

ARTICLE

Composition of Prosobranchia-Pulmonata (Mollusca: Gastropoda) in rocky intertidal zone in the Marine Priority Region 32, Guerrero, Mexico

Composición de Prosobranchia-Pulmonata (Mollusca:Gastropoda), asociada a la zona intermareal rocosa en la Región Marina Prioritaria 32, Guerrero, México

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Resumen. El objetivo de esta investigación fue la descripción de la taxocenosis de las subclases Prosobranchia y Pulmonata (clase Gastropoda), asociados a la zona intermareal rocosa de la Región Marina Prioritaria 32, Guerrero, México. Basada en la riqueza de especies, la composición de la comunidad a partir de la representación de las familias, se evaluó la abundancia, distribución geográfica de las especies, se estimó los estadísticos descriptivos de las tallas (en largo) de las poblaciones y la diversidad. El muestreo se llevó a cabo en 7 sitios, la unidad de muestreo fue de 1 m² y el área de muestreo de 10 m². Se identificaron 104 especies de prosobranquios y 4 de pulmonados. Las familias Columbelloidea y Muricidae fueron las mejores representadas en riqueza de especies y la familia Muricidae en abundancia. *Acanthais triangularis* se consideró como la representativa de la zona, la especie *Macrocypraea cervinetta* mostró la mayor talla. Además, 23 especies presentaron amplia distribución, 27 distribución regular y 54 distribución restringida. Veintiocho especies estuvieron representadas por un único organismo, y 6 especies por 2 organismos, estas especies son consideradas raras. Las especies raras se encontraron en las estaciones cuya característica de exposición del oleaje es de bajo a medio. La riqueza de especies fue alta y corresponde a lo esperado en una zona tropical.

Palabras clave: Gastropoda, riqueza, distribución geográfica, tallas, Guerrero

Abstract. The aim of this research was the description of the taxocoenosis of Prosobranchia and Pulmonata subclasses (Gastropoda) associated with the rocky intertidal zone of the Marine Priority Region 32, Guerrero, Mexico. Based on known species richness, we examine the composition of the community based on the representation of families, assess abundance, the geographic distribution of species, estimate descriptive statistics of size, and estimate diversity. Sampling was conducted at 7 sites, the sampling unit was 1 m² and the sampling area was 10 m². One hundred and four species of subclass Prosobranchia and 4 species of subclass Pulmonata were identified. Columbelloidea and Muricidae families showed higher species richness, meanwhile family Muricidae was the most abundant. *Acanthais triangularis* was the most representative species of the study area, and *Macrocypraea cervinetta* showed the greatest size. Twenty three species were found with broad distribution, 27 taxa with frequent distribution and 54 taxa with restricted distribution. Twenty eight species were represented by a single organism and 6 species with 2 organisms, these species were considered rare and were found in sites whose characteristic wave exposure is low to medium. Species richness was high and corresponds to that expected in the tropics.

Key words: Gastropoda, species richness, geographic distribution, size, Guerrero

INTRODUCTION

The state of Guerrero is considered one of the most biodiverse states of the Mexican Republic and the National Commission for the Conservation and Use of Biodiversity (initials in Spanish

CONABIO) determined the existence of 4 marine priority regions (30, 31, 32, and 33) for the conservation and use of biodiversity in the state of Guerrero and reported that knowledge

and understanding of biodiversity in these regions is limited (Arriaga *et al.* 1998).

The rocky intertidal zone of the Marine Priority Region 32 (MPR 32) is mainly located in the municipality of Acapulco. This rocky substratum is exposed to constant dives and rises, therefore its environmental conditions have vary greatly therefore allowing the development of many forms of life.

The molluscs of Gastropoda class, are part of the marine fauna that inhabits the MPR 32. These organisms are characterized by shells with various shapes and colors, some of them with an internal shell or without it at all. The main feature of the shell consists on its spiral shape. In the Gastropoda class not all organisms in their adulthood have a spiral shell, some present it before being adults and loose it in the process of growing into the mature stagestate (López & Urcuyo 2009).

