

Body size structure, biometric relationships and density of *Chiton albolineatus* (Mollusca: Polyplacophora) on the intertidal rocky zone of three islands of Mazatlan Bay, SE of the Gulf of California

Distribución de tamaños corporales, relaciones biométricas y densidad de *Chiton albolineatus* (Mollusca: Polyplacophora) en el litoral rocoso de tres islas de la Bahía de Mazatlán, SE del Golfo de California

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Resumen.- Las poblaciones del molusco poliplacóforo *Chiton albolineatus* fueron estudiadas en 6 sitios con diferente acción del oleaje en el litoral rocoso de 3 islas de la bahía de Mazatlán, en el sureste del golfo de California. Esta especie de quitón es endémico de las costas mexicanas del Pacífico. Para determinar sus patrones demográficos basados en su densidad y tamaño corporal se realizaron muestreos en sitios expuestos y protegidos al oleaje de la zona intermareal de estas islas de enero a diciembre de 2008. La longitud (L), ancho (B) y altura (H) del cuerpo de los quitones osciló entre 8,3 y 55,1 ($\bar{X} = 28,9 \pm 6,2$), 3,0-30,4 ($\bar{X} = 14,8 \pm 3,4$) y 0,9-19,1 ($\bar{X} = 5,0 \pm 1,8$) mm, respectivamente, y su peso húmedo (W) varió de 0,1 a 10,2 g ($\bar{X} = 1,7 \pm 0,9$). Las relaciones biométricas fueron $B = 0,478 (L) + 1,212$, $H = 0,198 (L) - 1,170$ y $H = 0,389 (B) - 1,277$, para los tamaños corporales y $W = 0,0002 (L)^{2,710}$, $W = 0,0008 (B)^{2,743}$ y $W = 0,0792(H)^{1,908}$ para el peso. Los valores de la pendiente de la relación longitud-peso significativamente menores de 3 indican que esta especie tiene un crecimiento alométrico negativo. Su densidad media, entre 0,1 a 2,9 org. m⁻², fue mayor en el lado expuesto al oleaje de cada isla posiblemente por una menor presión de depredación que en el lado protegido, mientras que su tamaño corporal fue mayor en el lado expuesto de 2 islas. Esto podría ser interpretado como resultado de la migración desde los sitios protegidos de la acción del oleaje, donde los individuos más pequeños tienen más probabilidades de supervivencia que en las áreas expuestas.

Palabras clave: Dimensiones corporales, quitones, exposición al oleaje, islas del Pacífico Mexicano

Abstract.- Populations of the polyplacophoran mollusk *Chiton albolineatus* were studied at 6 sites with different wave exposure of the rocky shores of 3 islands of Mazatlan Bay (southeastern side of the Gulf of California). This chiton species is endemic to the Mexican Pacific coast. Chitons were sampled on wave-exposed and wave-protected sites in the intertidal zone of these islands from January to December 2008 to determine its demographic patterns based on density and body size. Length (L), breadth (B) and height (H) of chiton body ranged between 8.3 and 55.1 ($\bar{X} = 28.9 \pm 6.2$), 3.0-30.4 ($\bar{X} = 14.8 \pm 3.4$) and 0.9-19.1 ($\bar{X} = 5.0 \pm 1.8$) mm, respectively, and their wet weight (W) varied from 0.1 to 10.2 g ($\bar{X} = 1.7 \pm 0.9$). The biometric relationships were $B = 0.478 (L) + 1.212$, $H = 0.198 (L) - 1.170$ and $H = 0.389 (B) - 1.277$, for size and $W = 0.0002 (L)^{2.710}$, $W = 0.0008 (B)^{2.743}$ and $W = 0.0792 (H)^{1.908}$ for weight. The value of the slope of the length-weight relationship was significantly lower than 3, which indicates negative allometric growth. Average densities ranged from 0.1 to 2.9 org. m⁻² and were higher in the exposed sites than in the protected sites of each island, possibly because of a lower predation pressure in areas exposed to high wave energy than in sheltered areas, while its body size were larger in the exposed sites of two islands. This could be interpreted as a result of migration from sites protected from the wave action, where survival of smaller individuals is more likely than in exposed areas.

