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Size Composition of *Hexaplex* (*Muricanthus*) *nigritus* (Mollusca: Muricidae) in the Intertidal Zone of Five Islands of the Southeastern Gulf of California, Mexico

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ABSTRACT

Background: Currently, there is no fishery regulation for *Hexaplex* (*Muricanthus*) *nigritus* in northwestern Mexico. The size composition of gastropod *H. nigritus* was recorded from five islands of Navachiste Bay, Sinaloa (Gulf of California, Mexico).

Methods: Samples were taken every two months from February to December 2018. Islands established a georeferenced GPS station: Guasayeye, La Huitussera, Tesobiate, El Metate and San Lucas, Sinaloa, Mexico. The snail *H. nigritus* was collected in the littoral zone of the islands during the low tide syzygy tides. The organisms were collected directly at random and the total length (TL), width (WI) and height (HI) (0.01 mm) and total fresh weight (W) and muscle foot weight (FW) (0.1 g sensitivity). In addition, the shape of the growth was estimated with the equation that describes the relationship between length and weight.

Result: The island of Guasayeye was a greater abundance (48%) and the least La Huitussera (4%). The mean total length (TL) was greater in San Lucas and La Huitussera (99.5±7.2 and 95.1±15.5 mm, respectively) and lower values were recorded in Tesobiate (73.8±11.4 mm). The maximum weight recorded was 347.2 g on El Metate island. A significance in length and weight were obtained between the islands. In addition, in *H. nigritus* high correlations were obtained relationships, indicating positive allometric growth. For their sizes and abundance, the snail *H. nigritus* is a potentially interesting fishing resource for the fishers of northwestern Mexico.

Key words: Black snail, Gulf of California, Island, Sizes.

INTRODUCTION

At present, there is no regulation on the capture sizes of the black snail *Hexaplex* (*Muricanthus*) *nigritus* (Philippi, 1845) in the Mexican Pacific that allows establishing protection criteria on this resource and in particular for the islands of the Navachiste Bay, southeastern Gulf of California. Even this snail, because of its size, easy access and capture, allows fishers in the region to frequently catch them in the intertidal part of the islands of Navachiste Bay without any control. The black snail *H. nigritus*, together with *H. princeps* of the family Muricidae, are commonly caught by fishers in the main bays of northwestern Mexico. Both species are morphologically similar by fishers. A fisher by snorkeling can capture approximately 700 organisms in 4 h of work (Escamilla-Montes *et al.*, 2018).

The size of the black snail *H. nigritus* in some bays of northwestern Mexico represents a species of commercial interest for the fishers of the region. Black snails are usually used for consumption or to market in local or national markets (Arzola-González *et al.*, 2013; Escamilla-Montes *et al.*, 2018). Also, the shells of these gastropods are used in the locality to manufacture various crafts (Ortiz-Arellano and Flores-Campaña, 2009).

The number of investigations on the species of *H. nigritus* in the Mexican Pacific is limited: except for the works by Cudney-Bueno and Rowell (2008), who estimated the growth, longevity and sizes of this snail related to the effects of its fishery. This species is mentioned in some faunal studies on gastropods collected in some islands of the Espiritu Santo Archipelago (González-Medina *et al.*, 2006) and islands of the Navachiste Bay (Ortiz-Arellano and Flores-Campaña, 2009), coastal zone of the Gulf of California (Hendrickx *et al.*, 2005; Moreno-Báez *et al.*, 2012; Escamilla-Montes *et al.*, 2018) and Mexican Pacific (Ríos-Jara, 2015). While in laboratory conditions, Góngora-Gómez *et al.* (2011) analyzed the reproductive aspects of this snail collected in Navachiste Bay.

This study was carried out to obtain information about the sizes structure and biometric relationships of *H. nigritus* in the intertidal zone of five islands in Navachiste Bay, Sinaloa (Gulf of California, Mexico).

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MATERIALS AND METHODS

In total, 228 organisms were analyzed. Samples were taken every two months from February to December 2018. The island established a georeferenced GPS station: Guasayeye, La Huitussera, Tesobiate, El Metate and San Lucas in Navachiste Bay, Sinaloa, Mexico (Fig 1). The gradient of the intertidal slope is not very pronounced and they are very similar between the five islands. The substrate of the Guasayeye, La Huitussera and El Metate islands are characterized by clay-muddy-muddy soils with isolated rocky outcrops. In the Guasayeye and San Lucas islands, clayey substrates with macroalgae and isolated rocks prevail (Gutiérrez-Rubio *et al.*, 2020).