In Mexico, the Gastropoda class is very important for the ecosystem services it provides, besides many species of this class are used as food, most of them to prepare local gourmet dishes, other species are used in the industry for fashion, jewelry and handicrafts products. This class has contributed to the development and evolution of many of the cultures that formed this country.

In the American Pacific, has been conducted research that deal with the taxonomy and distribution of the Gastropoda class (Keen 1971, Brusca 1980, Skoglund 2002, Tucker & Tenorio 2009, Tenorio *et al.* 2012). Meanwhile for the Mexican Pacific, in taxonomy, diversity, abundance, community composition, zonation, variation through time and geographical distribution of species (Holguín & González 1989, Reguero & García-Cubas 1989, Román *et al.* 1991, Holguín-Quiñones & González-Pedraza 1994, Ríos-Jara *et al.* 1996, 2009; Landa-Jaime & Arciniega-Flores 1998, Esqueda *et al.* 2000, Olabarría & Vega 2000, Villarroel *et al.* 2000, González-Villareal 2005, Landa-Jaime *et al.* 2007, 2013; Ortíz-Arellano & Flores-Campaña 2008, Vega *et al.* 2008, Zamorano *et al.* 2008, Flores-Rodríguez *et al.* 2010, 2014). Particularly for the coasts of Guerrero there are reports where the Gastropoda class is analyzed as part of the set of classes studied (Salcedo *et al.* 1988, Flores 2004, Flores-Rodríguez *et al.* 2007, 2012). For the MPR 32 there are reports that have analyzed the molluscs at different sites (Villalpando 1986, Delgado 1989, García 1994, Flores-Rodríguez *et al.* 2003, Barba-Marino *et al.* 2010, Torreblanca 2010, Flores-Garza *et al.* 2010, 2011; Torreblanca *et al.* 2012, Torreblanca-Ramírez *et al.* 2012, 2014).

Concerning the Gastropoda class in the MPR 32, there is need for many investigations such as conducting inventory of

species, record the composition of communities and populations, since this knowledge is essential to preserve and rationally use its biodiversity. The objective of this research was to analyze the composition of the Prosobranchia - Pulmonata taxocoenosis associated with the rocky intertidal zone of the MPR 32, based on known species richness, examine the composition of the community based on the representation of families, assess abundance, the geographic distribution of species, estimate descriptive statistics of size and the index of species diversity.

MATERIALS AND METHODS

In the marine ecoregion 17, is also called the Mexican Pacific Transitional region, besides the Guerrero coastal area in this ecoregion, the coasts of the states of Jalisco, Colima, Michoacán, Oaxaca and the southern tip of Baja California Sur are included. The physiography of this ecoregion is characterized by a narrow continental shelf with an amplitude of 10-15 km and a slope of less than 1°30', with a deep ocean trench and complex abyssal plains (Wilkinson *et al.* 2009).

The state of Guerrero has 470 km on costal length (Carranza-Edwards *et al.* 1986) and the MPR 32 is located between the Coyuca lagoon and Tres Palos lagoon (latitude 16°35'24''N, 17°28'12''W and longitude 99°25'12''N, 100°33'W) (Arriaga *et al.* 1998) (Fig. 1). Sampling was conducted at 7 sites at the rocky intertidal zone of this region (Fig. 1). Each location was geographically referenced and described according to the following criteria: length of the sampling area, type of substrate, types of rock, substrate stability and wave exposure. The descriptions of the collecting sites were based on Mottana *et al.* (1980) and maps (Acapulco E14-11, 1:50,000) produced by the National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía. INEGI) and were complemented with field observations (Table 1).

These sites vary in type, substrate stability and wave exposure. Substrate types were classified as: 1) massif rocks: fixed structures such as walls, cliffs, terraces, etc.; 2) blocks: loose rock larger than 50 cm in diameter, made of rocks that are submerged and immovable or difficult to move about by the impact of waves, 3) boulders: loose rock with a size of less than 50 cm and greater than 8 cm in diameter, rocks that can be easily moved by the impact of waves, 4) gravel: loose rock no more than 8 cm in diameter, 5) artificial substrate: concrete blocks or construction waste.

