



# Population, reproductive and ecological aspects of the music volute *Voluta musica* (Caenogastropoda: Volutidae) in northeastern Venezuela

M. SALOMÉ RANGEL<sup>1,2</sup>, ALEJANDRO TAGLIAFICO<sup>2</sup>, JEREMY MENDOZA<sup>3</sup>, LUIS FREITES<sup>3</sup>, JOSÉ SILVA<sup>3</sup>, ABEL VÁSQUEZ<sup>4</sup> & NATIVIDAD GARCÍA<sup>4</sup>

**Abstract.** *Voluta musica* is considered an endangered species in Venezuela for two main reasons: collectors appreciate shells and its incidental catch in fishery of *Arca zebra*. Population and ecological parameters including abundance, distribution, reproduction, length-frequency distributions, color pattern of shells and influence of biotic and abiotic factors on density were estimated through observations by line transect samples. Between February/2008 and January/2009, 178 individuals were collected, with an average total length of  $56.4 \pm 28.3$  mm, in Coche Island and coast of the Araya peninsula. Average monthly density was  $0.037 \pm 0.17$  org/m² with a maximum value in September  $(0.12 \text{ org/m}^2)$  and a minimum in October  $(0.0067 \text{ org/m}^2)$ . GLM showed that the factors with high influence on densities were: absence of *A. seminuda*, presence of muddy-fine grain sand and medium-grain sand bottoms, the zone corresponding to the channel between Coche Island and Morro de Chacopata. Egg capsules were found in dead shells of *A. seminuda*, *Pinna carnea* and *Anadara floridana*. The number of egg capsules found indicates a spawning period between June and November with a peak in August. We recommend estimating catches of music volutes in the ark shellfishery to assess the impact of this activity on their populations.

Keywords: Voluta musica, distribution, abundance, reproduction, Venezuela

Resumen. Aspectos poblacionales, reproductivos y ecológicos del caracol pentagrama Voluta musica (Caenogastropoda: Volutidae) en el nororiente de Venezuela. Voluta musica es considerada en riesgo por diversas causas: los coleccionistas aprecian sus conchas, y su captura incidental en arrastres de Arca zebra en Venezuela. Parámetros poblacionales y ecológicos como distribución, abundancia, estructura de tallas, patrón de coloración de las conchas, zonas y épocas de reproducción, así como factores bióticos y abióticos con influencia en las densidades, fueron estudiados mediante censos con transectas-bandas. Entre febrero/2008 y enero/2009, se encontraron 178 ejemplares al sureste de la isla de Coche y costas de Chacopata, con una longitud promedio de 56,4 □ 28,3 mm. La densidad promedio mensual fue de 0,037 □ 0.17 org/m², con un máximo en septiembre (0,12 org/m<sup>2</sup>), y mínimo en octubre (0,0067 org/m<sup>2</sup>). GLM demuestran que los factores con mayor influencia en las densidades fueron: ausencia de Atrina seminuda, presencia de arena de grano fino y fangoso y la zona del canal de navegación entre la Isla de Coche y el Morro de Chacopata. Se encontraron cápsulas ovígeras en conchas muertas de A. seminuda, Pinna carnea y Anadara floridana. El periodo de oviposición fue entre junio-noviembre, con un pico en agosto. Se recomienda estimar su capturas en los arrastres de Arca zebra, para medir el impacto de dicha actividad en sus poblaciones.

Palabras clave: Voluta musica, distribución, abundancia, reproducción, Venezuela

<sup>&</sup>lt;sup>1</sup>Universidad de Oriente Nueva Esparta, UDO-NE, Cursos Básicos, Área de Biología, Isla de Margarita, Venezuela. Email:salome453@gmail.com

<sup>&</sup>lt;sup>2</sup>Universidad de Oriente Nueva Esparta, UDO-NE, Escuela de Ciencias Aplicadas del Mar. Isla de Margarita, Venezuela.

<sup>&</sup>lt;sup>3</sup>Universidad de Oriente, IOV-UDO, Departamento de Biología Pesquera, Cumaná, Venezuela.

<sup>&</sup>lt;sup>4</sup>Universidad de Oriente, UDO-Sucre, Centro de Investigaciones Ecológicas de Guayacán, Península de Araya, Venezuela.

#### Introduction

Voluta musica Linnaeus 1758 is a tropical gastropod mollusk frequently found in shallow waters of the southern Caribbean, that lives in muddy, sandy and Thalassia testudinum bottoms (Flores 1978, Cervigón et al. 1992). V. musica is a predator that feeds on decayed and scavenger material and invertebrates, especially gastropods and (Cosel 1976). This caenogastropod is bivalves distributed from the Greater Antilles to Surinam (Clench & Torner 1974, Abbott 1974, Humann & Deloach 2006). In the Venezuelan coast, it has been reported from Paraguaná Peninsula (Falcón State) to Chacopata (Sucre State), and from Margarita, Coche, Cubagua, La Orchila islands and in Los Frailes, Los Roques, Los Testigos and Las Aves archipelagoes (Coomans 1958, Work 1969, Gibson-Smith 1973, Clench & Torner 1974, Carvajal & Capelo 1993, Capelo & Buitriago 1998, Prieto et al. 2001, Díaz & Liñero 2004, Fernández & Jiménez 2007, Gassman et al. 2007).