The snail *H. nigritus* was collected in the littoral zone of the islands of Navachiste Bay. The samplings were carried out during the low tide, syzygy tides, in a 2×25 m transect, parallel to the coastline and with the lower limit at low tide of each station, the organisms were collected directly at random and the total length (TL), width (WI) and height (HI) were recorded with a digital vernier (0.01 mm) and its total fresh weight (W) and muscle foot weight (FW) with a digital balance (0.1 g sensitivity) in the Lab of Faculty of Marine Sciences, Autonomous University of Sinaloa. In addition, the shape of the growth was estimated with the equation that describes the relationship between length and weight (Ricker, 1975). The normality and homoscedasticity of the morphometric data were verified with the Kolmogorov and Bartlett tests, respectively.

The average TL and W of *H. nigritus* between the islands were compared by ANOVA tests of a parametric or non-parametric test, depending on the normality and homoscedasticity tests. The statistical differences were identified with the Kruskal-Wallis test, later tests of Dunn´s multiple comparisons were made, all tests were performed with α=0.05 (Zar, 2009) and the statistical package, StatSoft V 7.0 (StatSoft, 2004) was used.

RESULTS AND DISCUSSION

A total of 228 organisms were collected. The maximum catch was Guasayeye island (110 individuals) and the minimum was La Huitussera with six snails. The means of TL and W between the islands were significant (p. Kruskal-Wallis, $p<0.05$). Larger and smaller organisms in TL (125.1 and 26.3 mm) and W (347.2 and 2.2 g) coincided on El Metate island (Table 1). The modal distribution in TL was presented in a range of 25 to 230 mm and W from 2 to 342 g, although the highest frequencies were located in TL of 65 to 110 mm and W between 12 and 52 g (Fig 2).

The *H. nigritus* collections are probably related to the type of substrate since black snails are associated with clay, humid and shaded microhabitats and, mainly, on rocky soils. The intertidal features of Guasayeye Island vary in types of substrates which are characterized by rocky soils like Tesobiate, but in smaller proportion; in contrast, the lowest number of snails collected were in the San Lucas and La Huitussera Islands, where they abound mostly algae and clayey soils with few rocky promontories. In addition, the collection of snails on Guasayeye Island was often lightly buried in small clayey areas between large rocks. The islands where the lowest snail percentages were collected (San Lucas and La Huitussera) were characterized by a littoral zone with small rocky inlets and minimal mangrove areas. The above coincided with Hendrickx *et al.* (2005), who indicated that *H. nigritus* is representative of diverse coastal ecosystems such as bays, islands, estuaries and rocky beaches of the Gulf of California, particularly between rocky cavities and slightly buried in clay soils on the coastline.

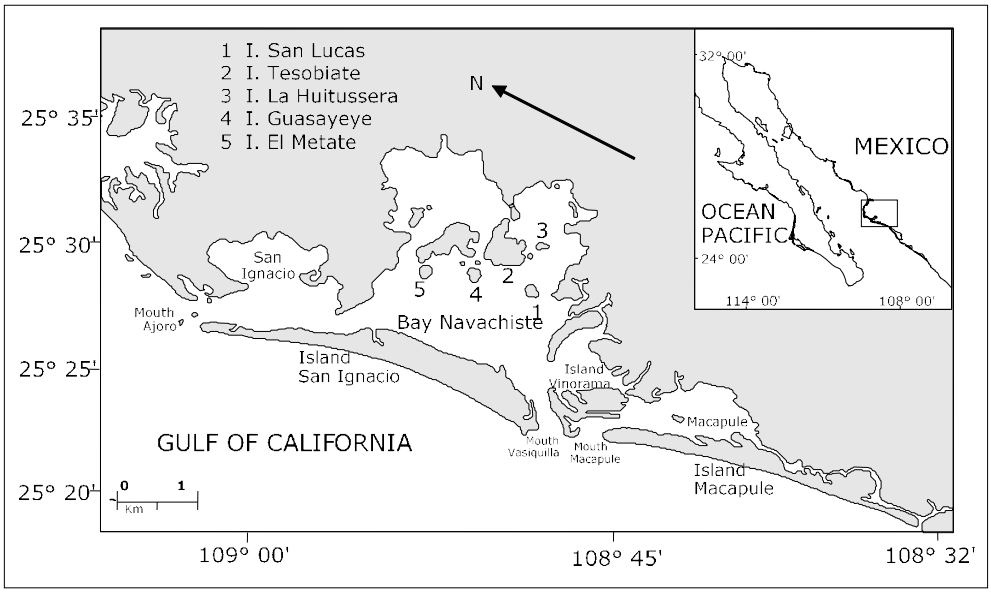

Fig 1: Bay Navachiste and location of the five islands. 1. San Lucas, 2. Tesobiate, 3. La Huitussera, 4. Gusayeye, 5. El Matate.