The stability of the substrate was classified as: 1) high: when the substrate remains virtually unchanged by the impact of waves, 2) middle: when the impact of the waves does not change the configuration of the substrate but there is rock movement, 3)

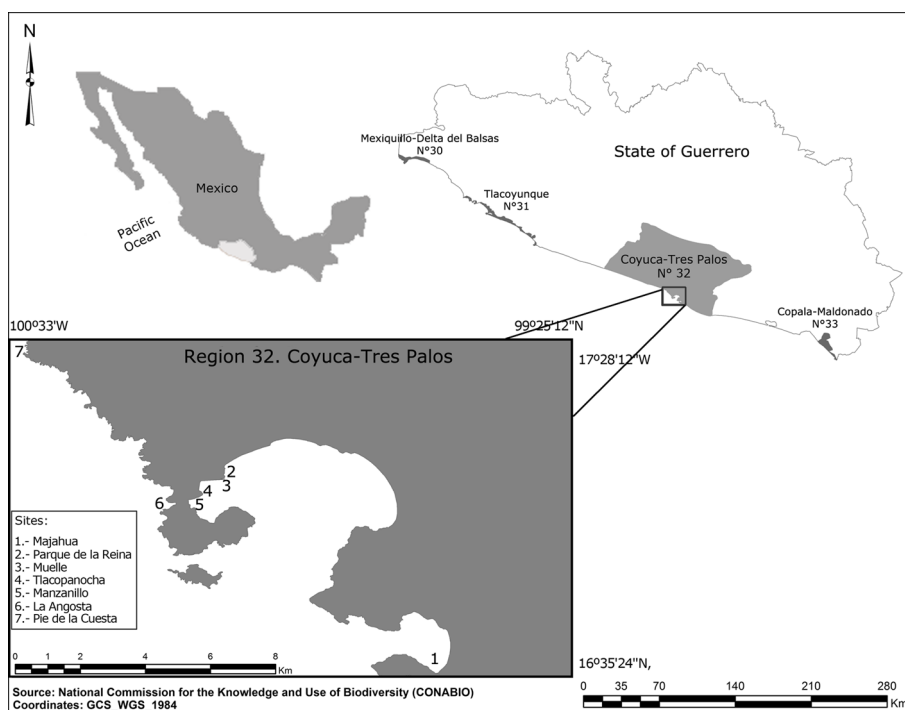


Figure 1. Marine Priority Regions in the state of Guerrero, Mexico and sampling sites / Regiones Marinas Prioritarias del Estado de Guerrero, México y sitios de muestreo

Table 1. Geographical location and the most relevant characteristics of the sampling sites / Localización geográfica y las características más relevantes de los sitios de muestreo

Site	Coordinates		Length of the site (m)	Type of substrate	Type of rock	Substrate stability	Wave exposure
	Latitude N	Longitude W					
Majahua	16°47'39.46''	99°50'28.94''	600	Blocks and Boulders	Metamorphic	High	Low
Parque de la Reina	16°51'01.21''	99°54'02.04''	66.74	Boulders and Gravel	Artificial substrate and igneous rocks	Low	Middle
Muelle	16°50'56.86''	99°54'02.39''	60	Blocks and Boulders	Metamorphic and artificial substrate	Meddle	Middle
Tlacopanocha	16°50'41.53''	99°54'25.02''	200	Blocks and Gravel	Artificial substrate and igneous rocks	Meddle	Middle
Manzanillo	16°50'27.90''	99°54'38.14''	22.87	Boulders and Gravel	Metamorphic and artificial substrate	Low	Low
La Angosta	16°60'29.86''	99°54'55.70''	48.14	Massif rocks and Boulders	Metamorphic	High	High
Pie de la Cuesta	16°52'25.64''	99°56'34.64''	66	Massif rocks and blocks	Metamorphic	High	High

low: when the site configuration is changed by the impact of waves, most of the rocks are moved. The wave exposure was classified as: 1) high: when the wave hits the substrate in a free manner, usually the sites that have this type of waves are outside of the protection of barriers such as bays or hooks, 2) middle: when the impact of the wave on the substrate is hindered by barriers or smoothing, as can occur at sites that are in front of the entrance of bays or at a distance from a wall of hooks, it also happens in places where subtidal rocky substrate emerges or is shallow and reduces the direct impact of the waves to the substrate, 3) low: when the wave does not directly hit the substrate, since the sites are protected by different types of barriers (Flores-Garza *et al.* 2012).