Key words: Body size, chitons, wave exposure, Mexican Pacific islands

INTRODUCTION

Chitons can be abundant mollusks in the intertidal and upper sublittoral zone of rocky shores and coral reefs (Hyman 1967, Slieker 2000, Kaas *et al.* 2006, Eernisse *et al.* 2007), but little is known about their spatial distribution, abundance and population size-structure. Additionally, information on factors such as topography, tidal height and wave exposure, that may affect their ecology and limit their distributions, is only available for a few species (Andrus & Legard 1975, Otaíza & Santelices 1985, Smith & Otway 1997, Harper & Williams 2001, Kelaher & Cole 2005, Jörger *et al.* 2008).

Historically, studies of the chiton assemblages of the Mexican Pacific coast have been focused on their taxonomy, distribution and species diversity (Keen 1971, Ferreira 1983, Reyes-Gómez & Salcedo-Vargas 2002, Reyes-Gómez 2004, García-Ríos & Álvarez-Ruíz 2007, Reyes-Gómez *et al.* 2010) but, with the exception of some studies concerning the populations of *Chiton articulatus* (Sowerby, 1832) in the Acapulco area, Socorro Island in the Revillagigedo Archipelago, and Pajaros and Venados Islands in the Bay of Mazatlan (Rojas-Herrera 1998, Holguin-Quiñones & Michel-Morfin 2002, Flores-Campaña *et al.* 2007a), the autoecology of most chitons of this region is poorly known.

The species *Chiton albolineatus* Broderip y Sowerby, 1829 is endemic to the Mexican East Pacific. It is common in the intertidal to shallow subtidal of islands of the southeastern part of the Gulf of California (Flores-Campaña *et al.* 2007b), and it is distributed in a restricted area along the western coast of Mexico, from Mazatlan southwards, down to Acapulco (Keen 1971, Kass *et al.* 2006). As far as we are aware, no information has been published on the general ecology and population structure of this species. This paper aims to determine demographic patterns based on density and body sizes of *C. albolineatus* of sheltered and exposed intertidal rocky shores of 3 islands located in the southeastern Gulf of California.

MATERIALS AND METHODS

STUDY SITE

The study was conducted in 3 islands (Pajaros, Venados and Lobos) located in the southeastern part of the Gulf of California, between $23^{\circ}13'20''$, $23^{\circ}15'17''$ N and $106^{\circ}27'59''$, $106^{\circ}28'41''$ W. The islands are rocky formations of volcanic origin with thin layers of soil and semi-weathered rocky terrain, facing the city of Mazatlan (Fig. 1).

