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Density, Sex Ratio, Size, Weight, and Recruitment of *Plicopurpura pansa* (Gastropoda: Muricidae) in Costa Chica, Guerrero, México

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ABSTRACT

Plicopurpura pansa is a cultural resource with economic importance since ink can be extracted from it to dye clothes. This snail inhabits the rocky intertidal zone of Mexican Pacific, is found attached to rocks in crevices and holes. The objective was to analyze the *P. pansa* population structure in Costa Chica of the State of Guerrero based in density, sex ratio, size and weight, besides to realize observations on mating and recruitment, for which quarterly sampling was made during an annual cycle in three beaches. The density was 4.83 snails/m^2. Sex ratio ranged from 0.76:1.00 to 1.00: 0.96 (F:M). Average size was 20.91 mm. The best represented sizes in females were from 10.5 to 28.5 mm and in males 13.5 to 28.5 mm. Averaged weight was 1.99 g, females showed a coefficient of variation in weight of 96.53%. Recruitment occurred for the entire year. In December 2006 and September 2007 a larger frequency of recruits was shown. Sex ratio showed a 1:1 tendency. Snail population was characterized by being small sized and in high densities. Weight variations in females were found related to their reproductive cycle.

Keywords: Gender; Recruitment; Intertidal; Ink

1. Introduction

Mexican Pacific Coast has large and very important rocky coast extensions; in the tropics, the rocky coast is a zone with high and very productive biological diversity [1,2], in this region many mollusks species are known to be of economic importance: and are being fished, such as the purple snail, *Plicopurpura pansa* (Gould, 1853), a marine gasteropod that belongs to family Muricidae [3].

Plicopurpura pansa has the role of top predator in the trophic net and is very active. According to Skoglund [3], purple snail has a distribution that goes from Bahia Magdalena, Baja California Sur to Colombia including Coco Islands, Malpelo and Galapagos. This organism lives in the rocky coasts and it is found attached to rocks, mainly in cracks and holes, the littoral fringe where it mostly inhabits is the upper intertidal zone [4].

Besides the ecological role that *P. pansa* has in the community, this gastropod represents cultural and economic importance given that it shows a gland that secretes a fluid, which in the presence of light and oxygen forms a purple ink that is used to dye threads and gets the name of "tyrian purple" [5,6]. Threads dyed with this ink have been used since prehispanic times by the Mexican indigenes such as Mixtecos and Nahuas to dye clothes related to social prestige, power and religion [7].

In last century, at the beginnings of the 80's, a Japanese company hired inexperienced people in harvesting the ink that the purple snail produces for silk thread coloring. By the lack of knowledge and faulty understanding on the process that these people had over ink harvesting and cotton thread coloring, this resource was managed inappropriately. Because of the bad management and the use of poor techniques for ink harvesting, the abundance of *P. pansa* populations were diminished considerably and the snail population structure size and collapsed, because larger organisms were seriously affected by the inappropriate handling by the management that this organization deployed for harvesting ink.

For the reasons exposed, many people that were native collectors for ink and thread dyers by their origins, their culture and traditions such as the Mexican indigenes, were displaced. On 1988, in the Official Diary of the Federation "Diario Oficial de la Federacion" an act was published to regulate the conservation and proper ex-

ploitation of the purple snail. Currently, *P. pansa* is considered as a species under special protection stated on the statute Mexican Official Statute "Norma Oficial Mexicana NOM-059-SEMARNAT-2010" [8], which determines species and subspecies of wild terrestrial and aquatic fauna and flora in danger of extinction, threatened, scarce, and under special protection, and establishes the specifications for its protection.

Because of the inappropriate management of the purple snail, its population status was severely affected, this created biological, ecological, and social problems that were analyzed from studies like the ones based on analysis of population structure and on reproductive aspects, among those of Hernández and Acevedo [9], Acevedo *et al.* [10], Álvarez [11], León [4], Acevedo *et al*. [12], Castillo-Rodríguez and Amezcua-Linares [13], Acevedo and Escalante [14], Holguín [15], Ramos-Cruz [16], Reyes [17], Flores [18], Acevedo *et al*. [19], Enciso *et al.* [20], Michel [21], Michel-Morfin *et al*. [22], Michel-Morfín *et al*. [23], Ramírez-Rodríguez and Naegel [24], García *et al*. [25], Michel-Morfin *et al.* [26].

Our work was carried out in the region of Costa Chica, on the State Guerrero, where there are not previous analysis about the of condition *P. pansa* population; the objectives was to analyze the population structure centered on its density, sex ratio, size, weight, besides detailed observations about recruitment and reproductive seasonality.

2. Methodology

2.1. Study Area

According to Carranza-Edwards *et al*. [27,28], The State of Guerrero is located in southeastern Mexico, its coordinates are 16˚18'N to 18˚48'N and 98˚03'W to 102˚12'W. It adjoins north with the States of Mexico and Morelos, northwest with Michoacan, northeast with Puebla, east with Oaxaca and from west to south with the Pacific Ocean. The coastline is approximately 470 km, located in the Morphotectonic Unit VIII of the State of Guerrero; it is a coastal front that according to its regional structure has a very narrow continental shelf, is parallel to the Mexico Mesoamerican oceanic trench. It is classified as continental collision coast, dominated by primary coasts formed by diastrophic movements, with faults and coasts of fault scarps. However there are to a lesser extent, secondary coasts characterized by wave's erosion, and coastal headlands and wave-cut terraces, also higher secondary coasts formed by marine deposition, same as barrier and hooks beaches.