Three samplings were conducted per site between 2010 and 2012. Each sampling was performed during the hours of low tide and new moon days, the sampling area was 10 m² and sampling unit was 1 m². Sampling was systematic. The starting point of the sample was randomly selected in the rocky intertidal zone and the sampling unit was delimited using a 1 m² frame made of PVC pipe. A rope 30 m in length, was placed next to the PVC frame, which extended parallel to the coast over the rocky intertidal zone, in order to define the transect on which sampling would be carried out.

Gastropods found alive within the sampling unit, were collected and placed into a plastic container filled with seawater and protected from direct sunlight. The following sampling unit was placed along the transect 2 m from the first sampling unit. This procedure was repeated to complete 10 m². The specimens were placed in bottles containing 96% ethyl alcohol and taken to the laboratory to be identified and quantified.

The identification of specimens and the update of the nomenclature, required confirmation in the laboratory, using literature such as Keen (1971), Skoglund (2002) and WoRMS (2015)¹.

The collected specimens were measured in length and width (mm). Species richness was assessed based on the number of species found in the samples. The community composition was analyzed using the representation of families, which was evaluated based on species richness and abundance of organisms per family and expressed as percentage. Relative abundance was measured as the percentage of each species in relation to the total number of specimens. The geographical distribution was evaluated based on the frequency of occurrence of species per site as follows: broad (frequency of 6 to 7 sites), frequent (frequency of 3 to 5 sites) and restricted (frequency of 1 to 2 sites). The composition analysis of the Gastropoda sizes was considered by measuring the length and obtaining the descriptive statistical values such as maximum, minimum, mean

and standard deviation for each of the species. The diversity was measured using the Shannon-Wiener index (H') and Pielou index (J').

RESULTS

We examined 12,881 specimens collected in the rocky intertidal zone of the MPR 32, from which 11,694 specimens belonged to the subclass Prosobranchia and 1,187 specimens belonged to the subclass Pulmonata. In total 29 families, 63 genera and 108 species were identified. The subclass Prosobranchia was composed of 28 families, 61 genera and 104 species and subclass Pulmonata by 1 family, 2 genera and 4 species (Table 2) (Figs. 2 and 3).

In subclass Prosobranchia, the Columbelloidea family was the best represented in species richness (10 genera and 19 species), followed by families Muricidae (10 genera and 13 species), Fissurellidae (3 genera and 13 species), Calyptraeidae (3 genera and 9 species) and Lottiidae (2 genera and 6 species). Families found represented by a single species were: Planaxidae, Epitoniaceae, Naticidae, Triviidae, Ovulidae, Cymantiidae, Melongenidae, Nassariidae, Olividae and Cancellariidae (Table 2). The Siphonariidae family, subclass Pulmonata was represented by 4 species.

The site with the highest species richness in both subclasses analyzed was Majahua, in which 74 species (70 prosobranchs and 4 pulmonates) were identified, in second place was Tlacopanocha (63 prosobranchs and 2 pulmonates), and followed by Manzanillo (55 prosobranchs and 2 pulmonates). The lower species richness was found on La Angosta (35 prosobranchs and 2 pulmonates) and Pie de la Cuesta (30 prosobranchs and 2 pulmonates) (Table 3).

In the MPR 32 of the subclass Prosobranchia, the family with the best representation in relative abundance was Muricidae (29.04%), followed by Columbelloidea (26.10%), Lottiidae (9.02%), and Trochidae (8.89%). The family Siphonariidae included in the Subclass Pulmonata also found within families had higher relative abundance (9.21%). 12 families had a value greater than 1% of relative abundance. Together these 12 families accounted for 97.09% of the total abundance found in the MPR 32. The families lowest value recorded in relative abundance were Triviidae (0.023%), Turridae (0.046%) and Cerithiidae (0.147%).