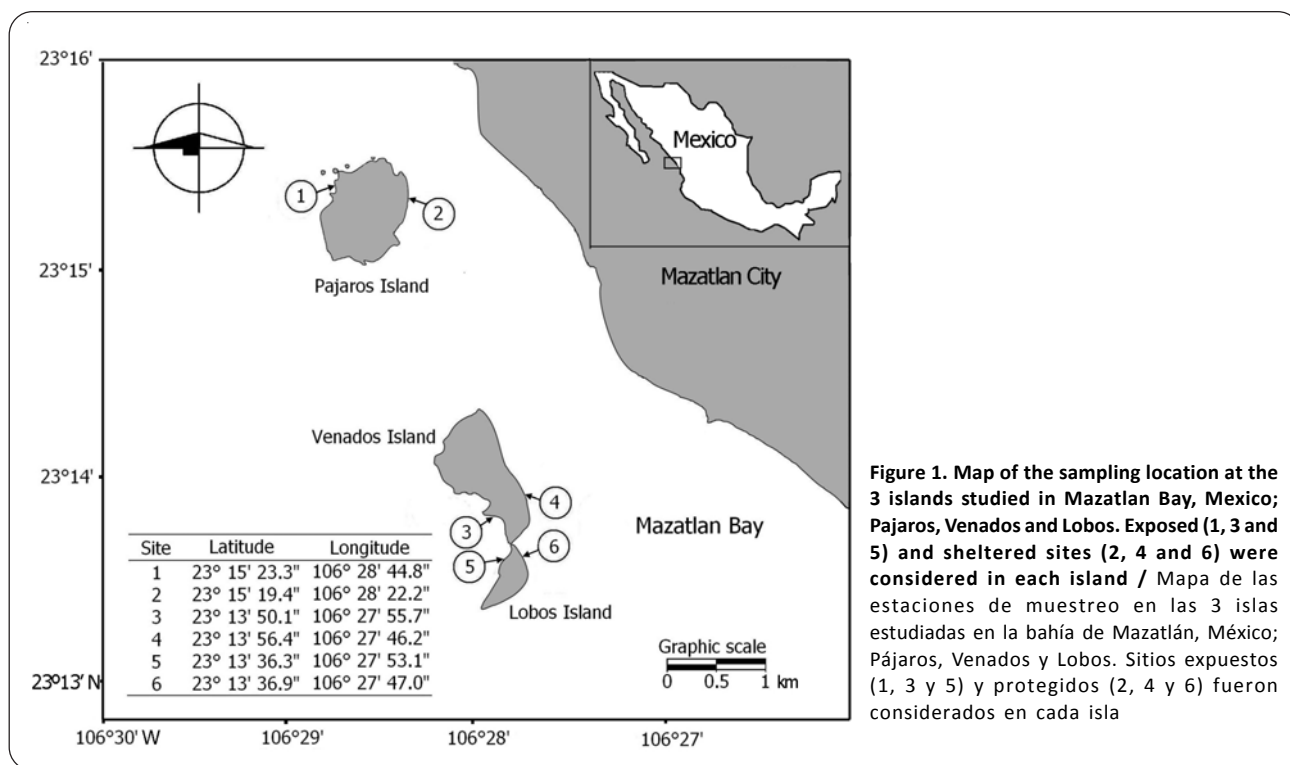


Figure 1. Map of the sampling location at the 3 islands studied in Mazatlan Bay, Mexico; Pajaros, Venados and Lobos. Exposed (1, 3 and 5) and sheltered sites (2, 4 and 6) were considered in each island / Mapa de las estaciones de muestreo en las 3 islas estudiadas en la bahía de Mazatlán, México; Pájaros, Venados y Lobos. Sitios expuestos (1, 3 y 5) y protegidos (2, 4 y 6) fueron considerados en cada isla

The intertidal area of these islands is narrow (5-15 m, depending on sites) and presents a variety of microenvironments as cliffs, flattened platform, intertidal pools, boulder fields and stones and cracks and crevices in rocks where *Chiton albolineatus* was collected. The exposed side features strong surf and abrupt topography, while the sheltered side has low wave energy and gently sloping small beaches, particularly on Pajaros and Venados islands.

SPECIES

Chiton albolineatus is easy to recognize because of its coloration pattern: dark and light olive green colour on central areas, with two longitudinal white lines on mucronal area; lateral areas with numerous white transverse zigzag lines and gray girdle (Reyes-Gómez *et al.* 2010). It has been recorded from Venados Island and other sites along the Mazatlan coastline, as well as in Isla Tres Marias, Manzanillo, Bahía Santiago and Acapulco (Reyes-Gomez 2004) and Huatulco Bays where it was found on living coral at a depth of 2 m, associated with *Stenoplax limaciformis* (Sowerby, 1832) (Reyes-Gómez *et al.* 2010).

Chiton albolineatus inhabits lower to medium rocky intertidal zones of Pajaros, Venados and Lobos Islands. During low tide it is commonly found under boulders, rocks and stones on both sides of Lobos and in the exposed side of Venados, as well as in depressions occupied by the sea urchin *Echinometra vanbrunti*, in the intertidal belt of the protected side of Venados (underneath the sea urchin, possibly for protection). Sometimes found also in cracks and crevices of rocky intertidal zones of these islands. On temperate and tropical shores, chitons usually remain hidden under a rock or wedged into a depression by day, and forage by night when visual predators are not a threat (Eernisse 2007).

Rich populations of *Chiton albolineatus* can be found on rocky shores associated with other chitons, such as *Stenoplax limaciformis*, *Radsia muscaria* (Gould, 1846), *Tonicia forbesii* Carpenter, 1857 and *Chiton articulatus* in Pajaros, Venados and Lobos Islands (Flores-Campaña *et al.* 2007b). Other species of this assemblage on the intertidal rocky zone of Pajaros, Venados and Lobos Islands are predators, such as the gastropods *Plicopurpura pansa* (Gould, 1853), *Thais speciosa* (Valenciennes, 1832), *T. triangularis* (Blainville, 1832) and *T. biserialis* (Blainville, 1832). Other mollusks, conspicuous because of their abundance, are *Littorina*

aspera Philippi, 1846, *Nerita funiculata* Menke, 1851, *N. scabricosta* Lamarck, 1822, *Collisella acutapex* (Berry, 1960) and *Mytella guyanensis* (Lamarck, 1819) (González-Medina *et al.* 1999). Common crustaceans in this area are *Calcinus californiensis* Bouvier, 1898, *Grapsus grapsus* (Linnaeus, 1758), *Pachygrapsus transversus* (Gibbes, 1850) and *Coenobita compressus* H. Milne-Edwards, 1837 (González-Medina *et al.* 1999, Peñuelas-Román 2002).

