

# Spatial and temporal distribution of *Cittarium pica* (Gastropoda: Tegulidae) in the intertidal rocky shore of southeastern of Cuba

## Distribución espacial y temporal de *Cittarium pica* (Gastropoda: Tegulidae) en la costa rocosa intermareal del sureste de Cuba

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### Abstract

The gastropod *Cittarium pica* is one of the main conspicuous herbivore-detrivore in the Caribbean intertidal rocky shore. The inadequate management of its fisheries throughout its distribution area is the main reason of the population decline and is considered a Vulnerable-specie by IUCN. On this paper, we evaluate the spatial and temporal variation of the density of this specie in four localities of southeastern Cuba. Bimonthly sampling campaigns were conducted between March 2013 and February 2014. The sampling unit was a square of 25 cm on side, placing 10 units in the rocky intertidal of each locality, separating 5 m one from the other. On each sampling unit was determined the number of specimens and the macroalgae coverage percent. The significance of the density variation among localities and months was tested with a PERMANOVA, and the relation between the density and the macroalgal coverage with a Mantel test. The spatial distribution pattern shown a marked variation among localities ( $p = 0.0034$ ), but not among months ( $p = 0.29$ ) and rainy-periods ( $p = 0.29$ ). The density of *C. pica* was inversely proportional to the macroalgae coverage on eutrophic areas, and directly proportional on non-eutrophic ones. The results show that the distribution of *C. pica* on the intertidal rocky shore of southeastern Cuba is strongly determined by the algal coverage and the exposed to eutrophication.

**Keywords:** density, eutrophication, algal coverage, Caribbean Sea, fisheries.

### Resumen

El gasterópodo *Cittarium pica* es uno de los más conspicuos herbívoros-detrívoros en la costa rocosa intermareal del Caribe. La gestión inadecuada de sus pesquerías en toda su área de distribución es la razón principal de la disminución de la población y la UICN la considera una especie vulnerable. En este trabajo se evalúa la variación espacial y temporal de la densidad de esta especie en cuatro localidades del sureste de Cuba. Se realizaron campañas de muestreo bimestrales entre marzo de 2013 y febrero de 2014. La unidad de muestreo fue un cuadrante de 25 cm de lado, el cual fue dispuesto 10 veces en el intermareal rocoso de cada localidad, separando 5 m uno de otro. En cada unidad de muestreo se determinó el número de ejemplares y el porcentaje de cobertura de macroalgas. La significación de la variación de densidad entre localidades y meses se probó con un PERMANOVA, y la relación entre la densidad y la cobertura de macroalgas con una prueba de Mantel. El patrón de distribución espacial mostró una marcada variación entre localidades ( $p = 0,0034$ ), pero no entre meses ( $p = 0,29$ ) ni períodos lluviosos ( $p = 0,29$ ). La densidad de *C. pica* fue inversamente proporcional a la cobertura de macroalgas en las áreas eutróficas y directamente proporcional en las no eutróficas. Los resultados muestran que la distribución de *C. pica* en la costa rocosa intermareal del sureste de Cuba está fuertemente determinada por la cobertura de algas y la exposición a la eutrofización.

**Palabras clave:** densidad, eutrofización, cobertura de algas, mar Caribe, pesca.

## Introduction

The gastropod *Cittarium pica* (Linnaeus, 1758) is known in Cuba and other Caribbean islands as “cigua” or “burgao”. It is distributed on the septentrional Caribbean, from Florida to the norther of South America (Robertson, 2003). This mollusc is one of the largest animals, and higher consumer of algae in the intertidal rocky shore (Randall, 1964; Castell, 1987). *Cittarium pica* is predated by other gastropods and octopuses, and its shell is used by several species of anomuran crabs (Robertson, 2003).

*Cittarium pica* has been fished since pre-Columbian times (Scudder & Quitmer, 1998) Currently, it is the most economic important gastropod, after *Lobatus gigas* (Linnaeus, 1758), on the West Indies (Robertson, 2003). It can be collected manually on rocky and reef bottoms, being one of the main incomes for several coastal communities, that use its flesh as food and bait, and the shell for craftwork (Nieto-Bernal *et al.*, 2013).