The Columbelloidea family in 6 sites was found as 1 of the 2 most abundant families, The Muricidae family was found in 5 sites and Siphonariidae, Trochidae and Fissurellidae families on 1 site (Table 3).

¹WoRMS. 2015. World Register of Marine Species <<http://www.marinespecies.org/aphia.php?p=taxdetails&id=456599>>

Table 2. Families and species, relative abundance, geographical distribution and descriptive statistics of sizes in length of species Prosobranchia and Pulmonata subclasses, associated with the rocky intertidal zone of The MPR 32, Guerrero, Mexico / Familias y especies, abundancia relativa, distribución geográfica y estadísticos descriptivos talla en largo de las especies Prosobranchia y Pulmonata subclasses, asociados a la zona intermareal rocosa de la RMP 32, Guerrero, México

Families / Species	N	Sampling sites							RAB Sp	Gd	Length (mm)			
		1	2	3	4	5	6	7			Min	Max	Ave	Sd
Subclass Prosobranchia														
FISSURELLIDAE														
<i>Octomarginula natlandi</i> (Durham, 1950)	1	1							0.01	R	15.2	15.1	15.1	15.1
<i>Diodora digueti</i> (Mabille, 1895)	1	1							0.01	R	10.5	10.4	10.4	10.4
<i>Diodora inaequalis</i> (G.B. Sowerby I, 1835)	35	6	4		3	20	2		0.27	F	8.8	25.5	17.2	4.2
<i>Diodora saturnalis</i> (Carpenter, 1864)	10				2	8			0.08	R	6.7	23.9	15.8	5.8
<i>Fissurella asperella</i> G.B. Sowerby I, 1835	1		1						0.01	R	16.9	16.9	16.9	
<i>Fissurella decemcostata</i> McLean, 1970	5	4		1					0.04	R	15.0	20.6	17.0	2.1
<i>Fissurella deroyae</i> McLean, 1970	2	1	1						0.02	R	11.2	12.8	12.0	1.1
<i>Fissurella gemmata</i> Menke, 1847	154							154	1.20	R	5.8	27.4	21.1	3.3
<i>Fissurella macrotrema</i> G. B. Sowerby I, 1835	1		1						0.01	R	9.8	9.8	9.8	
<i>Fissurella microtrema</i> G. B. Sowerby, 1835	5	1				4			0.04	R	6.7	32.4	20.4	9.5
<i>Fissurella nigrocincta</i> Carpenter, 1856	227					2		225	1.76	R	6.5	27.8	18.8	4.3
<i>Fissurella obscura</i> G. B. Sowerby I, 1834	1		1						0.01	R	22.0	22.03	22.0	
<i>Fissurella rubropicta</i> Plisbry, 1890	1		1						0.01	R	8.5	8.5	8.5	
LOTTIIDAE														
<i>Lottia acutapex</i> (S. S. Berry, 1960)	29						28	1	0.23	R	2.41	17.02	5.14	2.71
<i>Lottia mitella</i> (Menke, 1847)	98				3	4	49	42	0.76	F	3.45	17.95	8.45	3.69
<i>Lottia mesoleuca</i> (Menke, 1851)	146	76	11	11	5	1	2	40	1.13	B	9.36	30.51	17.83	4.36
<i>Lottia pediculus</i> (Philippi, 1846)	289	2	2	38	54	1	192		2.24	B	4.11	26.08	12.35	3.7
<i>Lottia fascicularis</i> (Menke, 1851)	599	34	12	276	98	21	108	50	4.65	B	4.62	31.85	15.25	5.75
<i>Patelloida semirubida</i> (Dall, 1914)	2	1			1				0.02	R	5.82	11.59	8.7	4.08
TROCHIDAE														