Due to its large size and because it is easily accessible, *Chiton articulatus*, known as 'marine cockroach' or 'dog's tongue' is the only chiton exploited for human consumption along the Pacific coast of Mexico (Reyes-Gómez & Salcedo-Vargas 2002). In Mazatlan, where it reaches body lengths of up to 86 mm and population densities of 7.9 animals m⁻², it is caught in various sites of the intertidal rocky shores, including Pajaros, Venados and Lobos Islands (Flores-Campaña *et al.* 2007a, Jiménez-Díaz 2009). In contrast, although it may reach a relatively large size, *C. albolineatus* is not exploited due to its rather small foot (Reyes-Gómez *et al.* 2010).

SAMPLING

From January to December 2008, the population density of *Chiton albolineatus* were estimated visually during the lowest low tides of each month, on both the exposed (stations 1, 3 and 5) and sheltered (stations 2, 4, and 6) sites of each of island. Living specimens detected within a transect of 50 m² (Holguín-Quiñones & Michel-Morfin 2002), marked by two 25-m strings enclosing a 2-m sampling swath in the intertidal zone at 2-3 m of the water line and parallel to the coastline, were counted by 2 teams of 3-4 people each. This was carried out during the nearly 2 h of the low tide period, within a time span of 30-35 min at each sampling station.

The density (org. m⁻²) of *Chiton albolineatus* in each transect was determined in February, March, October, November and December, since the lowest low tides were at night in the other months. Since we observed that the distribution of chitons is patchy, the number of patches (aggregation of chitons) and of the specimens in the largest patch were recorded.

Each month, a sample of 10-20% of the chitons observed in each transect was obtained at random for size measurements (Holguín-Quiñones & Michel-Morfin 2002). The actual number collected in each case was decided by the ledger-keeping team member, halfway through the sampling of each transect. As to patches, each sample was proportional to the size of each patch.

The total number obtained through the sampling period was 1371. All chitons observed, as well as those collected, were found inactive, under rocks and stones.

Their body length (L), breadth (B) and height (H) were measured with a digital caliper (± 0.1 mm), and the individual wet weight (W), including shell, was obtained with a digital balance (± 0.1 g). Length was determined as the major distance between the front and the posterior parts of the extended body, breadth was measured from side to side of the belt between the fourth and fifth plate, and height was from the bottom of the foot to the dorsal region of the fourth and fifth plate. Measurements in chitons are not as for other mollusks, because they include shell dimensions as well as muscle girdle (Baxter 1982, Baxter & Jones 1986).

DATA ANALYSIS

Body length was used for size-frequency histograms, using size intervals of 2 mm (Flores-Campaña *et al.* 2007a). Body length, breadth, height and weight were used to calculate their respective relationships. The relationships between size parameters were adjusted to the linear model $L = a + bH$, and the potential model $W = a(L)^b$ was used for size and weight (Ricker 1975). The constant (b) of the relation size-weight was compared to the theoretical value (3) for isometric growth with a Student's t test.

The variances of the 4 size measurements were homogeneous, but the data distribution was not normal (Bartlett's and Lilliefors' tests, respectively). Therefore, the median values of length, breadth, height and wet

weight determined for each station were compared using Kruskal-Wallis and Dunn's multiple comparison tests. The data of population density of each sampling station were normal and homoscedastic, and were compared using one ANOVA for repeated observations test. The level of significance was $\alpha = 0.05$ for all tests (Zar 1999).

RESULTS

SIZE STRUCTURE

The mean length was 28.9 ± 6.2 mm, from a minimum of 8.3 to a maximum of 55.1 mm. Breadth ranged from 3.0 to 30.4 mm, with a mean value of 14.8 ± 3.4 mm. Mean height was 5.0 ± 1.8 mm (minimum and maximum: 0.9 and 19.1 mm, respectively). Wet weights varied between 0.1 and 10.2 g, and the mean value was 1.7 ± 0.9 g (Table 1).