The music volutes are characterized by a delicate design on their shells: a creamy background color, marks and shades from blackish to reddish brown and a distinctive series of lines resembling a musical staff encircling the upper half of the shell (Humann & Deloach 2006). Because of this delicate and colorful design it has attracted interest from collectors all over the world. This species has not been reported in the IUCN red list, but, however, it has been included on the red list of Venezuelan fauna, in the lower risk category, due to insufficient data on population status and the presence of risk factors that could affect population viability (Rodríguez & Rojas-Suárez 1995).

Regarding reproduction, the male fertilizes the female internally which later spawn egg capsules that develop directly, so there is no free swimming stage and juveniles come out from the capsule as miniature adults (Penchaszadeh & Miloslavich 2001). As a result, these organisms have a narrow biogeographic range and spread slowly. This may cause local, isolated population extinctions by overextraction, as has been reported for other members of the Volutidae family (Orensanz et al. 1996, Willan & Dredge 2004). Moreover, in some regions of the southern Caribbean, V. musica and V. virescens are of interest to fisheries and are collected by hand and occasionally with dredges and trawls in deeper waters and consumed locally raw or cooked. (Cervigón *et al.* 1992).

Some factors that may have a local impact on the vulnerability of this species in northeastern Venezuela are: a) the presence of music volutes as incidental catch during trawling targeting the ark shell (*Arca zebra*); b) the trade of *V. musica* for international markets (where snails can be quoted between 19 and 50 U\$D) and c) TBT-induced imposex which causes sterilization and finally a decrease in abundance of gastropod populations exposed to the compound (Oehlmann *et al.* 1996).

This study is a contribution to integrated management of this resource. Population and ecological parameters including maps of distribution and abundance, possible breeding areas, length structure, color pattern of shells of its population and some biotic and abiotic factors that determine the densities of *V. musica* in northeastern Venezuela are analyzed and discussed.

#### **Materials and Methods**

## Study Area

This study was conducted in waters northwest, west and south of Coche Island (Nueva Esparta State, Venezuela), including the vicinity of Lobos and Caribe islets, which are located west of Morro de Chacopata (Fig. 1). This geomorphologic underwater unit is known as "Cumbre de Coche", and is characterized by a depth range of 0-15 meters, the presence of coarse sand, gravel and clast, medium and fine sand, and the occurrence of coral reefs and oyster beds which are the cause of these relatively coarse sediments (Ginés *et al.* 1972, Álvarez 1987, Llano 1996).

The whole area is a very fertile marine ecosystem as a result of upwelling of nutrient-rich deep waters and bathymetric features that make it an almost completely euphotic zone (Carvajal & Capelo 1993). Furthermore, this area supports important shellfisheries, targeting species such as the ark shell *Arca zebra*, the pearl oyster *Pinctada imbricata*, the Caribbean fighting conch *Strombus pugilis*, the pen shell *Atrina seminuda* among other species, which sustain a large population of artisanal fishermen in the area (Ginés *et al.* 1972, Salaya & Salazar 1972, Gómez 1999, Marval & Cervigón 2008).

## **Fieldwork**

The study area was divided into 360 cells of 250,000m<sup>2</sup>. Each month, 30 stations were chosen

randomly for sampling. The center of each cell was a taken as reference for the location of each station and located in the field by using a GPS. Assessment of *V. musica* was made with visual census transects. Once in the proximity of the center of each station, two scuba divers swam parallel to a 5m long PVC tube and covered an area of 1m on each side of the tube, that is a total area of 10m<sup>2</sup> by station. A caliper (precision: 1 mm) was used to measure the length between the apex and the end of the shell's siphon of

all specimens obtained during sampling. In addition, the status of the individuals (alive or dead), color's shell patterning, the presence of hosts such as hermit crabs and observations on feeding behavior were registered. Also, the type of substrate was determined by visual inspection, and the presence and number of egg capsules on empty bivalve shells counted in order to establish areas and periods of reproduction.

