

Population structure and accompanying biota of the snail *Turbo (Callopora) funiculosus* (Gastropoda: Turbinidae), on Socorro Island, Revillagigedo Archipelago, Mexico

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Received 10-VI-2002. Corrected 13-I-2004. Accepted 29-V-2006.

Abstract: The porcelain snail, *Turbo funiculosus*, is a potential fishery resource that almost has not been studied or used commercially. In March of 1992, we sampled *T. funiculosus* in Bahía Binnars and Bahía Blanca, Socorro Island, Revillagigedo Archipelago, using 25 m² quadrants. We found that total length varies between 3.0 and 85 mm, proportional weight between 3.0 and 228 g, and density between 6.21 and 9.87 ind/m². The largest organisms (over 50 mm) contain 30.6 % of soft parts. Porcelain snail populations remain unexploited on Revillagigedo Archipelago and could be a potential resource under an adequate management strategy. Rev. Biol. Trop. 54 (4): 1079-1084. Epub 2006 Dec. 15.

Key words: *Turbo funiculosus*, mollusk, density, weight, length, Socorro Island.

Among the marine invertebrates, mollusks are one of the most important groups on Socorro Island. Turban shells are benthic marine animals, fairly common on the Revillagigedo Islands, which can also be found in tidal pools, shallow rocky bottoms, and weed-covered reefs. They are members of the order Archeogastropoda, family Turbinidae. They are primitive prosobranchs with radula modified for herbivory (Brusca and Brusca 1990) and possess a single snail-like shell. They also possess a thick operculum, a calcareous plate used to protect the animal when it withdraws into its shell.

The porcelain snail, or turban shell *Turbo funiculosus*, stands out because of its abundance and its possible integral uses in this insular place. This is also true of the indopacific species *T. marmoratus* and *T. brunneus* (Devaraj 1996, Castell and Sweatman 1997, Dorairaj and Soundararajan 1998, Kikutani

et al. 2002), the foot and shell of which have a high market value. Other internal parts are also used as food for domestic animals. The foot is actually utilized in Socorro Island only in subsistence fisheries. It is still an important resource since it has not been fished commercially (Holguin 1991). Keen (1971) states that this species is widely distributed on the islands of the Revillagigedo Archipelago. He also mentions that it can be found, though less frequently, in the area of Cape San Lucas B.C.S.

The faraway location of the Revillagigedo Archipelago from the continental coasts had been one of the factors that has made it difficult to complete any scientific study. The biological or ecological aspects of the population of *T. funiculosus* were not studied by researchers. The state of the populations of this mollusk is practically unknown in its area of geographical distribution. Knowledge of this species on Socorro Island is limited to the

references made by Strong and Hanna 1930 (as *T. fluctuosum*), Keen 1971, Chan 1974, Holguin 1991, Holguin *et al.* 1992, Bautista-Romero *et al.* 1994, Holguin 1994, Mille-Pagaza *et al.* 1994, Emerson 1995, and Reyes-Bonilla 1999. Nonetheless, these works do not address any aspects of its biology, fishery, or population status. Chan (1974) made 36 dives at depths between 3 and 23 m in Bahía Braithwaite and found the species at approximately 15 fathoms. There is no additional information in the literature about the abundance and distribution of this species.

Many species coexist with overlapping ranges and food resources. Very few reports exist about the fauna that accompanies *T. funiculosus* (Bautista-Romero *et al.* 1994, Holguin 1994, Mille-Pagaza *et al.* 1994). Numerous species of algae, invertebrates, and fish occupy the intertidal and splash zones with partial overlapping ranges. A typical rocky shore setting might show the sequence Littorinidae, Acmaeidae, Mytilidae, Ostreidae, *Turbo*, chitons, and Trochidae as the most conspicuous forms of mollusks from the splash zone (Engeman and Hegner 1981).

MATERIALS AND METHODS

The Revillagigedo Archipelago (Fig. 1) is located approximately 350-650 km southeast of the Baja California Peninsula, 580 km west of the Colima coast (Llinas-Gutierrez *et al.* 1993), and is comprised of Socorro, Clarion, San Benedicto, and Roca Partida islands. Socorro Island, with a surface area of 167 km², is the largest of the islands and has a maximum diameter of 16 km in a NW-SW direction. Geographically, Socorro Island is located at 18°41'57" N and 110°56'33" W (Troyo-Diéguez and Pedrín 1994). The island is composed primarily of braced igneous rock, with the presence of smooth stones and sandy or stone-sandy beaches (Holguin 1994).