The weather is warm-subhumid with summer rains (Aw, wi) and with five to 10% of winter rain [29].

The territory of the state has seven regions, from which three are located in the coastal fringe: Costa Chica, Acapulco, and Costa Grande.

Costa Chica region is located in the southeastern part of the state, its territory adjoins north with the regions of La Montaña and Centro, south with the Pacific Ocean, east with the State of Oaxaca and west with Acapulco. This study was carried on in the rocky intertidal zone of three sites in this region: 1) Punta Madonado, located at the Cuajinicuilapa municipality on 16˚19'35.49"N, 98˚34'12.65"W. Composed of sedimentary rocks sandstone-type from Upper Tertiary period with grayish tonalities. Beach of intense waving classified as exposed, substrate is relatively fragile, it has a great quantity of holes with variable depths and diameters widely distributed throughout the area; 2) Las Peñitas, Marquelia municipality, its coordinates are 16˚33'14.4"N, 98˚46'22.0"W. Composed of metamorphic rocks classified as Gneiss from Jurassic Period with grayish colors and black strips that weathers in brown and yellow tones. Beach with soft waving classified as protected. Substrate hard and resistant to waving action with rough surface composed of protuberances, great quantity of fissures, cracks, and holes such as fold-less surfaces; 3) Playa Ventura, located at Copala municipality its coordinates are 16˚32'8.3"N, 99˚54'44.6"W. Composed of intrusive igneous rocks, granodiorite-type from Tertiary Period forming great compact structure blocks. Beach with intense waving classified as exposed. Substrate hard and resistant to waving, with great quantity of cracks, fissures, and holes distributed heterogeneously with rough surface (**Figure 1**). Beaches descriptions were realized according to geological charts from Instituto Nacional de Estadística, Geografía e Informática and observations made out during the present research.

2.2. Field Methodology

Sampling was carried on in upper rocky intertidal zone of the three sites. Each site was sampled six times, visiting dates were: September and December 2006, March, June,

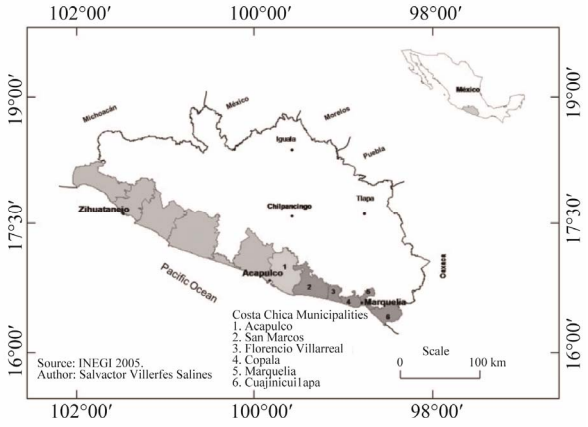

Figure 1. Coast of Guerrero, México.

September, and December 2007. Sampling was realized during low tide and daylight time. Sampling area size was 20 m^2 for each site, calculated from dispersion grade of *P. pansa* through variance/average ratio, as well as from Morisita's [30] and Morisita standardized [31] indexes. Later, observed frequencies were adjusted to negative binomial probability distribution (according to organism's dispersion) with 90% confidence level and 30% standard error.

Sampling was systematic. The sample starting point was selected at random, and then a 30 m length rope was placed parallel to coastline on the intertidal zone. The sampling unit was a one square meter frame made of PVC tube. Two levels were specified for sampling; level one had its lower limit near to barnacle's zone or subtidal zone, and level two had its upper limit near to nerita's and litorina's zone or the most remote to subtidal zone. Once the starting point was selected, a sampling unit was placed at level one of the selected point. All *P. pansa* found within the area of sampling unit were collected and placed in a labeled plastic bowl or container with sea water, and protected from direct sunlight for later work on all the specimens for each site. After the first squared meter had been checked, the sampling unit was moved on upwards and immediately placed at level two. When both levels had been concluded, a 2 m space was left on the rope, and the next sampling unit was then placed again at level one. This operation was repeated until completing the 20 m^2.

Once all the collected specimens for all transects were gathered, the specimens were separated by sex, the sexing of organisms was possible because of male's copulative organ can be easily observed. In order to it, organisms are taken with the hands and shaken, a minute or so later, the snails reinitiates its activity when opens and spread its foot, the right side of the organism is observed to see if there is the presence or absence of penis (**Figure 2**). Once sexing was finished, the specimen was weighed in grams with a 0.01 resolution digital balance, and the length measured in mm (from apex tip to the siphonal channel opening) with a digital Vernier caliper, all the data for the total number of organisms per sampling unit was recorded in field sheets for later analysis.

Observations with respect to the reproductive season were recorded directly by counting the amount of pair mates on the area copulating in each sampled unit and registered on the field sheets. After finished sexing, biometrics notations and recording all the observations within the field sheets, the sampled purple snails were returned to their original habitat, placing them over humid rocks in shady places protected from the immediate direct waving action in order to guarantee their survival. Through all of these procedures, no specimens were lost.