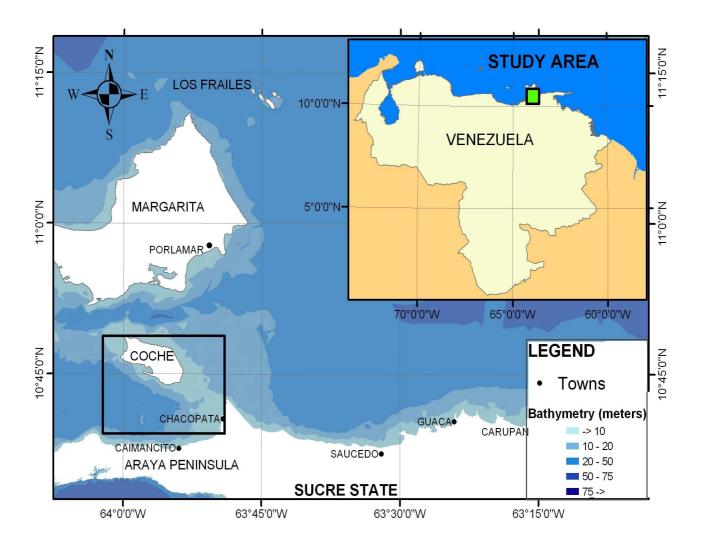


Figure 1. Location of study area in northeastern Venezuela.

# Statistical analysis

To determine the type of spatial distribution of the species in the study area, the variance to mean ratio of density estimates was calculated. Once a random distribution pattern (ratio variance/mean density=1) was rejected, the frequency of occurrence of organisms per transect was determined and the

M. SALOMÈ RANGEL *et al.* 

expected frequencies for a negative binomial distribution (associated to aggregated distributions) were calculated using a preliminary estimate of k (degree of aggregation of organisms) by the following formula:

$$\hat{k} = \frac{\overline{x}^2}{s^2 - \overline{x}}$$

Where x is the mean and s is the standard deviation.

Then, k was calculated iteratively by maximum likelihood, solving and trying to match the 2 following equations:

$$n * \log_e * \left(1 + \frac{\overline{x}}{\hat{k}}\right) = \sum \left(\frac{A_{(x)}}{\hat{k} + x}\right)$$

where A(x) is the sum of observed frequencies greater than x for each x, and where x is the number of organisms found by transect (Elliot 1977).

Additionally, the ArcView software was used to create maps of interpolated continuous surfaces by the kriging method from the densities found in field, limiting the area of each interpolated surface with their respective standard error. This method analyzes the spatial behavior of a variable on a defined area, resulting in the influence of data at different distances (Krige 1951).

A Generalized Linear Model (GLM function in R) was used to identify the environmental factors that had statistically significant relationships with V. musica densities observed in situ (Bolker 2007). Factors used were: zone, month, presence/absence of Atrina seminuda, relative depth (calculated by dividing the depth value at each station between the maximum recorded in all sampling stations, and coded on a scale of 1 to 5), presence/absence of Thalassia testudinum and type of bottom (with the following categories: mud-fine sand, mediumgrained sand, gravel-coarse sand). For the selection of alternative models to explain the behavior of the dependent variable (logarithm of the density or logdensity) in response to factors, the Akaike information criterion (AIC) was used, which measures the goodness of fit of an estimated statistical model providing a relative measure of the loss of information when using a particular model to

explain a real situation (Akaike 1974).

In order to relate reproductive activity (appearance of egg capsules) with surface water temperature during the study period, NOAA-OUP temperature records of 8 geographical points distributed throughout the sampling area were obtained from the "Observatorio Oceanográfico Digital de Venezuela" website (http://ood.cbm.usb.ve/historial/sst\_noaa/).

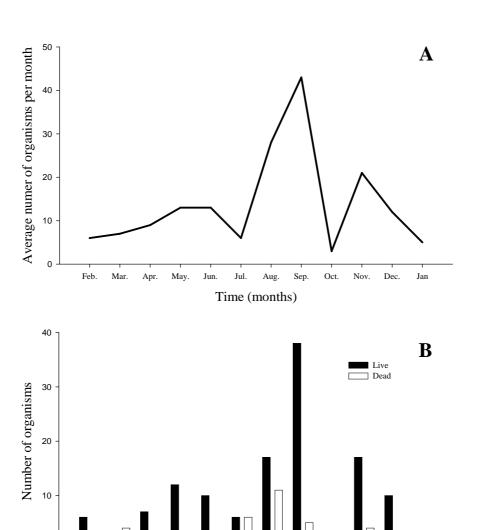
#### Results

## Spatial distribution and abundance

A total of 360 stations (30 monthly) were sampled from February 2008 to January 2009, resulting in a total of 178 specimens of music volutes (131 alive and 47 dead) found in 57 stations. The months of September and October showed the highest (N=43) and lowest (N=3) number of individuals, respectively (Fig. 2A). Also, a significant number of juveniles (at hatching stage) (N=21) were observed in September, with an average size of  $6.95\pm0.67$  mm. In general, the abundance of individuals showed an increasing trend from February to September and then a decrease from October to January. In each month, the number of live individuals was greater or equal to the number of dead shells found, except in March (4 dead and 3 alive) (Fig. 2B).