<i>Calliostoma aequisculptum</i> Carpenter, 1865	2	2							0.02	R	16.9	16.85	16.85	
<i>Tegula globulus</i> (Carpenter, 1857)	1128	64	199	843		18		4	8.76	F	5.47	9.72	7.21	1.09
<i>Tegula panamensis</i> (Philippi, 1849)	4	2		2					0.03	R	6.34	11.13	8.35	2.32
<i>Monilea patricia</i> (Philippi, 1851)	12	10	1					1	0.09	F	4.21	10.33	7.05	1.98
TURBINIDAE														
<i>Arene hindsiana</i> Pilsbry & Lowe, 1932	3	2	1						0.02	R	5.47	6.67	6.07	0.84
<i>Uvanilla unguis</i> (W. Wood, 1828)	21	11	8	2					0.16	F	8.76	41.22	17.93	8.3
NERITIDAE														
<i>Nerita scabricosta</i> Lamarck, 1822	26	5	9	5		3		4	0.20	F	9.28	17.64	12.13	2.29
<i>Nerita funiculata</i> Menke, 1851	105	50	3	1		50		1	0.82	F	3.64	15.18	8.24	2.46
<i>Eulithidium perforatum</i> (Philippi, 1848)	1				1				0.01	R	3.12	3.12	3.12	
LITTORINIDAE														
<i>Echinolittorina aspera</i> (Philippi 1846)	205	65	70	58		9		3	1.59	F	2.54	13.43	6.61	3.09
<i>Echinolittorina peruviana</i> (Lamarck, 1828)	3			3					0.02	R	6.1	6.41	6.29	0.16
<i>Echinolittorina modesta</i> (Philippi, 1846)	113	36	15		8		8	46	0.88	F	1.89	15.4	7.96	3.45
RISSOIDAE														
<i>Rissoina stricta</i> (Menke, 1850)	66	1	2	52	9	1	1		0.51	B	4.63	8.09	6.59	0.66
CERITHIIDAE														
<i>Cerithium menkei</i> Carpenter, 1857	4	1				3			0.03	R	6.55	8.22	7.31	0.84
<i>Cerithium gemmatum</i> Hinds, 1844	3	1		2					0.02	F	6.98	9.93	8.45	2.08
<i>Seila assimilata</i> (C. B. Adams, 1852)	6	1		2	3				0.05	R	4.28	7.51	5.27	1.13
PLANAXIDAE														
<i>Planaxis obsoletus</i> Menke, 1851	154	59	1	19	11		5	59	1.20	B	4.77	16.42	12.12	2.39
EPITONIIDAE														
<i>Epitonium cookeanum</i> Dall, 1917	2			2					0.02	R	7.28	8.07	7.67	0.55
HIPPOCIDAE														
<i>Hipponix panamensis</i> C. B. Adams, 1852	9	2	1			6			0.07	F	6.93	28.67	12.74	6.31
<i>Hipponix delicatus</i> Dall, 1908	19	14	1		3	1			0.15	F	6.47	14.09	10.03	2.06
<i>Pilosabia trigona</i> (Gmelin, 1791)	1					1			0.01	R	16.12	16.12	16.12	
CALYPTRAEIDAE														
<i>Bostrycapulus aculeatus</i> (Gmelin, 1791)	122	30	4		2	86			0.95	F	6.95	27.99	18.97	4.49
<i>Crepidula excavata</i> (Broderip 1834)	31	2				29			0.24	R	8.4	30.42	19.52	4.5
<i>Crepidula incurva</i> (Broderip, 1834)	32	19	3	2		8			0.25	F	4.2	11.99	8.11	2.3
<i>Crepidula onyx</i> G. B. Sowerby, 1824	5		5						0.04	R	13.6	13.64	13.64	
<i>Crepidula striolata</i> Menke, 1851	9	2	1			6			0.07	F	9.8	36.04	22.02	7.7
<i>Crucibulum subactum</i> Berry, 1963	31	2	2	2	2	10	10	3	0.24	B	3.08	26.12	10.57	5.2
<i>Crucibulum umbrella</i> (Deshayes, 1830)	230	142	53	13	8	10	3	1	1.79	B	8.39	65.85	38.29	10.99