(a)

(b)

Figure 2. Snail *Plicopurpura pansa*. (a) Male; copulative organ (presence of penis); (b) Female; copulative bursa (absence of penis).

2.3. Data Analysis

Density was calculated dividing the total number of collected snails by the total of sampled meters (snails/m^2). This operation was made with the total of harvested snails in all samplings units by total of sampled meters in all three beaches for all the visits. Density was also calculated per date in which sampling was made, and the calculus was done based on the total of harvested snails per date in which each sample was made and total of sampled area per each visit date.

To know the sexual proportion, a calculus was carried on which consisted in dividing the total of collected females by total number of males, the result was expressed as females are to males (F:M) ratio. This calculus was done based on the total of females and males that were collected in all samplings and the total per each sampled area in all three beaches, also, calculus based on the total of collected males and females per each sampling date and total sampled area per each visit were recorded.

For sex ratio equity test, in each calculus a Chi-square homogeneity test ($p < 0.05$) was made [32]. Size structure analysis (expressed in millimeters) and weight (expressed in grams) was made, obtaining the descriptive statistical values as maximum, minimum and average. Because of the wide variations in weight that *P. pansa* showed, weight variation coefficient was also calculated

[33]. Descriptive statistics were obtained for the total of examined specimens; this calculus was also made by separating organisms by sex, and with the analyzed amount of organisms per sampling date. The best represented sizes were obtained from frequency distribution histograms. These histograms were made separately for females and males and analyzed in the samples set.

Plicopurpura pansa population recruitment analysis was based on size frequency histograms; this analysis was carried on by making histograms for each sampling date, using the total of analyzed specimens without sex segregation. Those organisms that presented less than 10.5 mm in size were contemplated as recruits because they were rated as the youngest age group. To determine the reproductive season, direct observations over snail's sexual activity was made by counting the mating pairs that were found copulating in each sampling unit for each date and place.

3. Results

3.1. Density and Sex Ratio

A total of 1739 organisms of *P. pansa* were examined, from which 828 resulted females and 911 males. Estimated density for all sampled units and dates was 4.83 snails/m^2 from it 2.30 were females and 2.53 males. Minimal density was registered in September 2006 with a value of 3.75 organisms/m^2 from which 1.73 was females and 2.02 males. Maximal density was registered on December 2007 as 5.78 snails/m^2 in which, 2.95 was females and 2.83 males.

The sex calculated ratio in Costa Chica including the total of examined snails was 0.90 females per male. The range of sex ratio was 0.76:1.0 (F:M) to 1.0:0.96 (F:M), these values were shown in March and December 2007 respectively. Chi-square test ($p < 0.05$) on the total of organisms represented in all the samples applied to sex ratio indicated the existence of statistically significant differences, but when analyzed per each sampled date did not present differences in five sampling dates, but statistically significant differences were found in March 2007 (**Table 1**).

3.2. Size and Weight

About *P. pansa* overall population size and structure (**Table 2**), females presented the largest and the smallest size. Overall averaged estimated size was 20.91 mm (sd =

Table 1. Total of analyzed specimens, density (organisms/m^2), sex ratio (F:M), and results of Chi-square test, in sampling dates for *Plicopurpura pansa* population in Costa Chica, Guerrero, México (September 2006 to December 2007).

Date	Gender	N	D	Sex ratio	Significant difference
All	Both	1739	4.83	0.90:1	YES
	Female	828	2.30		
	Male	911	2.53		
Sep. 06	Both	225	3.75	0.85:1	NO
	Female	104	1.73		
	Male	121	2.02		
Dec. 06	Both	327	5.45	1:0.93	NO
	Female	169	2.82		
	Male	158	2.63		
Mar. 07	Both	275	4.58	0.76:1	YES
	Female	119	1.98		
	Male	156	2.60		
Jun. 07	Both	249	4.15	0.80 : 1	NO
	Female	111	1.85		
	Male	138	2.30		
Sep. 07	Both	316	5.26	0.88:1	NO
	Female	148	2.46		
	Male	168	2.80		
Dec. 07	Both	347	5.78	1:0.96	NO
	Female	177	2.95		
	Male	170	2.83		

N = Total of analyzed and harvested organisms; D = Density; x^2 $P < 0.05$ = significant difference according to Chi-square test.

Table 2. Size and weight of the snail *Plicopurpura pansa* per sampling dates, on Costa Chica, Guerrero, México (September 2006 to December 2007).