There were not statistically significant differences in density or abundance for different types of bottoms (ANOVA; F (4,52)=1.082; p=0.375). However, *Thalassia* beds seem to be a preferred substrate (56%) against absence of *Thalassia* (44%); instead coarse sand-gravel bottoms (49%) and medium-grained sand (44%) were mostly preferred than sandy-muddy bottoms.

In general, *V. musica* was widely distributed throughout the study area. Throughout the area average estimated density was 0.037±0.17 org/m²; with the highest average value (0.12 org/m²) in September and the lowest in October (0.006 org/m²) (Fig. 3). The frequency of organisms observed per transect followed an aggregate distribution, with a very low value for parameter k (0.06) from the negative binomial distribution. The stations with the highest densities were found at the center of the channel between Coche Island and Morro de Chacopata (Fig. 4). These stations had less than 9 m depth and presented medium-grain sand and coarse sand and gravel.



**Figure 2. A.** Total number of organisms per month; **B.** Number of live and dead organisms per month in the study area in the period February-2008 to January-2009.

Time (months)

Jul

May.

Regarding the GLM analysis, the binomial model was selected as it showed the lower AIC value (96.78). Factors included in the model were zone, bottom type, presence or absence of *T. testudinum*, and presence or absence of *A. seminuda*. Based on statistical significance levels, the factors that are most influential on values of *V. musica* densities were (in order of importance): absence of *A. seminuda* (negative effect, p<0.01), presence of muddy-fine grain sand and medium-grain sand bottoms (negative effect, p<0.05), the zone corresponding to the center of the channel between Coche Island and Morro de Chacopata (positive effect, p=0.06).

Feb

#### Population dynamics

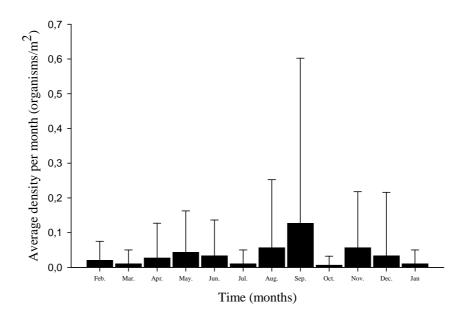
Sep

Oct.

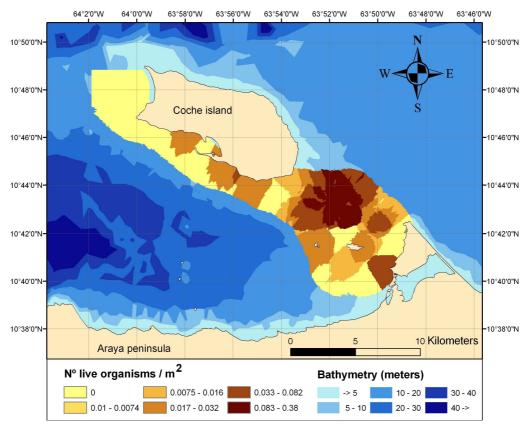
The length range of specimens was between 5 and 104mm with an average of 56.4±28.3 mm. The shells of dead organisms had a lower average length than live individuals, except in September and October (Fig. 5), which is due to the presence of many dead newly hatched juveniles during these particular months.

Were found statistically significant and

differences in the sizes of organisms in presence absence of *Thalassia testudinum*, with sizes smaller individuals presents in seagrass beds (ANOVA; F (1,55)=4.28; p= 0.043).



**Figure 3.** Average density per month and its standard deviations for *Voluta musica* in northeastern Venezuela.



**Figure 4.** Continuous surface map for density data (organisms/m²) for *Voluta musica* in northeastern Venezuela, obtained by the Kriging interpolation method.

Factor	Estimated	Estimated Standard	Z	Significance
	Coefficient	Error	value	
Intercept	1.86684	1.39441	1.339	0.18063
Muddy and fine-grain sand bottom	-3.78262	1.61485	-2.342	0.01916*
Medium-grain sand bottom	-2.90626	1.29575	-2.243	0.02490*
Absence of Thalassia testudinum	-0.96246	0.57607	-1.671	0.09478.
Zone Northwest of Coche Island	-9.05426	58.53818	-0.155	0.87708
Zone Southwest-south of Coche Island	0.08098	0.94145	0.086	0.93145
Navigation channel between Coche Island and	1.31361	0.70022	1.876	0.06065.

**Table I.** Coefficients for factors of the final binomial model for data of *Voluta musica* in northeastern Venezuela.

Significance Codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' '

-2.39853

The annual length structure showed a bimodal pattern with high frequencies of very small specimens (sizes between 5 and 7 mm) and of sizes between 50 and 90mm total length (Fig. 6). The monthly length frequency histograms show a similar structure, but with variations probably associated with the low number of samples (Fig. 7).