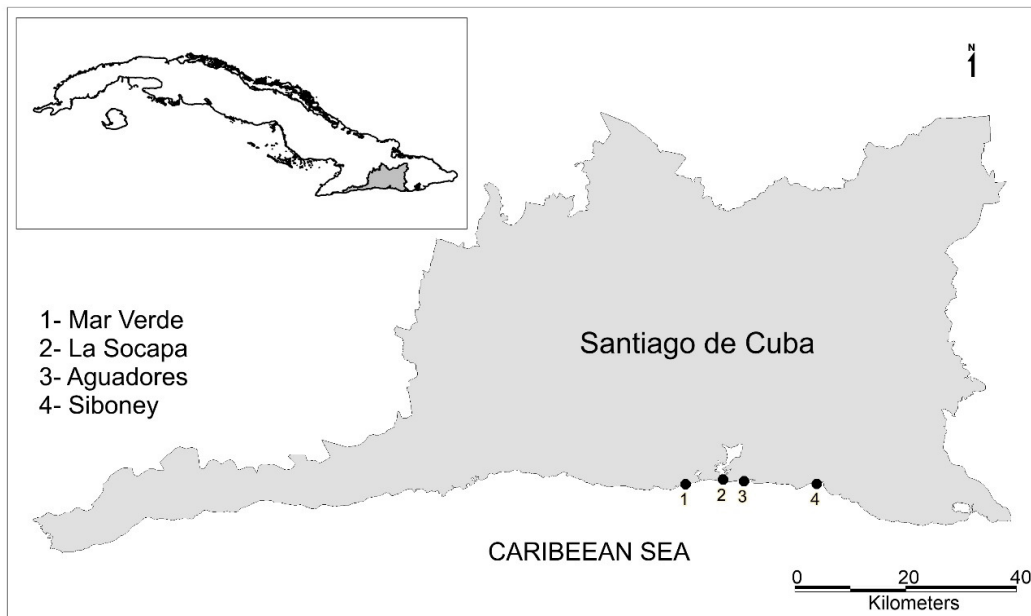
Currently, some studies show that the populations of *C. pica* have decreased in last decades due to excessive fisheries (Schmidt *et al.*, 2002; Rico *et al.*, 2017; Daza-Guerra *et al.*, 2018). Despite this situation, the conservation status of the species has not been evaluated globally. However, in Colombia and Venezuela it is classified as Vul-

nerable (Gracia & Díaz, 2002, Rodríguez & Rojas-Suárez, 2008). In Cuba, *C. pica* is recognized in Critical Risk although there are not studies that prove its population decline in the archipelago (CITMA, 2011). On the southeastern coast of Cuba, have been identified areas severely affected by eutrophication, being the most affected the areas closest to the bay. This process affects the structure of invertebrate populations, particularly molluscs, affecting density and growth. Therefore, studies on the distribution and abundance of *C. pica* in Cuba are necessary, in order to evaluate the impact of the fisheries and pollution.

In this study, we characterized the spatial and temporal variation of the density of *C. pica* in four localities of the southeastern coast of Cuba and the relationship of the density of this specie with the coverage of macroalgae in the intertidal rocky shore.

## Materials and methods

Bimonthly samplings were conducted from March 2013 to February 2014, in four localities of southeastern Cuba (Fig. 1): Mar Verde (19°57'56" N; 75°56'37" W), La Socapa (19°58'25" N; 75°52'22" W), Aguadores (19°58'01" N; 75°49'55" W), and Siboney (19°57'36" N; 75°42'17" W).



**Figure 1.** Geographical location of the study localities in Santiago de Cuba province.

**Figura 1.** Ubicación geográfica de las localidades de estudio en la provincia de Santiago de Cuba.

Rainy and non-rainy periods were represented during the collecting period (Lecha *et al.*, 1994). The localities were selected according to the criteria of Jover *et al.* (2014). The sampling unit was a square of 25 cm of side, placing 10 units on each locality, separated at 5 m one from the other. The macroalgae coverage percent was determined visually on each unit (Veiga, 1999), likewise the number of specimens of *C. pica* in order to calculate the density.

A PERMANOVA test was performed in order to determine the significance of the density variation among localities, eutrophized (La Socapa and Aguadores) and non-eutrophized areas (Mar Verde and Siboney) (Diez *et al.*, 2013), and months, using the statistic program Past v. 3.0 (Hammer, A. T. Harper & P. D. Ryan, 2001). Statistical signification of each relation was detected using 10 000 permutations ( $p < 0,05$ ). The relation between the density and the algal coverage was detected with a Mantel test, using the XLStat Pro v.6.0 package (Addinsoft, 2013).

## Results

**Spatial variation:** On the sampling period were detected 151 specimens of *C. pica*. The highest density was found in Siboney (29.4 ind.m<sup>-2</sup>) and the lowest density in La Socapa (1.9 ind.m<sup>-2</sup>) (Table 1). The spatial distribution of the density shown significant differences among the localities (PERMANOVA,  $F = 5.989$ ;  $p = 0.0034$ ) and between eutrophic and non-eutrophic areas ( $F = 6.713$ ;  $p = 0.0068$ ).

**Temporal variation:** The months where was found the highest density corresponded with the rainy period (August and October). The lowest density was found on April, corresponding to the transition between the rainy and the non-rainy period (Table 1). The temporal distribution of the density did not show significant differences among months (PERMANOVA,  $F = 0.962$ ;  $p = 0.29$ ) and rainy periods ( $F = 1.377$ ;  $p = 0.29$ ).

**Table 1.** Density (ind.m<sup>-2</sup>) of *Cittarium pica* on the intertidal rocky shore of four localities of the southeastern Cuba (April 2013 to February 2014).

**Tabla 1.** Densidad (ind.m<sup>-2</sup>) de *Cittarium pica* en la costa rocosa intermareal de cuatro localidades del sureste de Cuba (abril de 2013 a febrero de 2014).