In March of 1992, some observations about the densities by area were done. They determined the relationship between size and weight

of *T. funiculosus* in two locations of the island: Bahía Binners in the southern part and Bahía Blanca NW (or Playa Blanca) located in the northeast of the same island (Fig. 1).

The data was obtained out of a total of eight quadrants, which were made using a 20 m cord marked every 5 m. The squares were 5 x 5 m with an area of 25 m² each. The data about the relative abundance or density of the organisms is the result of the counting and gathering of all the live shells found in the eight quadrants (200 m² in total), situated in tide pools and rocky areas of the intertidal fringe.

The sampled specimens in only one quadrant by location were used to elaborate histograms of size frequency. In Bahía Blanca a small lot of 50 individuals was taken to get information of the proportion of the weight of the viscera and the weight of the foot respective to the total weight. The register of the size parameter was done using a 0.5 mm accuracy vernier calliper, considering the height or major dimension along the columellar axis. The total weight (including the shell) was taken by a 0.5 g accuracy triple arm scale. After being measured, all animals were liberated in the rocky intertidal zone.

The analysis of the weight and sizes was carried out using the computer program Stat

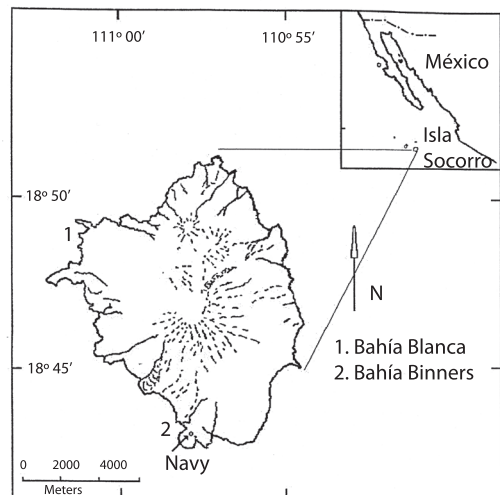


Fig. 1. Sampling sites on Socorro Island, Revillagigedo, March 1992.

Graphic 3.0 and a multiplying model of simple regression: $Y = ax^b$ for size weight correlation, obtaining regressions by sampling areas.

RESULTS

In comparison to other zones that presented a high degree of difficulty and risk, the relative ease of disembarking at the two stations distant from one another made sampling possible. The basaltic coast exposed to continuous wave action is populated by *T. funiculosus* in the rocky intertidal zone and tide pools, as well as in the upper subtidal zone. It was observed that the small sizes have a gregarious distribution and it is well known that the juveniles (under 25 mm) are located in groups, usually in quiet tide pools, protected areas, between rocks and stones, or in those areas which are not very exposed to wave action. On the contrary, adults of bigger sizes live well dispersed and inhabit turbulent waters at midlittoral fringe to 15 fathoms of depth (Chan 1994). Shallow areas, such as tide pools with abundant small rubble, may represent good conditions for individuals of <25 mm, but rocky coasts exposed to waves and deeper areas with larger rocks are better for individuals of greater than 25 mm.

The porcelain shells feed predominantly on macro and microalgae, which they scrape with their radula. In the sampling locations, the tide wells and propitious areas for their development are frequently found. These gastropods interact in such an environment with numerous species of algae, invertebrates, and fish. *Turbo* shells, especially the smallest, are part of the diet of the sea crown of thorn stars *Acanthaster planci* (Holguin *et al.* 1992), and of predator gastropods: *Conus tiaratus*, *Thais planospira*, *T. speciosa*, *Plicopurpura pansa*, the cephalopod *Octopus bimaculatus* (Holguin 1994) and the fishes *Melichthys niger*, *Calotomus spinidens* and *Diodon hystrix*, among others (Bautista-Romero *et al.* 1994), all of which share their habitat.

Among the frequently found invertebrates which accompany the *Turbo* shell are the

mollusks *Barbatia bailyi*, *Isognomon janus*, *Chama squamuligera*, *Littorina* spp., *Nerita* spp., *Cerithium maculosum*, *Petalococonchus complicatus*, *Columbella socorroensis*, *Mitrella baccata*, *Hipponix pilosus*, *H. panamensis*, *C. tiaratus*, *Chiton articulatus* and *O. bimaculatus*, the echinoderms *Echinometra vanbruntii*, *E. oblonga*, *Tripneustes depressus* and *Toxopneustes roseus*, the crustaceans *Pachygrapsus transversus*, *Calcinus explorator*, *Petrolistes* spp. and *Ozius* spp., among others. The algae which accompany the *Turbo* shell are *Enteromorpha flexuosa*, *Chaetomorpha gracilis*, *Caulerpa racemosa*, *Dictyota dichotoma*, *Hypnea cervicornis*, *Amphiroa* spp., *Jania capillacea*, *Ceramium gracillillum*, *Centroceras clavulatum*, *Herposiphonia tenella* and *Laurencia* spp. (Holguin 1994).