The higher length values (13.3 to 54.9 mm; $\bar{X} = 38.4 \pm 8.8$ mm) were recorded in the exposed site of Pajaros. The sheltered site of Pajaros and Lobos and the exposed site of Venados had intermediate sizes: 12.3 to 41.0 mm ($\bar{X} = 28.4 \pm 6.3$); 8.3 to 55.1 mm ($\bar{X} = 31.3 \pm 6.2$) and 14.0 to 40.2 mm ($\bar{X} = 28.8 \pm 4.4$), respectively. Smaller sizes were recorded in sheltered site of Venados (9.9 to 44.4, $\bar{X} = 24.2 \pm 5.4$ mm) and exposed site of Lobos (8.3 to 55.1, $\bar{X} = 22.6 \pm 6.0$ mm) (Fig. 2). There were significant differences in length, breadth, height and wet weight distributions between most sampling stations (Kruskal-Wallis and Dunn's tests, H statistic ranging from 365.91 to 462.68, $P < 0.001$ for all variables tested).

Table 1. Minimum (Min), maximum (Max), mean and standard deviation (s.d.) values of length, breadth, height and weight of *Chiton albolineatus* recorded at Pajaros, Venados and Lobos Islands of Mazatlan Bay (Mexico), in 2 sites each: ES, exposed site; and SS, sheltered site / Valores mínimos (Min), máximos (Max), promedio y desviación estándar (s.d.) de la longitud, ancho, altura y peso del *Chiton albolineatus* registrados en las islas Pájaros, Venados y Lobos de la bahía de Mazatlán (México), en 2 sitios de cada isla: ES, sitio expuesto, y SS, sitio protegido

Islands	Sites	n	Length (mm)				Breadth (mm)				Height (mm)				Weight (g)			
			Min	Max	Mean	s.d.	Min	Max	Mean	s.d.	Min	Max	Mean	s.d.	Min	Max	Mean	s.d.
Pajaros	ES	188	13.3	54.9	38.4a	8.8	7.8	30.4	19.8a	4.2	2.1	13.8	6.9a	2.2	0.2	10.2	3.7a	2.0
	SS	92	12.3	41.0	28.4bc	6.3	4.0	21.0	14.2b	3.7	1.2	7.9	4.9b	1.6	0.1	4.1	1.6b	0.8
Venados	ES	345	14.0	40.2	28.8c	4.4	4.0	22.0	14.7b	3.9	2.2	19.1	5.6b	2.6	0.1	3.5	1.6b	0.6
	SS	222	9.9	44.4	24.2d	5.4	4.6	26.8	12.5c	2.7	1.1	7.4	4.0c	1.2	0.1	2.0	0.9c	0.5
Lobos	ES	233	8.3	55.1	22.6d	6.0	3.0	19.2	11.6d	2.9	0.9	13.2	3.6c	1.5	0.1	2.4	0.8c	0.5
	SS	291	13.2	47.3	31.3b	6.2	3.9	24.5	16.1b	3.2	1.7	16.8	5.2b	1.5	0.1	5.3	1.8b	1.0
Kruskal-Wallis test			H = 459.46 $P < 0.001$				H = 403.67 $P < 0.001$				H = 365.91 $P < 0.001$				H = 462.68 $P < 0.001$			

*Different letters in mean values indicate significant differences in length, breadth, height and weight, among sites (Dunn's multiple comparison test)