Chacopata

Absence of Atrina seminuda

In the study area a total of 233 egg capsules of *V. musica* were found on dead specimens of the bivalves *Atrina seminuda*, *Pinna carnea* and *Anadara floridiana* (Fig. 8). These capsules had a number of larvae that ranged between 0 and 5 individuals, with an average of 3.41 larvae/capsule.

During the first three months (February-March) of sampling no egg capsules were found at sampling locations and then from May to August there was a gradual increase in numbers. After a peak in August the number of capsules declines until January 2009 when they were no longer observed on empty bivalve shells (Fig. 9). In August, the first hatched capsules were found and the maximum number was registered in November, afterwards they decline sharply and disappear in January. These results suggest an approximate period of embryonic development and hatching of about 2-3 months, and a spawning period between May and November, with a peak in August (Fig. 9).

Surface water temperature showed a gradual increase from April to July and then increases significantly to reach maximum values during September-November (26.8-28.3°C), afterwards temperatures decline to values similar to those recorded in the beginning of the study period (24-25°C) (Fig. 10). In general, there seems to be a relationship between increasing temperatures and spawning of this species in the study area.

0.83158

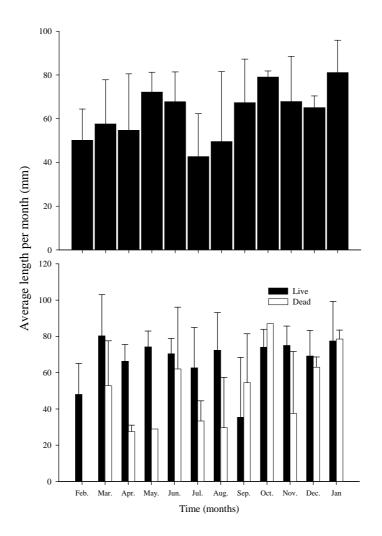
-2.884

0.00392 \*\*

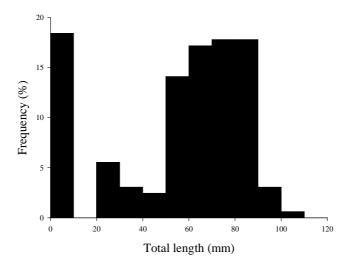
The stations with the largest number of egg capsules were located close to shore in depths shallower than 10 meters (Fig. 11). The key spawning areas were located southeast of Coche Island (at the center of the channel between Coche Island and Morro de Chacopata) and adjacent to the coast of Morro de Chacopata.

## Shell patterning and Interspecific relationships

The music volutes registered in northeastern of Venezuela showed a wide spectrum of coloration, although most of the shells sampled presented a creamy-brown color, there were also some individuals that presented orange and gray color patterns.



**Figure 5. A.** Average total length per month; **B**. live and dead organisms per month, with its respective standard deviations for *Voluta musica* in northeastern Venezuela.



**Figure 6.** Length structure of *Voluta musica* in the period February/2008 – January/2009 in northeastern Venezuela.

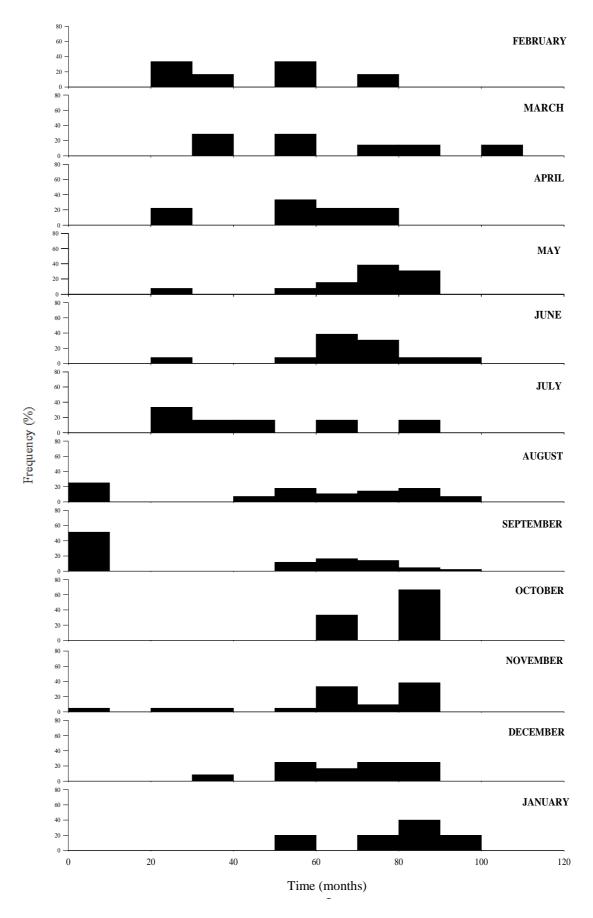
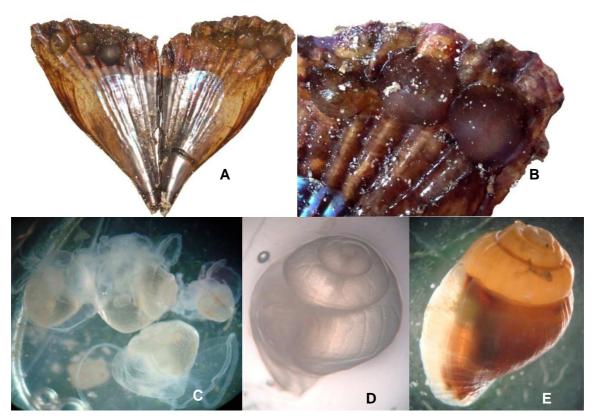
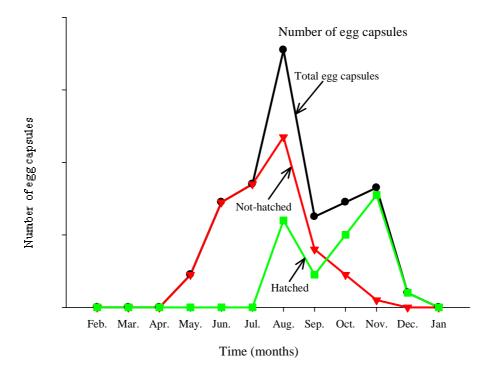