Information about relative densities of the accompanying fauna was obtained. The density data obtained in the study of benthic communities in March 1992 on Socorro Island is given in a genera level comparison (Table 1).

The high density of the turban shell population in the intertidal fringe is due, among

TABLE 1
Relative densities of the accompanying invertebrate fauna associated with *T. funiculosus* on Isla Socorro, Revillagigedo

Species	Location	
	Bahía Binners	Bahía Blanca
	Orgs/m ²	Orgs/m ²
<i>Turbo funiculosus</i>	4.7	15.1
<i>Thais speciosa</i>	0.22	0.1
<i>Cerithium maculosum</i>	0.11	—
<i>Petalococonchus complicatus</i>	20.5	0.6
<i>Hipponix pilosus</i>	2.0	33.0
<i>Plicopurpura pansa</i>	0.27	0.18
<i>Isognomon janus</i>	9.1	16.4
<i>Chiton articulatus</i>	3.72	—
<i>Echinometra vanbruntii</i>	1.22	—
<i>Tripneustes depressus</i>	0.33	—
<i>Calcinus explorator</i>	4.0	2.1
<i>Pachygrapsus transversus</i>	3.55	0.93

other reasons, to the elevated availability of food, the stable conditions of the environment, and the moderated effect of certain predators in this level. For the month of March, the counting by quadrant of turbo shell in two locations gave the next density values, with the size and weight intervals shown in Table 2.

Size frequency for both locations shows the separation of groups. In Bahía Binners (Fig.

2) groupings of individuals of 3 and 24 mm and others of 24 and 54 were found. In Bahía Blanca (Fig. 3). We observed three groups: 16 to 32, 32 to 56, and 56 to 85 mm.

T. funiculosus is very well represented in all the series of sizes in the midlittoral, fluctuating between 3.0 and 85 mm of length (Fig. 2, 3) and the proportional weight varies between 3.0 and 228 g. The Fig. 4 and 5 show

TABLE 2
Density values and size and weight intervals

Location	Area m ²	Total Number	Average orgs/m ²	Max. Density orgs/m ²	Length mm	Weight g
Bahía Binners	100	621	6.21	14	5-55	0.3-70
Bahía Blanca	100	987	9.87	19	12-85	0.5-228

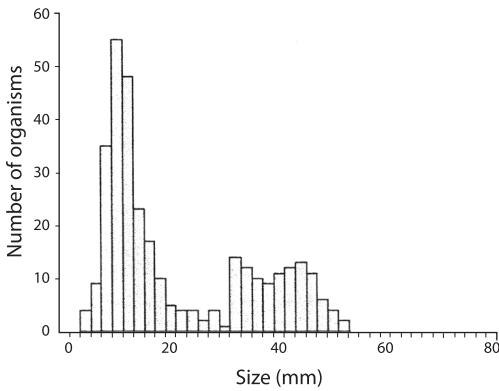


Fig. 2. Size frequencies of *T. funiculosus* on Bahía Binners, March 1992.

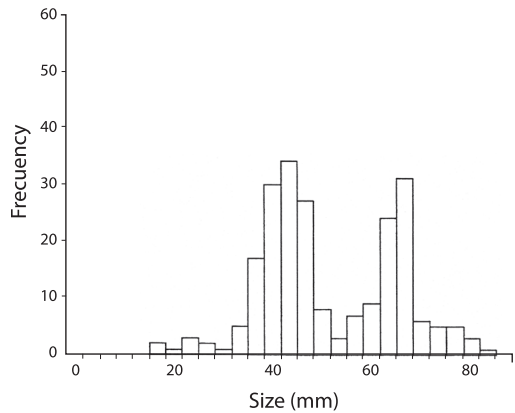


Fig. 3. Size frequencies of *T. funiculosus* on Bahía Blanca, March 1992.