Dates	Gender	Length (mm)				Weight (g)				
		Average	Min.	Max.	s.d.	Average	Min	Max	s.d.	V. C. (%)
All	Bo	20.9	6.9	45.6	5.6	1.9	0.1	15.2	1.6	80.9
	Fe	20.6	6.9	45.6	6.6	2.0	0.1	15.2	1.9	96.5
	Ma	21.1	7.3	38.3	4.4	1.9	0.1	9.7	1.2	61.7
Sep. 06	Bo	20.7	6.9	37.1	6.1	2.0	0.1	8.1	1.6	80.2
	Fe	20.5	6.9	37.1	7.4	2.0	0.1	8.1	2.0	96.6
	Ma	20.8	10.1	33.4	4.6	1.9	0.2	7.1	1.2	61.6
Dec. 06	Bo	19.1	7.7	39.1	5.9	1.5	0.1	10.6	1.5	96.2
	Fe	18.6	8.4	39.1	6.8	1.5	0.1	10.6	1.8	116.4
	Ma	19.7	7.7	36.0	4.6	1.6	0.1	8.2	1.1	70.0
Mar. 07	Bo	21.7	7.3	40.4	5.3	2.1	0.10	12.6	1.7	82.8
	Fe	22.3	11.2	40.4	6.4	2.3	0.2	12.6	2.2	96.2
	Ma	21.3	7.3	36.2	4.4	2.0	0.1	8.1	1.2	64.5
Jun. 07	Bo	22.9	8.6	45.6	4.2	2.3	0.1	15.2	1.5	65.9
	Fe	23.4	8.6	45.6	5.0	2.5	0.1	15.2	2.0	77.8
	Ma	22.5	13.3	35.7	3.4	2.2	0.5	7.3	1.1	50.0
Sep. 07	Bo	21.0	8.2	43.0	4.9	1.9	0.1	13.7	1.3	67.6
	Fe	20.8	8.2	43.0	6.1	2.0	0.1	13.7	1.7	87.8
	Ma	21.1	8.5	30.4	3.5	1.9	0.1	5.0	0.8	41.5
Dec. 07	Bo	20.4	8.9	38.4	6.0	1.9	0.1	11.0	1.6	86.9
	Fe	19.7	9.2	38.4	6.7	1.8	0.1	11.0	1.8	100.0
	Ma	21.1	8.9	38.3	5.0	2.0	0.2	9.7	1.5	74.2

Min. = Minimum; Max. = Maximum; sd = standard deviation; V. C. = variation coefficient; Bo = Both; Fe = Female; Ma = Males.

5.61) including for all sampling dates.

The analysis for average size per sampling date indicated that the smallest average size was 19.17 mm (sd = 5.91) registered in December 2006 and the largest average size 22.95 mm (sd = 4.24) recorded in June 2007. For the female's group, the smallest size was 6.90 mm found in September 2006 and the largest size was 45.60 mm found in June 2007. Average estimated size including all sampling dates for total of females was 20.69 mm (sd = 6.68). For the average size analysis per sampling date on females, the result indicated that the smallest average was 18.64 mm (sd = 6.89) in December 2006, and highest average size was 23.46 mm (sd = 5.07) and registered in June 2007.

According to male's size structure, the smallest one was 7.30 mm registered on in March 2007 and the largest was 38.30 mm found in December 2007.

Average estimated size including all sampling dates for total of males was 21.12 mm (sd = 4.40). Average size analysis per sampling date indicated that the smallest average was 19.73 mm (sd = 4.60) found in December 2006, and the highest average size was 22.55 mm (sd = 3.40) and it was registered in June 2007. Size frequency distribution histogram results (**Figure 3**) showed that the best represented sizes in females occurred between 10.5 and 28.5 mm, since in this size range was shown the highest abundance. For males, the best represented sizes were found between 13.5 and 28.5 mm.

In Costa Chica weight average for all *P. pansa* organisms was 1.99 g (sd = 1.61), ranging from 0.10 to 15.20 g. Females showed an average of 2.02 g (sd = 1.95) and males 1.96 g (sd = 1.21).

The weight had greater variability than the length. We observed a 96.53% coefficient of variation in weight for females, ranging from 77.82% to 116.4% between the different sampling dates. In males the coefficient of variation in weight was 61.73%, ranging from 74.25% to 41.53% (**Table 2**).

When analyzing per sampling date, on the weight variation coefficient value in females, it was observed that it reached its maximum value in December 2006, followed by December 2007, and September 2006. In March and June samples, an important reduction of this coefficient value had occurred (**Table 2**).