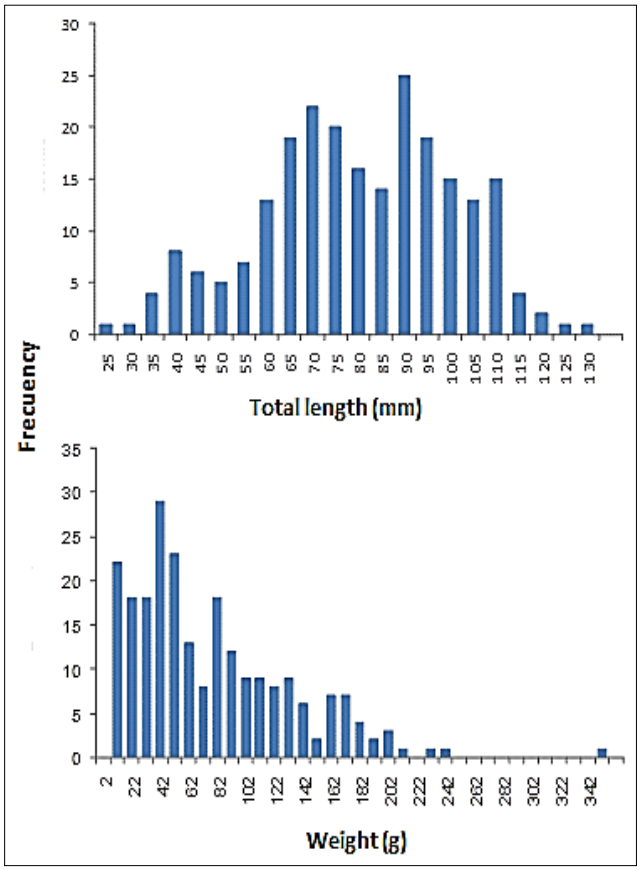

Fig 2: Modal distribution of total length (mm) and total weight (g) of *Hexaplex* (*Muricanthus*) *nigritus* in the intertidal zone islands of the southeastern Gulf of California, Mexico.

Likewise, Ortiz-Arellano and Flores-Campaña (2009) pointed out the presence of *H. nigritus* distributed on the subtidal strip between rocky-sand substrates of Navachiste Bay. The reported habitats of *H. nigritus* were reefs or sandy bottoms in the intertidal zone and subcoastal shallow waters of the Gulf of California (Hendrickx, 2005) and in the Ohuira lagoon, Sinaloa (Escamilla-Montes *et al.*, 2018). Elías-Castro (2012) determined that this species is part of the biodiversity of gastropods mollusks of the Sinaloa Islands. In addition, Brusca (1980) and Escamilla-Montes *et al.* (2018) pointed out that the presence of the black snail in these mentioned ecosystems is because it feeds on some bivalves or other snails in the coastal area of the Gulf of California.

The TL of *H. nigritus* collected in Navachiste Bay were located slightly below Brusca (1980), who indicated a length of 150 mm but for organisms collected on the coasts of the Gulf of California. Although, Ortiz-Arellano and Flores-Campaña (2009) estimated a range of TL sizes from 49 to 100 mm, HI from 36 to 86 mm and WI from 30 to 75 mm, located below the present study. The maximum size reported was 150 mm of length (Brusca, 1980), although the most common size is 120 mm (Escamilla-Montes *et al.*, 2018), coinciding with these last authors with this study (maximum TL=125.1 mm).

The above means that the population of *H. nigritus* in this area, when they are juveniles, first increases their length but not their body weight. Still, when these snails are considered adults, their weight increases rapidly, while their increase is reduced in length. Cudney-Bueno and Rowell (2008) pointed out that organisms of this species, as they increase their age decrease their growth rate so that smaller snails grow more rapidly than adults.

The modal distribution allows more excellent visualization of the size structure of the organisms. It has been applied in other similar mollusks species for fisheries biological studies where they have considered their analysis according to mode, as in *Plicopurpura pansa* (Ramírez-

Table 1: Number, maximum, minimum, mean and standard deviation (SD) of *Hexaplex* (*Muricanthus*) *nigritus* in the intertidal zone in five islands of the southeastern Gulf of California, Mexico.