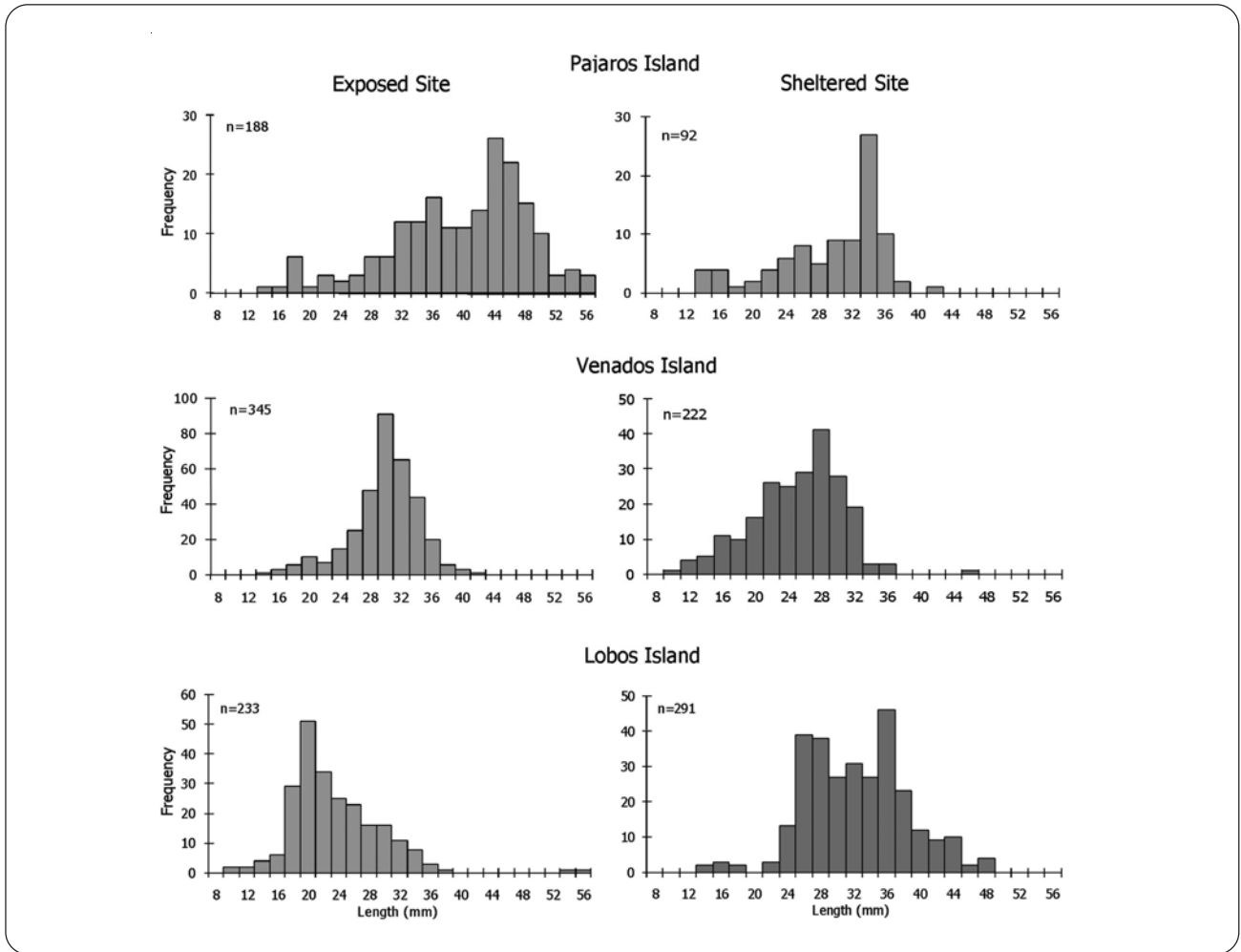


Figure 2. Body length frequency histograms of *Chiton albolineatus* at 6 sites sampled on Pajaros, Venados and Lobos Islands of Mazatlan Bay, Mexico / Histogramas de frecuencia de la longitud corporal de *Chiton albolineatus* en los 6 sitios muestreados en las islas Pájaros, Venados y Lobos de la bahía de Mazatlán, México

BIOMETRIC RELATIONSHIPS

All the biometric relationships among sizes and between size and weight obtained gave a determination coefficient (R^2) ranging from 0.816 to 0.887. The values of the slope of size vs. weight relationships were 1.9 in the case of height and 2.7 when length and breadth were used (Table 2). In all cases the value of the slope was significantly lower than the theoretical value for isometric growth ($t = 8.72$ for length-weight, $t = 7.98$ for breadth-weight and $t = 47.43$ for height-weight; $P < 0.001$).