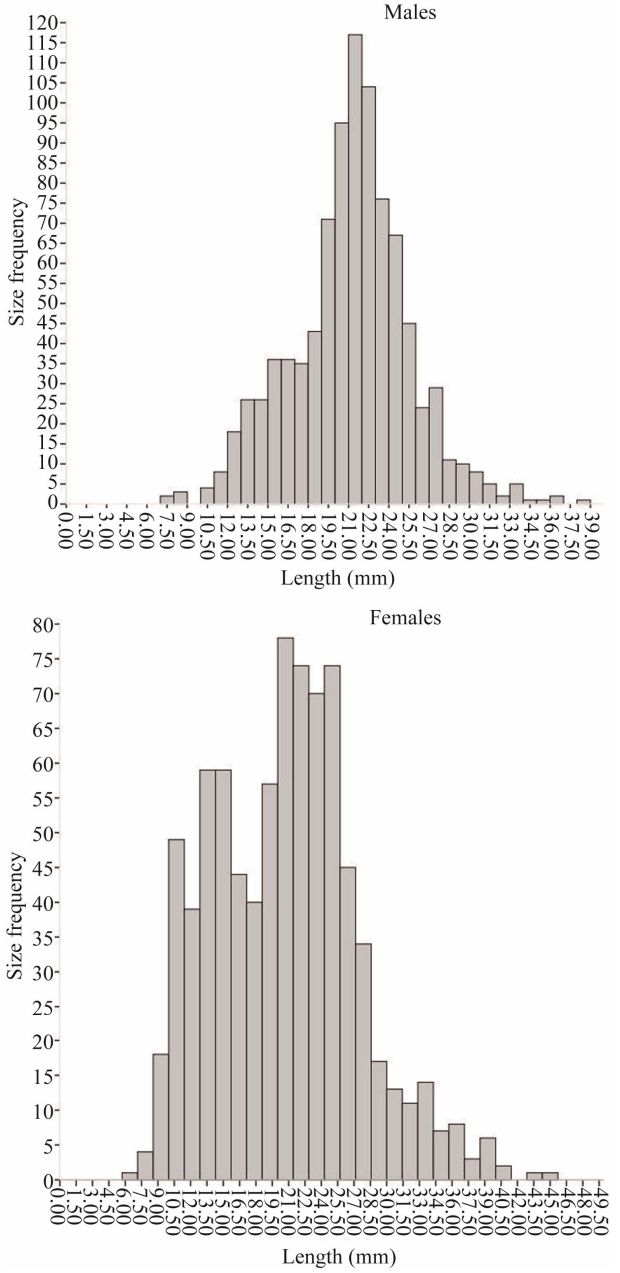

Figure 3. Histogram of size frequency distribution for males and females of *Plicopurpura pansa* at Costa Chica region, Guerrero, México (September 2006 to December 2007).

3.3. Recruitment and Reproductive Seasonality

In the mating observations, the highest number of copulating pairs was registered in March 2007. In June 2007 an important quantity of copulating mates was also observed, nevertheless the number was smaller than the previous sampling date. In other sampling dates, copulating mates were present but the observed quantity was significantly smaller than the observed for March and June 2007.

In Costa Chica there swas recruitment of *P. pansa* during the whole year, presenting the highest quantity of recruits in December 2006 and September 2007, while in March and June, presence of organisms with sizes up to 10.5 mm in the rocky intertidal zone of the analyzed sites diminished considerably (**Figure 4**).

4. Discussion

4.1. Density and Sex Ratio

Estimated density of the purple snail *P. pansa* for Costa Chica for the present report is higher than that presented in literature for other places in the Mexican Pacific Ocean shore. Flores [18] reports the highest density and it is for Acapulco, Guerrero. Density found in the present study is very similar to that reported by García *et al.* [25] for Guerrero State's coast. With what was found in the literature and the reported here, the State of Guerrero is ranked as the one with the highest densities of *P. pansa* for the Mexican Pacific coast.

The high density found for the State of Guerrero is contradictory to what was reported in by Acevedo *et al.* [18] who point out that in Mexican Pacific coast have a density pattern based in the latitude, where density increases according to the increment in latitude and indicated that "the three states that are located Northwards (Jalisco, Nayarit, and Sinaloa) are the ones that present better conditions in terms of density".

Based on literature reports about density of *P. pansa* in Mexican Pacific shores, we believe that it is not possible to define a density distribution pattern based on the latitude only.

On sex ratio considering all the analyzed data during the six sampling dates, in Costa Chica there are significant differences in the amount of females with respect to males, nevertheless, when separated analysis for each of the sampling dates were conducted, the result was that for most of the time female-male proportion did not show statistically significant differences, which clearly indicated that in Costa Chica at the State of Guerrero, the tendency is towards an equal proportion of female to male (1.0:1.0).

Michel [21] analyzed sex ratio in different beaches of Mexican Pacific and found that this proportion has a tendency towards the unit (1.0:1.0), this behavior is similar to what was found in our work; however Acevedo *et al.* [19] report that males are more abundant than females, and that this happens throughout Mexican Pacific coasts. Reports realized by other studies indicate a higher quantity of males, such as Holguín [15] where males double females, on the contrary Michel [21] determined for Baja California Sur a male per each 1.85 females. Although most literature reports are about 1.0:1.0 sex ratio in *P. pansa*.