Months	Localities			
	Mar Verde	La Socapa	Aguadores	Siboney
April	1.6	4.8	-	6.4
June	6.4	-	-	14.4
August	25.6	-	14.4	56.0
October	6.4	-	1.6	48.0
December	11.2	-	8.0	-
February	8.0	4.8	1.6	22.4

**Relation with macroalgae coverage:** The macroalgae coverage was higher on August and February in Aguadores, and on April in La Socapa, both localities are eutrophized. Mar Verde and Siboney were the localities with the lowest macroalgae coverage, and both are non-eutrophized areas (Table 2). In eutrophized zones the density of *C. pica* was inversely related to the macroalgae coverage; this relation was significant (Aguadores:  $pM = 0.045$  and La Socapa:  $pM = 0.034$ ). In non-eutrophic zones, the density was directly related to the macroalgae coverage, however, this relation

was not significant (Mar Verde:  $pM = 0.87$  and Siboney:  $pM = 0.49$ ).

## Discussion

The density of *C. pica* in the intertidal rocky shore in Santiago de Cuba was higher than the critical values for some areas of the Caribbean Sea, where it reaches 4.7 ind.m<sup>-2</sup> (Osorno *et al.*, 2009). Lower values of density were found in Aguadores and La

Socapa. This finding can be related to the influence of the eutrophication, due these areas have been considered very eutrophized (Diez & Jover, 2013; Diez *et al.*, 2013). The eutrophication is the main reason for the decrease of the biodiversity in Caribbean ecosystems (Osorno *et al.*, 2009). These

localities are nearby to urban areas of Santiago de Cuba, and are preferred by fishermen. Osorno (2005) indicated a high degree of exploitation of this resource in areas close to population settlements.

**Table 2.** Macroalgae coverage (%) on the intertidal rocky shore of four localities of the southeastern Cuba (April 2013 to February 2014).

**Tabla 2.** Cobertura de macroalgas (%) en la costa rocosa intermareal de cuatro localidades del sureste de Cuba (abril de 2013 a febrero de 2014).

Localities	Months					
	April	June	August	October	December	February
Mar Verde	20	15	50	25	45	25
La Socapa	80	50	75	70	-	60
Aguadores	35	35	80	65	85	85
Siboney	25	10	10	10	-	10

The higher density found in Siboney can be determined by its topographic characteristic, because it is mostly a cliff coast and it difficult to the fishermen collect the molluscs. Additionally, Siboney is a non-eutrophized area. In areas of Costa Rica where *C. pica* is not under fisheries, its density is three times higher than in areas under fisheries (Schmidt *et al.*, 2002). In addition, the rocky intertidal in Siboney is exposed to strong waves. In other localities from the Caribbean it has been recorded highest densities of *C. pica* in environments subjected to strong waves (Debrot, 1990a, b).

The medium value of density between the studied localities (10.9 ind.m<sup>-2</sup>) is lower than the recorded by Schmidt *et al.* (2002) from Costa Rica (14.0 ind.m<sup>-2</sup>). However, values found in Siboney and Mar Verde (9.9 ind.m<sup>-2</sup> and 29.4 ind.m<sup>-2</sup>) are higher than the critical density value considered for some areas of the Caribbean (4.7 ind.m<sup>-2</sup>) (Osorno *et al.* 2009). These values of density of *C. pica* recorded for the Caribbean have been conditioned by it over fishery. The highest density detected in August can be determined because this is one of the months when spawning has been detected in the Caribbean rocky shore (Daza-Guerra *et al.*, 2018). In addition, during the months of the rainy season there are strong winds and waves that subserve the higher density of *C. pica* (Debrot, 1990a,

b). These meteorological conditions also difficult the exploitation of the animal by fishermen (Osorno, 2005; Osorno & Díaz, 2009; Daza-Guerra *et al.*, 2018).

Density on the intertidal rocky shore is inversely related to the macroalgae coverage on eutrophic zones, due this species has a lower tolerance to eutrophication (Lubchenco and Menge, 1978). However, it has been demonstrated that the presence of macroalgae is favourable for *C. pica*, because they provide refuge and food (Fernández and Niell, 1983). It is known that in the intertidal rocky shore of Santiago de Cuba the macroalgae coverage determines the spatial and temporal variation of the molluscs (Jover *et al.*, 2014). Previously, in the Caribbean the abundance and distribution of the populations of *C. pica* have been related to the macroalgae present in the intertidal rocky shore (Osorno *et al.*, 2009; Daza-Guerra *et al.*, 2018). According to these authors, the macroalgae provide food, refuge and camouflage, minimizing the predation of *C. pica*.

## Conclusions

The spatial distribution of the density of *Cittarium pica* shown a distinctive variation among localities;

this finding seems to be determined by the eutrophication. The temporal distribution of the density of *C. pica* is related with the succession of rainy and non-rainy periods, due the increase of organic matter during rainy periods. The density of *C. pica* is related with macroalgae coverage, due it provides conditions for the survival of this species.

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