RELATIVE DENSITY

The highest and lowest densities (9.18 and 0.1 org. m^{-2}) corresponded to the exposed site of Venados Island and the sheltered site of Pajaros, respectively. The average

Table 2. Equations of biometric relationships of *Chiton albolineatus*, and variance explained in each case (R^2), studied in 3 islands presents in Mazatlan Bay, Mexico; Pajaros, Venados and Lobos. Total number of specimens = 1371 / Ecuaciones de las relaciones biométricas de *Chiton albolineatus*, y varianza explicada en cada caso (R^2), estudiada en 3 islas presentes en la bahía de Mazatlán, México; Pájaros, Venados y Lobos. Número total de especímenes = 1371

Relationship	Equation	R^2
Length-Height	$H = 0.1985L - 1.1701$	0.8257
Length-Breadth	$B = 0.4777L + 1.2121$	0.8870
Height-Breadth	$H = 0.3891B - 1.2775$	0.8163
Length-Weight	$W = 0.0002L^{2.7097}$	0.8776
Breadth-Weight	$W = 0.0008B^{2.7428}$	0.8700
Height-Weight	$W = 0.0792H^{1.9085}$	0.8334

densities ranged from 0.16 to 2.87 org. m⁻², with a combined average value for the six sampling sites of 0.96 org. m⁻² (Table 3).

Maximum density of 106 org. m⁻² was observed in small sections along the transect on the exposed site of Venados. Additionally, the number of individual aggregations (patches) was higher in the exposed than in the sheltered side of each island, and varied from 3 in the protected site of Pajaros to 30 in the exposed site of Venados. With the exception of the sheltered site of Pajaros and the exposed site of Venados, the number of specimens in individual aggregations ranged from 10 to 26 and there were significant differences among most mean densities values of each island except Pajaros (repeated measurements ANOVA, using a significant level of 0.05).

DISCUSSION

This is the first study to provide information on *Chiton albolineatus* size distribution. There are only sporadic records of its body length (Keen 1971, Kass *et al.* 2006, Reyes-Gómez *et al.* 2010). The size range (8.3 to 55.1 mm in length) obtained in these islands is wider than the range known for this species, since Keen (1971) mentions that common lengths for adults of this species range from 25 to 40 mm. Kass *et al.* (2006) and Reyes-Gómez *et al.* (2010) suggest that these values correspond to medium sized specimens. The largest specimen on record appears to be one reported by Kass *et al.* (2006), with 43 mm L.

There was no previous information on the biometric relations for *Chiton albolineatus*, although similar equations were given for the length-weight relationship of *C. articulatus* in the Acapulco area and Socorro Island (Rojas-Herrera 1998, Holguin-Quiñones & Michel-Morfin 2002) and between sizes (length, breadth and height) and sizes-weight on Pajaros and Venados Islands of Mazatlan Bay (Flores-Campaña *et al.* 2007a).

The values of the slope of the size-weight relationships were significantly lower than the theoretical value of 3 for isometric growth. This indicates a negative allometric growth, and the most likely explanation for the remarkably low value in the case of height-weight is the habitat of *Chiton albolineatus*, which is commonly located under rocks and stones during low tide and has therefore limited space available for vertical growth. This coincides with its description, as a moderately elevated to somewhat flattened species (Kass *et al.* 2006, Reyes-Gómez *et al.* 2010).

Allometry has been sparsely documented in polyplacophorans, and the scarce information available, such as that for *Lepidochitona cinereus* (Linnaeus, 1767) (Baxter 1982) and *Tonicella marmorea* (Fabricius, 1780) (Baxter & Jones 1986) indicate that in the case of chitons any size study should consider the wide variability of the whole animal measurements in comparison to those of gastropods and bivalves: since they include both the shell dimensions and the muscular girdle, variability may

Table 3. Density of *Chiton albolineatus* at 6 sites on Pajaros, Venados and Lobos islands of Mazatlan Bay, Mexico. February, March, October, November and December 2008. Sampling area = 50 m². ES, exposed site; SS, sheltered site; Max/patch = highest number of organisms observed in an individual aggregation of chitons / Densidad de *Chiton albolineatus* en 6 sitios de las islas Pájaros, Venados y Lobos de la Bahía de Mazatlán, México. Febrero, marzo, octubre, noviembre y diciembre de 2008. Área de muestreo = 50 m². ES, sitio expuesto; SS, sitio protegido; Max/patch = máximo número de organismos observados en una agregación de quitones

Island	Site	n	Density (org. m ⁻²)				Number of patches	Max /patch
			Min	Max	Mean	s.d.		
Pajaros	ES	76	0.36	0.74	0.30d	0.31	5	14
	SS	32	0.08	0.42	0.16d	0.13	3	5
Venados	ES	718	0.44	9.18	2.87a	3.57	30	106
	SS	144	0.18	1.08	0.58c	0.35	10	10
Lobos	ES	285	1.12	2.98	1.14b	1.24	24	26
	SS	184	0.78	1.98	0.74c	0.66	15	15

*Different letters indicate significant differences between mean density values (ANOVA for repeated observations test, $\alpha=0.05$; a>b>c>d)

be related to differential growth rates of the different components, as well as to the flexibility of the girdle (Baxter & Jones 1986). Thus, the allometric characteristics of chitons could be the result of a combination of shell shape, differential growth rates and environmental influences that force these organisms to seek protection under stones.