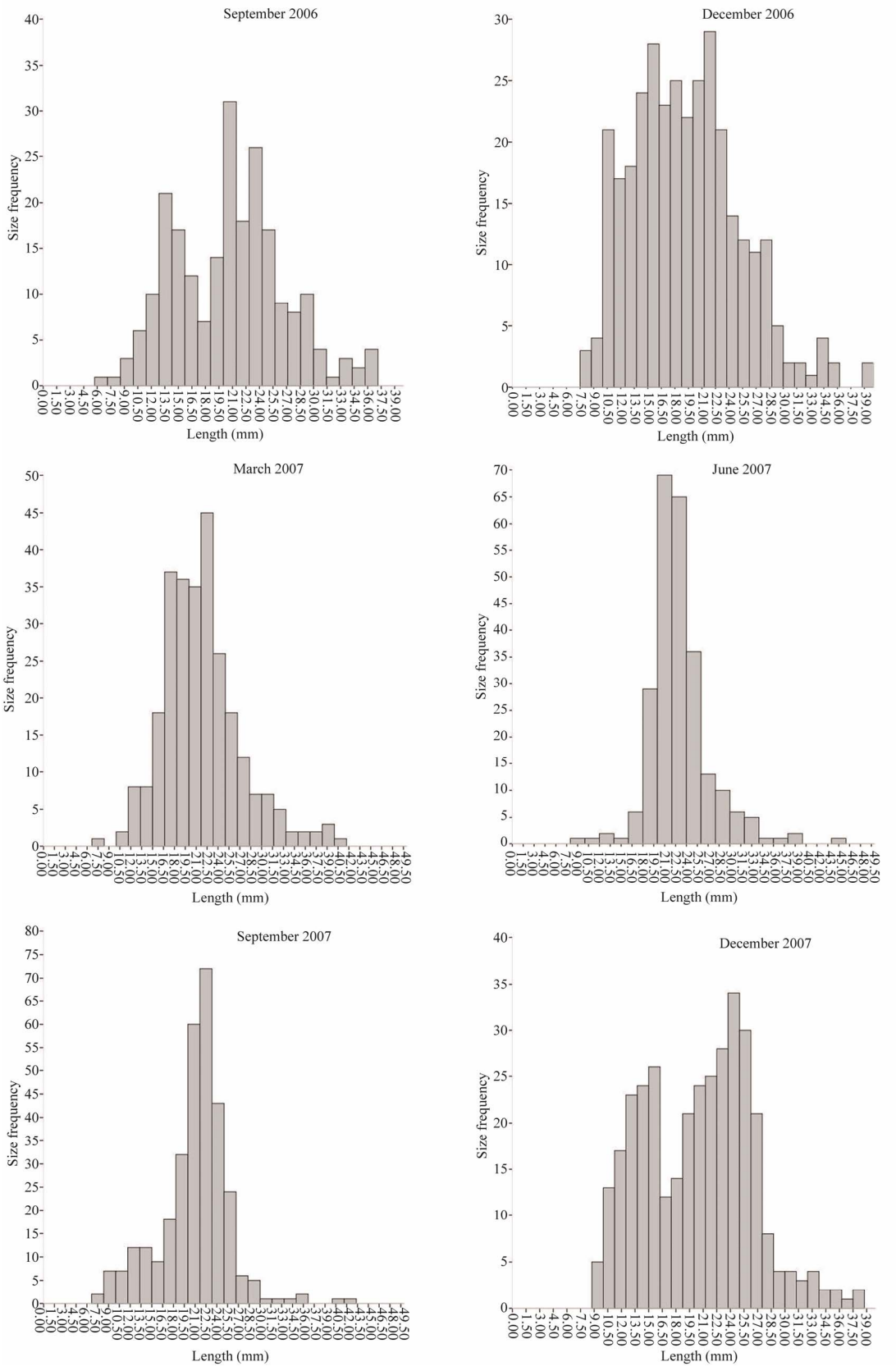

Figure 4. Size frequency histogram for different sampling dates of *Plicopurpura pansa* population in Costa Chica Region, Guerrero, Mexico.

4.2. Size and Weight

Few records in literature where size analysis is included mention to have found sizes smaller than 10 mm. In most of the reports the minimum registered sizes are higher than 15 mm. In the present study sizes of 10.5 mm or smaller represented a considerable proportion of the total sampled specimens and formed the first age group, therefore considered as recruits.

According to size comparison among males and females, the larger ones were females. In literature, studies that analyze this aspect report that females are bigger than males.

Most specimens of purple snail in Costa Chica were found congregated in a size interval from 10.5 to 28.5 mm. In studies like those made by Hernández and Acevedo [9], Acevedo *et al.* [10], León [4], Acevedo *et al.* [12], Acevedo and Escalante [14], and Enciso *et al.* [20] reported that most of the organisms on which size was analyzed were larger than 20 mm. The amount of snails smaller than 20 mm registered in Costa Chica, was approximately half of the total quantity of analyzed specimens; best represented sizes belonged to small sized specimens, which indicated that snail population at Costa Chica was characterized by presenting small sizes and high densities. The literature reported tendency for the Mexican Pacific shores, where that female registered individual larger sizes, in agreement with what was seen in this study.

With the data reported by Flores [18] for Acapulco, Guerrero and in this report, it can be considered that the state has favorable environmental conditions for the existence of high densities and small sizes of *P. pansa*, which differs from that reported by Michel-Morfín *et al.* [23], who mention that larger average and individual sizes are found towards South of Mexico and this could be owed to the snail's affinity for tropical environment. Michel-Morfín *et al.* [26] report larger average size than that reported in other studies at a beach of Jalisco. It is considered that one of the most important factors that influence the differences among reported results in literature, and what was found in this work, may have its base on the variations of the collecting methodology employed by each researcher.

Purple snail's weight data was the most variable. Females varied more than males, weight coefficient of variation in females exceeded 100%. It was observed that the smaller weight variation for females was registered in March and June, while weight variations for males in the same dates were nil.