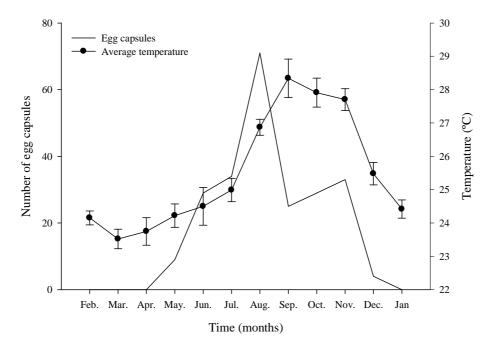
Figure 7. Total length Frequency histograms per month of *Voluta musica* in northeastern Venezuela.



**Figure 8. A)** Atrina seminuda shell where there are 6 egg capsules; **B)** Detail of egg capsules; **C-D)** Intracapsular Larvae of Voluta musica; **E)** Newly hatched specimen.



**Figure 9.** Total number of egg capsules, non-hatched and hatched per month found at shells of dead bivalves *Atrina seminuda*, *Pinna carnea* and *Anadara floridana* in northeastern Venezuela.



**Figure 10.** Local average temperature of surface water and total number of egg capsules of *Voluta musica* recorded during the period February/2008 and January/2009 in northeastern Venezuela.

During field work it was possible to occasionally observe feeding behavior of the music volutes: a) in May an individual *V. musica* (84mm) was found feeding on an specimen of the genus *Olivella*; b) in September another specimen was observed feeding on a small *Chicoreus brevifrons*.

Also it was possible to note that hermit crabs inhabited approximately 10% of shells of dead music volutes.

## Discussion

The results show that *Voluta musica* has a wide distribution in the study area, although there are higher concentrations in the channel between Coche Island and Morro de Chacopata, including Lobos and Caribe islets. This spatial distribution pattern coincides with that observed by other authors (Carvajal & Capelo 1993, Prieto *et al.* 2001).

Average density observed in the study area (0.37±0.17 org/m²) is similar to that reported for other species of Volutidae, such as *Cymbiolacca pulchra* (0,02-0,08 org/m² in an area of high relative abundance) and *Amoria maculata* in the Great Barrier Reef, Australia (Catterall *et al.* 1992), although coral reefs and seagrass beds are

structurally different, but no other work reports densities for music volutes to enable more specific comparisons.

The spatial distribution of *V. musica* in the study area may be wider because, in general, it is quite difficult to visualize the specimens in field, therefore it would be underestimating the specie's distribution, either because they are hidden among the seagrass or because they are buried in the sand, so they can easily go unnoticed. Only large size specimens can be easily found buried in the sand showing a prominent mound on the substrate. Although it is not unusual to detect them during the day, this species is generally nocturnal (Sutty 1992), which makes it more difficult to localize. However, the sampling operations were conducted during daylight hours, usually between 8:00 a.m. and 2:00 p.m., so it should be assumed that the densities found in this study probably underestimate true density. In general, studies with other species have shown that Volutidae populations are rather scarce or rare (Cosel 1976, Catterall et al. 1992); however, in general, species are considered rare until enough is known about their biology to detect large aggregations based on reproductive or feeding behavior (Gaston 1997, Guisan et al. 2006). On the other hand, the progressive increase in the number of

organisms found at the beginning of the study period may reflect increased expertise and experience in location of specimens during the course of sampling. Poppe and Goto (1992) established that volutes are usually buried in the substrate and that in the breeding season move from deep to shallow areas, which could explain the increase in number of individuals of *V. musica* at the time that egg capsules were more abundant in field observations.