Differences in size of mollusks inhabiting sheltered and exposed rocky shores have been documented in several works, mostly for gastropods, and they have been mostly explained by selective migration due to mean tidal height and wave exposure (Hobday 1995, Tanaka *et al.* 2002, Ríos-Jara *et al.* 2004) although in the case of *Chiton articulatus* of Pajaros and Venados Islands, Flores-Campaña *et al.* (2007a) mentioned that, in addition to these factors, differences in size could also be the result of external factors such as selective predation by tourists, or by fishermen, since this species is locally consumed.

The presence of smaller specimens of *Chiton albolineatus* in sheltered areas coincide with the observations on *Acanthopleura echinata* (Barnes, 1824) and *Chiton latus* Sowerby 1825 (central Chile), with the larger individuals occurring in exposed habitats and the smaller in sheltered areas (Otaiza & Santelices 1985), which might be interpreted as recruitment areas, where smaller individuals are more likely to survive, whereas in sites exposed to wave action the presence of large individuals might be result of migration from sheltered sites.

On the other hand, larval settlement and colonization of the juveniles of some species of gastropods at a lower level of the intertidal zone, where environmental variability is lower, may be considered more conducive to survival (Lysaght 1944, Saier 2000) than at the higher levels colonized by adults, where the greater exposure is more likely to cause environmental stress (Smith & Newell 1955, Hobday 1995).

The population density of *Chiton albolineatus* is lower than that recorded for other chitons. *Cyanoplax hartwegii* (Carpenter, 1855) reaches 5 org. m⁻² in California (Connor 1975) and *Ischnochiton dispar* (Sowerby, 1832) reaches 214 org. m⁻² on the Pacific coast of Costa Rica (Jörger *et al.* 2008) and in other locations along the Mexican Pacific coast, where *Chiton articulatus* may reach from 4.2 org. m⁻² at the Acapulco seaside (Rojas-Herrera 1988), up to the 5.3 org. m⁻² registered by Holguin-Quiñones *et al.* (2002) in Socorro Island, both lower than the 7.9 org. m⁻² of these islands (Jiménez-Díaz 2009).

The higher abundance of intertidal species in exposed rather than in protected areas of rocky shores may be explained by the effect of environmental (*e.g.*, coastal currents and waves exposure among others) or biological (*e.g.*, competition, predation) factors. Other environmental factors such as substrate chemistry, granulometry or sedimentation may also have an impact on distribution (Menge & Branch 2001). In this case, the greater density of *Chiton albolineatus* observed in the exposed side of each island is possibly related to wave frequency. This would cause an intermittent exposure of the rocky shore, decreasing the efficiency of predators and allowing a greater abundance of grazers (Connell 1975).

Chiton albolineatus is commonly distributed in patches along the rocky coastline of the 3 islands at low tide. In fact, the clustered distribution is relatively common in mollusks on rocky intertidal shores and it is a consistent pattern in some chiton species, irrespective of their average abundance (Grayson & Chapman 2004, Jörger *et al.* 2008). This agrees with the high number of patches and high numbers of specimens in the largest patch, possibly related to the topography of the intertidal rocky shore, since *C. albolineatus* seeks refuge under boulders and stones at low tide to prevent desiccation or predation, such as we observed on both zones of Lobos and the exposed site of Venados.

The average density and the body sizes of *Chiton albolineatus* related to wave exposure documented by this study are only indicative of what may be found in other intertidal chiton communities along the Mexican Pacific coast. Further studies at different sites and other chiton species are needed to indicate whether the patterns observed at these islands can be generalized to similar habitats elsewhere in the tropics. Also, more data are needed to reveal overall patterns of the influencing environmental factors on chiton shape and size, on their distribution and abundance allowing a better understanding of chiton ecology in intertidal rocky shores.

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