4.3. Recruitment and Reproductive Seasonality

At Costa Chica *P. pansa* recruitment occurred through the whole year, registering its maximum value in December 2006 and September 2007. In March and June the quantity of registered recruits was very low. According to the recruitment observed in the present work, it is in agreement with that observed by Michel-Morfín [21] for Playa Cuastecomate, Jalisco, where they reported recruitment practically during the entire year (from July 1993 to May 1994). On the other hand, Álvarez [11] mentions that recruits appearance in Michoacán was in August, besides that there are extra-seasonal recruitments. Enciso *et al.* [20] observed recruitment over most of the year, starting in August and observed a larger quantity of recruits in December. Other studies observed recruitment just only in some months of the year, such as Hernandez and Acevedo *et al.* [10] which reported it in July, August, and September. Acevedo *et al.* [12] point out the existence of recruitment for males in March and June, and females in May and more evidently in the months of January and March.

Plicopurpura pansa copulate during the whole year, but most of such activity was registered during March 2007. Maximum weight coefficient of variation values for females occurred in September and December 2007, and minimum values in March and June 2007. Most copulation activity was observed when the minimum weight coefficient of variation values occurred for females, which indicates that most of them in that moment had empty gonads. This is the reason why minimum weight variation values were registered, hence, maximum coefficient of variation in weight values most be related to a rise in weight because of energy stored for gonad maturity.

The wide weight variations in females of the purple snail in Costa Chica are related to the reproductive cycle, from the above mentioned it can be concluded that most of the sexually mature female population are activate for copulation during March and June, which is the period were smaller weight variations are recorded. About this, Ehrhardt [34] mentions that there can be changes in weight, as an example when there is a rise in weight during spawning season and a sudden lost of it as soon as spawning products eject have occured. It can then be perceived that the exponent produced in the length-weight relationship reflects the dynamic processes related to feeding and reproduction success.

REFERENCES

[1] T. Spight, "Diversity of Shallow-Water Gastropods Communities on Temperate and Tropical Beaches," *America Naturalist*, Vol. 111, 1977, pp. 1077-1097. doi:10.1086/283239

[2] C. A. Miller, "Comparison of the Species Richness and Trophic Roles of Gastropods and Chitons on Rocky Shores of Temperate and Tropical West America," *The Veliger*, Vol. 26, No. 1, 1983, pp. 62-68.

[3] C. Skoglund, "Additions to the Panamic Province Gastropods (Mollusca) Literature 1971 to 1992," *The Festivus*, Vol. 32, 2002, p. 169.

[4] H. León, "Estructura Poblacional, Producción y Tiempo de Recuperación del Tinte de *Purpura pansa* (Gould 1853) (Gastropoda: Thaididae) en Algunas Playas Rocoas de la Bahía de Cuastecomate San Patricio Melaque Jalisco," Universidad de Guadalajara, México, 1989.

[5] L. Naegel and C. J. Cooksey, "Tyrian Purple from Marine Muricids, Specially from *Plicopurpura pansa* (Gould 1853)," *Journal of Shellfish Research*, Vol. 21, No. 1, 2002, pp. 193-200.

[6] B. M. S. Giambastiani, "Evoluzione Idrologica ed Idrogeologica Della Pineta di San Vitale (Ravenna)," Ph.D. Thesis, Bologna University, Bologna, 2007.

[7] M. Turok, A. Sigler, E. Hernández, J. Acevedo, R. Lara and V. Turcott, "El Caracol Púrpura: Una Tradición Milenaria en Oaxaca," Dirección General de Culturas Populares, Mexico, 1988.

[8] Anonymous, "Norma Oficial Mexicana NOM-059-ECOL-2010, que Determina las Especies y Subespecies de Flora y Fauna Silvestres, Terrestres y Acuáticas en Peligro de Extinción, Amenazadas, Raras y las Sujetas a Protección Especial, y que Establece Especificaciones para su Protección," Diario Oficial de la Federación, Órgano Constitucional de los Estados Unidos Mexicanos, México, 2010, 78 p.

[9] E. Hernández and J. Acevedo, "Aspectos Poblacionales y Etnobiológicos del Caracol *Purpura pansa* (Gould, 1853) en la Costa de Oaxaca," Universidad Nacional Autónoma de México, México D. F., 1987.

[10] J. Acevedo, E. Hernández and V. Turcott, "Informe Sobre la Factibilidad de Explotación del Tinte de *Purpura pansa* GOULD 1853 en la Costa de Michoacán," Dirección General de Culturas Populares Departamento de Programas Científicos y Tecnológicos, México, 1987.

[11] A. Álvarez, "Relaciones Ecológicas y Algunos Aspectos Poblacionales del Caracol *Purpura pansa* (Gould 1853) en la Costa del Estado de Michoacán, México," Universidad Michoacana de San Nicolás de Hidalgo, Morelia, 1989.

[12] J. Acevedo, M. A. Escalante and R. C. López, "Aspectos Poblacionales del Caracol de Tinte *Purpura pansa* (Gould 1853) en las Costas de Nayarit," *Revista Inter*, Vol. 1, No. 1, 1990, pp. 18-22.

[13] Z. G. Castillo-Rodríguez and F. Amezcua-Linares, "Biología y Aprovechamiento del Caracol Morado *Plicopurpura pansa* (Gould 1853) (Gastropoda: Neogastropoda) en la Costa de Oaxaca, México," *Anales del Instituto de Ciencias Del Mar y Limnología*, Vol. 19, No. 2, 1992, pp. 223-234.