Statistical analysis indicates an aggregated spatial distribution pattern for music volutes, which would increase the probability of finding other snails once one is located. This phenomenon of aggregation probably involves intra-specific interactions of competition for food, mating and availability of empty bivalve shells for spawning, among others.

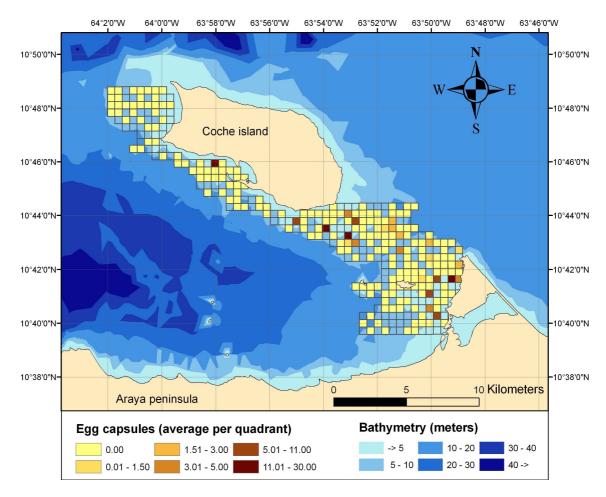


Figure 11. Average number of egg capsules of Voluta musica by sampling stations in northeastern Venezuela.

Voluta musica appears to show preference for medium-grain sand and coarse-sand and gravel bottoms, as most specimens where found in sampling stations with this type of substrate. On the other hand, the GLM analysis showed a significant negative effect of muddy, fine sand and medium-grain sand bottoms on the values of density. The aggregation of this carnivorous gastropod (Cosel 1976) in this type of bottom could be determined by

the presence of preys (Catterall *et al.* 1992), especially bivalves with limited capacity of mobilization and evasion from predators. Another factor that could explain this preference is that larger grain size facilitates the constant oxygenation of the sub-surface layers of the seabed (Cai & Sayles 1996, Glud 2008) where, in most cases, these gastropods are buried for long periods of time, allowing protection and predator voidance. *In situ* 

observations allowed recording one music volute when burying in the seabed in coarse sediments, an activity that took less than 1 minute. Also, *V. musica* could show preference for specific substrate during the spawning period, or indirectly, due to specific substrate requirements of the bivalve species used for laying egg capsules. In fact, the GLM analysis indicated a highly significant negative effect of the absence of *Atrina seminuda* on density of *V. musica*. In general, it is considered that the music volute avoids muddy bottoms (Cosel 1976), as observed in this study because there were only two individuals found on this type of substrate.

There was no clear preference of *V. musica* for inhabiting *Thalassia* meadows, but there was a significant but negative effect of the absence of seagrass beds on densities reported in field.

The observation of 2 peaks in length frequency histograms for the entire sampling period is indicative of the presence of at least 2 cohorts of organisms, with sizes between 5-7 mm and 50-90 mm. However, it is assumed that not all sizes where recorded in samples, especially those individuals under 25 mm in length, which could be the result of high natural mortality of juveniles or that location of these small organisms buried in the substrate is difficult.

In relation to substrate for oviposition, were recorded egg capsules on dead bivalve shells of the genera *Anadara*, in addition to *Atrina*, *Pinna* and *Trachycardium* (Penchaszadeh and Miloslavich 2001).

Temperature appears to act as a trigger mechanism for spawning, as our results indicate an increase in the number of egg capsules in the field as temperature rises. The regulatory effect of temperature on the development of gonads in gastropods (Giese & Pearse 1974, Martel *et al.* 1986) has been demonstrated in some species of the Volutidae family such as *Adelomelon brasiliana* and *Zidona dufresnei* (Cledón *et al.* 2005a, Giménez & Penchaszadeh 2001).

The average number of embryos in egg capsules found in this study is consistent with previous reports in the same region (Penchaszadeh & Miloslavich 2001), as well as the size of newly hatched individuals. Based on the time elapsed between the appearance of the first egg capsules and the appearance of the first hatched capsules, an embryonic development period of about 2-3 months can be estimated, implying that the intra-capsular fluid contains a high nutrient content to allow proper

development of juveniles (Penchaszadeh & Miloslavich 2001). Also, according to the presence of egg capsules observed in the field, the spawning period extends from June to November, which contrasts with the continuous annual reproductive cycle reported for the Volutidae family member *Odontocymbiola magellanica* in the Strait of Magellan, Argentina (Bigatti *et al.* 2008).

Spawning areas were concentrated in the channel between Coche Island and Morro de Chacopata and the west coast of Morro de Chacopata, so these areas appear to be critical for the species and should be considered for its protection and management, since in this area many local fishermen extract a wide variety of fishery resources with diverse fishing gears (Ginés *et al.* 1972, Iriarte 1997, Marval & Cervigón 2008).

