=Physa acuta, F=Biomphalaria havanensis, G=Helisoma duryi, H=Marisa cornuarietis, I=Tarebia granifera, J=Melanoides tuberculata)

Implications for conservation

The fact that freshwater mollusc communities display poor species richness is a common worldwide rule, if we compare them to their marine and land relatives. The Cuban Archipelago does not escape this rule. However, as it has been presented in this work, an important number of Cuban freshwater molluscs are endemic. It is then of considerable concern that no special attention is given to this group.

It is clear from our survey that most of the mollusc endemic species reported might be endangered or vulnerable. Shrinkage in distribution range of populations, introduction of exotic species, and habitat loss due to human activity are probably the main drivers of population declines. The continuous growth of the Cuban population has forced many populations of endemic molluscs to withdraw from many localities. This has been the result of, first, the construction of buildings near these species populations, which generate an associated pollution of the freshwater environment, and, second, a direct transformation to the ecosystems where the molluscs occur due to water consumption. The Cauto River, the largest river in Cuba, is an example of this transformation with the rerouting of some segments to build dams in order to provide water for the nearby cities.

Many recreational infrastructures for tourism have been built in Cuba in the vicinity of areas where endemic freshwater molluscs are found. This is a common problem in places like Viñales, Soroa, Zapata Swamp, and Baracoa, which are among the most important tourist destinations in Cuba. It is important to note that the four cited places fall within the limits of protected areas. Although ecotourism guidelines might be followed in these sites, it is impossible to ascertain if there is an impact on the freshwater mollusc populations when their presence is not known. The study of these molluscs would surely give the area another value to show to the public, something that may contribute to the conservation of these species.

The preservation of the Cuban endemic freshwater molluscs (Fig. 3) will not only help to sustain ecosystem functioning, but could also have an important impact on public health. Many of the introduced species of molluscs are usually considered as intermediary hosts of parasites responsible for some tropical diseases [6]. These opportunistic species can establish themselves in disturbed ecosystems, reaching high densities in a short period of time [27]. However, some of the

endemic species may serve as biological control agents, which could outcompete the exotic molluscs and prevent their successful establishment if the natural habitat remains unaltered.

Finally, direct actions to promote the conservation of Cuban freshwater molluscs should include further field studies regarding aspects of their ecology, behavior, and genetics. Also, considering these species when selecting and delimiting a protected area could be a key action in their conservation in the future.

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Appendix 1. Cuban protected areas with endemic freshwater molluscs, introduced species and types of ecosystem. (Categories of protected areas in decreasing order of protection: RE=Ecological Reserve, PN=National Park, RFM=Floristic Managed Reserve, END=Outstanding Natural Element, APRM=Protected Area of Managed Resources).

Protected area	Category	Endemic species	Introduced species	Type of ecosystem
Sierra de San Carlos	RE	*Hemisinus brevis*		River
Viñales	PN	*Hemisinus brevis*	*Tarebia granifera*	Stream / River
Mogote de Pico Chico	RFM	*Hemisinus cubanianus, Nephronaias gundlachi, Nephronaias scammata*		River
Mil Cumbres	APRM	*Hemisinus cubanianus*		Stream / River
Sierra del Rosario	APRM	*Pomacea poeyana*	*Tarebia granifera*	Lake
Botinos	RFM	*Pomacea poeyana*	*Tarebia granifera*	River
Península de Zapata	APRM	*Viviparus bermondianus, Pomacea poeyana*	*Melanoides tuberculata, Tarebia granifera*	Swamp / River
Pico Cristal	PN	*Pachychilus violaceus*		River
Yara - Majayara	END	*Pachychilus violaceus*		River
Cuchillas del Toa	APRM	*Pachychilus violaceus, Pomacea poeyana*	*Tarebia granifera*	River
Sur de la Isla de la Juventud	APRM	*Pomacea poeyana*		Small Lake