[14] J. Acevedo and M. A. Escalante, "Análisis de la Población de *Purpura pansa* en la Costa de Sinaloa. Resúmenes del XII Congreso Nacional de Zoología," Nuevo León, 1993.

[15] O. E. Holguín, "Distribución Abundancia y Composición Peso-Talla de *Purpura pansa* (Mollusca-Gastropoda) en Isla Socorro Archipiélago Revillagigedo, México," *Zoología Informa*, Vol. 25, 1993, pp. 24-33.

[16] S. Ramos-Cruz, "Abundancia y Estructura Poblacional del *P. pansa* (Gould 1853) en el Área de Huatulco Oaxaca México," *Final Research Report*, Secretaría de Pesca, Instituto Nacional de la Pesca, Centro Regional de Investigación Pesquera Salina Cruz, Oaxaca, 1993.

[17] S. C. Reyes, "Estimación Poblacional, Producción, Foto-Oxidación y Rendimiento del Tinte del Caracol Purpura pansa (Gould 1853) de la Zona sur del Litoral Rocoso de Jalisco," Universidad de Guadalajara, Guadalajara, 1993.

[18] R. P. Flores, "Evaluación Biológico—Pesquera del Caracol de Tinte *Purpura pansa* (Gould, 1853) del Litoral Rocoso del Municipio de Acapulco, Guerrero, México," *Final Research Report*, Universidad Autónoma de Guerrero, Acapulco, 1995.

[19] J. Acevedo, M. A. Escalante and M. Turok, "El caracol Púrpura," In: A. Sanchez, F. Dilio, C. Fuentes and S. García-Real, Eds., *Pesquerías Relevantes de México Secretaría del Medio Ambiente Recursos Naturales y Pesca*, México, 1996, p. 1100.

[20] C. Enciso, V. M. Ramírez, A. R. Tirado and A. Vallarta, "Evaluación de la Población y Épocas de Reproducción del Caracol Purpura pansa (Gould 1853) en Mazatlán Sinaloa, México," Universidad Autónoma de Sinaloa, Sinaloa, 1998.

[21] J. E. Michel, "Ecología y Aprovechamiento del Caracol de Tinte *Plicopurpura pansa* en las Costas del Pacífico Mexicano," Instituto Politécnico Nacional de México, Mexico City, 2000.

[22] J. E. Michel-Morfin, A. Chavez and V. Landa, "Population Parameters and Dye Yield of the Purple Snail *Plicopurpura pansa* (Gould 1853) of West Central México," *Journal of Shellfish Research*, Vol. 19, No. 2, 2000, pp. 919-926.

[23] J. E. Michel-Morfín, A. Chávez and L. González, "Estructura de la Población Esfuerzo y Rendimiento del Tinte del Caracol *Plicopurpura pansa* (Gould 1853) en el Pacífico Mexicano," *Ciencias Marinas*, Vol. 28, No. 4, 2002, pp. 357-368.

[24] M. Ramírez-Rodríguez and L. Naegel, "Crecimiento del Caracol de Tinte *Plicopurpura pansa* en Baja California Sur, México," *Ciencias Marinas*, Vol. 29, No. 3, 2003, pp. 283-290.

[25] S. García, R. Flores, P. Flores and A. Valdes, "Densidad y Tallas de *Plicopurpura patula pansa* Relacionadas con el Sustrato y Oleaje en la Costa Rocosa de Guerrero, México," *Hidrobiológica*, Vol. 14, No. 2, 2004, pp. 127-136.

[26] J. E. Michel-Morfin, M. Hernandez, V. Landa, J. Arciniega, D. Kosonoy and R. Flores, "Estimation of the Abundance and Population Structure of the Purple Snail *Plicopurpura pansa* (Gould 1853) Comparing Tow Methods," *The Open Marine Biology Journal*, Vol. 3, 2009, pp. 49-58. doi:10.2174/1874450800903010049

[27] O. Wright and W. Wright, "Flying-Machine," US Patent No. 821393, 1906.

[28] A. Carranza-Edwards, M. Gutiérrez-Estrada and R. Rodríguez-Torres, "Unidades Morfo-Tectónicas Continentales

de las Costas Mexicanas," *Anales del Instituto de Ciencias Del Mar y Limnología*, Vol. 2, No. 1, 1975, pp. 81-88.

[29] E. García, "Modificaciones al Sistema de Clasificación Climática de Köppen: Para Adaptarlo a las Condiciones de la República Mexicana," Dirección General de Publicaciones Universidad Nacional Autónoma de México, México, 1981.

[30] E. Brower, H. Zar and N. Von Ende, "Field and Laboratory Methods for General Ecology," McGraw Hill, New York, 1998.

[31] J. Krebs, "Ecological Methodology," Addison Wesley Longman, Boston, 1999.

[32] W. Daniel, "Bioestadística Base Para el Análisis de las Ciencias de la Salud," Limusa Wiley, México City, 2002.

[33] R. G. D. Steel and J. H. Torrie, "Bioestadística Principios y Procedimientos," McGraw Hill, México City, 1997.

[34] M. Ehrhardt, "Curso Sobre Métodos de Evaluación de Recursos y Dinámica de Poblaciones Tercera Parte Parámetros Poblacionales," FAO-CICIMAR, México, 1981.