Globally, threatened species have been adversely affected by habitat loss and fragmentation due to short (trawl fisheries) and long term (climate change) human activities. The resulting habitat fragmentation could result in many threatened species tending to exist in a small number of isolated subpopulations (Catterall et al. 1992, Harrison & Bruna 1999, McDonnald-Madden et al. 2008). It is generally considered that Volutidae stocks depend on relatively closed and isolated populations (Cosel 1976) due to slow dispersal and narrow biogeographic range, which makes them highly vulnerable to excessive local extraction by fishing and disturbances affecting lower trophic level species (Catterall et al. 1992, Orenzans et al. 1996, Willan & Dredge 2004).

Some species of the Volutidae family (Giménez et al. 2004, Cledón et al. 2005b, Bigatti et al. 2008), as well as other gastropods of fishing importance, such as Californian abalones Haliotis spp. (Rogers-Bennett et al. 2002), Caribbean queen conch Strombus gigas (Rodríguez & Posada 1994, Bastidas & Rada 1997, Appeldoorn 1994, Stoner & Ray-Culp 2000), and Chilean "loco" Concholepas concholepas (Rabí & Maraví 1997) show slow growth and late sexual maturity, which makes them particularly vulnerable to over-exploitation. Even though there is no evidence that V. musica has slow growth and late maturity in the study area, the described characteristics of the egg capsules suggest that it has low fecundity.

Many music volute shells can be observed in areas where the remains of processed ark shells (*Arca zebra*) are deposited on the mainland in Chacopata and the islands of Coche and Margarita showing how this fishing activity affects populations

M. SALOMÈ RANGEL *et al.* 

of *V. musica* in the study area. This fishery has been developing intensively and represents a significant percentage of marine landings in Venezuela (SARPA 1996) and, for example, in the years 1997-1998 a total of about 3818 fishing trips/month was reported (Arias *et al.* 2002). This fishery is especially concentrated in the vicinity of Morro de Chacopata and present landings are of approximately 50,000 tons per year (Rengel Jimenez, Instituto Nacional de Investigaciones Agrícolas, personal communication).

Ark shell extraction is made by dredging (Novoa et al. 1998, Arias et al. 2002). This type of fishing practice has been shown to affect coastal marine habitats by direct removal of living organisms, modification of bottom topography and creating disturbances in the community structure, their impact depending on the spatial and temporal variations of fishing effort (Langton & Robinson 1990, Watling et al. 2001). Some functional groups such as bivalve filter feeders are more vulnerable to such disturbances (Lindeboom & de Groot 1998, Jennings et al. 2001, Kaiser et al. 2002, Thrush & Dayton 2002). In addition, this type of fishing practice causes a reduction of the benthic size spectrum resulting in an association of organisms dominated by small species (Queiros et al. 2006). Therefore, it may be considered an activity that affects V. musica directly as incident catch and indirectly by habitat modification. Particularly, in other species of the Volutidae family, environmental changes associated with dredging and trawling seem to affect the survival of juveniles and causes emigration or death of larger specimens (Catterall et al. 1992). In addition, the long stay of specimens on board fishing vessels, prior to a possible discard, may cause death by anoxia, dehydration, pressure trauma, thermal shock or predation while adapting or recovering in the post-discard period, or by discarding in an area with inappropriate substrate (Carranza y Horta 2008).

In general, music volute densities were relatively low in the study area. Therefore, although individuals of *V. musica* were found in stations where *Arca zebra* was either present or absent, the rapid development of this fishery (Arias *et al.* 2002, Marval & Cervigón 2008) and the possibility of an expansion in the area of exploitation represent a threat to *V. musica* population levels.

In Australia, assessment of criteria such as range, type of development, fertility, accessibility to fishing activities and price of shells on markets, were used to rank the vulnerability of

mollusks (Ponder & Grayson 1998). In northeastern Venezuela, using some of these criteria, a medium to high vulnerability may be assigned to *Voluta musica*, considering that: A) The species has direct development, which causes a slow dispersion of juveniles and therefore a restricted population range; B) It is distributed in low to middle depths, which are relatively accessible to fishing activities; c) Although the shells reach relatively low prices in the international shell market, some large specimens in good condition can cost up to 50 \$.

Finally, it is recommended that mortality from incidental catch of *V. musica* in the ark shellfishery be estimated. Also, we recommend regular monitoring of music volute densities and that collectors avoid capture of live specimens, and instead search for shells in pearl oyster and ark shell heaps, which are present in the vicinity of fisher communities of Coche Island, Araya Peninsula (Chacopata, Caimancito and Guayacán, Sucre State) and Margarita Island (Punta de Piedras, Nueva Esparta State) where large quantities of music volute shells can be found in perfect conditions.

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