Island	Number (n)	Maximum	Minimum	Average	±SD
		TL (mm)			
Guasayeye	110	117.4	30.7	76.8^{b}	21.0
El Metate	69	125.1	26.3	75.0^{b}	22.4
San Lucas	12	110.6	89.0	99.1^{a}	7.2
La Huitussera	6	108.5	58.3	95.1^{a}	15.5
Tesobiate	31	104.3	56.1	73.8^{b}	11.4
		WI (mm)			
Guasayeye		84.2	20.0	53.4	15.9
El Metate		99.5	13.8	54.4	19.3
San Lucas		90.2	53.4	66.7	9.1
La Huitussera		77.4	41.0	67.1	11.6
Tesobiate		70.1	34.7	51.9	8.6
		HI (mm)			
Guasayeye		79.8	16.2	41.3	13.0
El Metate		86.2	13.7	41.7	13.8
San Lucas		59.4	45.7	52.5	4.6
La Huitussera		61.7	34.4	52.7	5.4
Tesobiate		65.4	30.5	42.4	8.8
		W (g)			
Guasayeye		229.6	3.2	67.9^{b}	52.5
El Metate		347.2	2.2	71.1^{b}	62.9
San Lucas		158.1	86.6	128.5^{a}	24.6
La Huitussera		209.3	22.3	135.3^{a}	58.4
Tesobiate		138.1	20.6	51.9^{c}	26.7
		FW (g)			
Guasayeye		59.3	0.2	18.3^{b}	14.1
El Metate		69.4	0.2	16.8^{b}	14.8
San Lucas		46.0	16.4	31.0^{a}	8.0
La Huitussera		41.9	3.7	27.6^{a}	10.7
Tesobiate		47.6	6.6	16.4^{b}	9.2

TL= Total length; WI= Width, HI= Height (mm) and W= Fresh weight and FW= Muscle foot weight (g). Equal or common letters indicate a lack of significant difference between mean values.

Table 2: Biometric relationships between lengths and weight of *Hexaplex* (*Muricanthus*) *nigritus* in the intertidal zone in five islands of the southeastern Gulf of California, Mexico.

Variable	Equation	Coefficient of determination (r^2)
W-TL	$W=0.00005TL^{3.198}$	0.9759
WI-TL	WI=0.7516TL-3.6791	0.9128
W-WI	$W=0.0012WI^{2.6962}$	0.9331
HI-WI	HI=0.7218WI+3.109	0.8598
W-WI	$W=0.0013HI^{2.8462}$	0.9218
HI-TL	HI=0.5739TL-1.9918	0.8785
FW-TL	$FW=0.000003TL^{3.4994}$	0.9444

TL= Total length; WI= Width and HI= Height, in mm and W= Fresh weight and FW= Muscle foot weight in g.

Rodríguez and Naegel, 2003), *Osilinus strata* and *O. sanciatus* (Ramírez *et al.*, 2005), although for population analysis the mean is commonly used as a descriptive measure than mode. However, in the present study, both the mean and mode in length and weight were very approximate.

The value of the exponent (b) of the equations obtained from biometric correlation (coefficient of determination above r^2=0.891) that describes the length-weight relationship was not significantly ($p<0.05$) lower than the theoretical value of three, indicating in all cases an isometric growth, in addition, the r^2 values determine a high dependence between the morphometric variables of the black snail *H. nigritus* (Table 2).

The values of the slopes (b) in the biometric correlation between the length resulted in around three, being not significantly ($p<0.05$) less than the theoretical value of three, indicating in all cases an isometric type growth, coinciding with Cuyney-Bueno and Rowel (2008) who determined that *H. nigritus* presents an isometric growth in the same relation. In contrast, in other mollusks, García *et al.* (2005) reported allometry between length, width and height concerning the dry weight of the soft tissues of *Perna viridis*. Likewise, Filgueira *et al.* (2008) determined in *Mytilus galloprovincialis* a significant growth in an allometric shape between length and weight.

The resulting values of the coefficient of determination (r^2) in the lengths-weight ratio indicated a high dependence between the lengths and weight of the black snail *H. nigritus*. In addition, the value of the correlation coefficient suggests that between 87 and 99% of the variability is explained by the model, that is, by the distribution of the slope, while a small percentage between 1 y 13% corresponds to the variability that does not explain the model and probably related to conditions of randomness among the organisms of *H. nigritus* in the Navachiste Bay.

The sizes here registered and according to the indications of Moreno-Báez *et al.* (2012), the population of the black snail in the Gulf of California can be considered a small-scale fishery because its extraction is mainly by autonomous diving or directly (hand collecting) on the coastline of some bays. In addition, for its easy access of capture and sizes of the black snail, especially when other species of commercial interest decrease their catches or are closed.

CONCLUSION

The black snail *H. nigritus* could be considered a highly viable resource for fishers in the northwestern area of Mexico. Although at present, more studies are needed focusing on the population analysis of *H. nigritus* that allows, at a certain moment, the institutions in charge of their fishing regulation to establish criteria of protection against the illegal capture that is made on this resource in the islands of southeastern Gulf of California, Mexico.

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Conflict of interest: None.

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