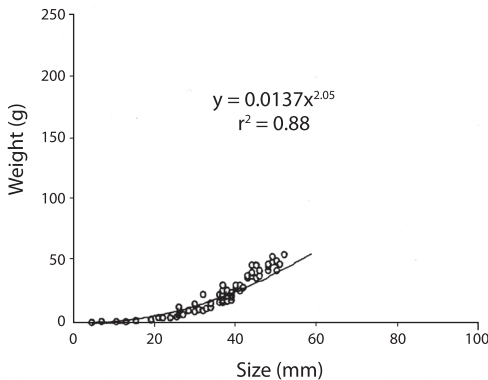


Fig. 4. Regression of size-weight for *T. funiculosus* on Bahía Binners, March 1992.

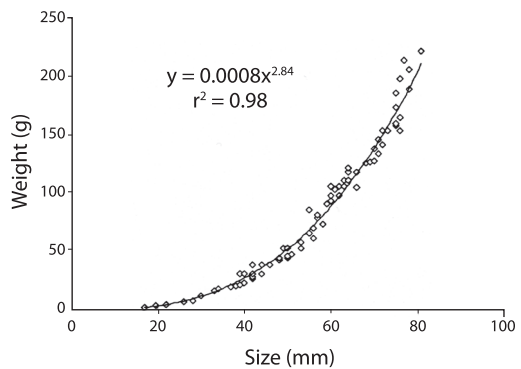


Fig. 5. Regression of size-weight for *T. funiculosus* on Bahía Blanca, March 1992.

the regression of size-weight found in two concentrations of living organisms, belonging to the two study locations.

The relation of weight in the soft parts in sizes bigger than 50 mm is 30.6 % of the total weight of the living organism, 7.44 % corresponds to the foot or callus, and 23.16 % to the viscera. These proportions were not previously reported in the literature for this species.

DISCUSSION

As a result of the observation of the coastal strip of the superior midlittoral and the infralittoral parts of Socorro Island, the abundance of *T. funiculosus* was determined. The densities of some important species that occupy the same area were also determined. The turban shell is abundant on Socorro Island and has an elevated commercial value because of its meat and its shell. Various accompanying species like *P. pansa* (Michel-Morfin *et al.* 2002) and *C. articulatus* (Holguin and Michel-Morfin 2002), have commercial value and represent potential resources on Socorro Island.

It is evident in the location of Bahía Binnars that the sizes larger than 40 mm are less represented. On the contrary, in the samplings of Bahía Blanca they are predominant. This is due to the fact that the first location is very close and very accessible to an island village (naval sector), which in the year 1992, before an Everman Volcano eruption, had an average population of 150 people. This caused the extraction for food consumption of the major sizes in the intertidal zone (this is possible to verify observing the shells left on the beach). On the other side, Bahía Blanca is very far from any populated zone and it is not accessible by land, which is why the population structure of the *Turbo* shell in this location remains unaltered.

Some parts of the island are inaccessible by land and barely accessible by sea. For that reason the population of this species remains unaltered by exploitation and its harvesting could be only possible under strict measures of

protection and under an adequate management plan. However, new population studies are required in order to know some aspects about population dynamics, like growth, mortality, recruitment and reproduction, beside new population abundance estimations around all island rocky shores are important.

ACKNOWLEDGMENTS

We are grateful to the Dirección de Estudios de Posgrado e Investigación del Instituto Politécnico Nacional and Consejo Nacional de Ciencia y Tecnología for funding this work. Thanks to the Comisión de Operación y Fomento de Actividades Académicas. Thanks to Silvia Mille P., Alicia Pérez and Ma. de Jesús Parra for their help with the field work, and Ma. Consuelo González and Bryan Keagle for the help on the English manuscript.

RESUMEN

El caracol porcelana, *Turbo funiculosus*, es un recurso pesquero potencial que casi no ha sido estudiado ni se ha utilizado comercialmente. En marzo de 1992, se realizó un muestreo de *T. funiculosus* en Bahía Binnars y Bahía Blanca, isla Socorro, archipiélago Revillagigedo, empleando cuadrantes de 25 m². Se encontraron variaciones en la longitud total entre 3.0 y 85 mm, el peso proporcional entre 3.0 y 228 g, y la densidad entre 6.21 y 9.87 ind/m². Los organismos de mayor tamaño (más de 50 mm) contienen 30.6 % de partes suaves. Las poblaciones del caracol porcelana siguen siendo inexploradas en el archipiélago Revillagigedo y podrían ser un recurso potencial de la industria pesquera bajo un adecuado plan de manejo.

Palabras clave: *Turbo funiculosus*, molusco, densidad, peso, longitud, Isla Socorro.

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