Table 2. Continued / Continuación

<i>Crucibulum cyclopium</i> Berry, 1969	14		3			11			0.11	R	26.2	59.25	44.58	10.67
<i>Crucibulum scutellatum</i> (Wood, 1928)	32	17	2	1	2	4	3	3	0.25	B	11.2	43.06	23.38	10.11
NATICIDAE														
<i>Natica grayi</i> (Philippi, 1852)	1	1							0.01	R	2.32	2.32	2.32	
TRIVIIDAE														
<i>Niveria pacifica</i> (Sowerby 1832)	3	1				2			0.02	R	8.48	10.15	9.31	1.18
CYPRAEIDAE														
<i>Macrocyprea cervineta</i> (Kiener, 1843)	20	2	7	7	1	2	1		0.16	B	7.97	84.48	37.82	24.12
<i>Mauritia arabicula</i> (Linnaeus, 1758)	44	7	14	8	4	11			0.34	F	17.8	31.27	23.47	3.47
OVULIDAE														
<i>Jenneria pustulata</i> (Lightfoot, 1786)	24	5	3	1		15			0.19	F	10.1	18.91	14.48	2.66
CYMANTIIDAE														
<i>Monoplex vestitus</i> (Hinds, 1844)	1	1							0.01	R	49.6	49.63	49.63	
MURICIDAE														
<i>Aspella hastula</i> (Reeve, 1844)	1		1						0.01	R				
<i>Acanthais brevidentata</i> (Wood, 1828)	4	1	1					2	0.03	F	19.12	25.28	22.76	3.04
<i>Vasula speciosa</i> (Valenciennes, 1832)	228	21	26	54	23	18	64	22	1.77	B	5.5	28.88	16.55	4.83
<i>Acanthais triangularis</i> (Blainville, 1832)	1642	149	41	724	41	36	452	199	12.75	B	3.11	17.09	10	2.34
<i>Murexul zeteki</i> (Hertlein & Strong 1951)	45	6	2	6	1	30			0.35	F	7.73	48.96	17.05	5.93
<i>Hexaplex princeps</i> (Broderip, 1833)	1					1			0.01	R	49.1	49.1	49.1	
<i>Plicopurpura columellaris</i> (Lamarck, 1835)	7				1	1	2	3	0.05	F	17.04	26.52	21.95	3.52
<i>Plicopurpura pansa</i> (Gould, 1853)	433	3		4	36	3	266	121	3.36	B	10.12	34.53	18.84	4.37
<i>Stramonita biserialis</i> (Blainville, 1832)	774	85	19	376	57	84	76	77	6.01	B	3.88	50.56	12.61	6.01
<i>Trachypollia lugubris</i> (C.B. Adams, 1852)	601	25	5	213	23	28	304	3	4.67	B	2.73	25.88	13.81	4.15
<i>Vasula melomes</i> (Duclos, 1832)	1			1					0.01	R	39.15	39.15	39.15	
<i>Vitularia salebrosa</i> (King, 1832)	3	3							0.02	R	15.65	19.99	18.53	2.49
<i>Coralliophila parva</i> (E. A. Smith, 1877)	1			1					0.01	R	9.05	9.05	9.05	
BUCCINIDAE														
<i>Gemophos sanguinolentus</i> (Duclos, 1833)	59	11	6	7	4	17	14		0.46	F	15.3	27.58	20.89	2.7
<i>Engina tabogaensis</i> Bartsch, 1931	131	67	7	3	2	46	6		1.02	F	4.43	14.71	10.45	2.09
<i>Engina pulchra</i> (Reeve, 1846)	1				1				0.01	R	6.45	6.45	6.45	
COLUMBELLIDAE														
<i>Aesopus eurytoides</i> (Carpenter, 1864)	1		1						0.01	R				
<i>Columbella auro-mexicana</i> (Howard, 1963)	5	1	1	2	1				0.04	F	5.82	14.92	10.85	4.62
<i>Columbella fuscata</i> G. B. Sowerby I, 1832	693	154	25	334	72	76	29	3	5.38	B	3.87	26.98	14.84	4.05
<i>Columbella major</i> G. B. Sowerby I, 1832	72	6	13	1	2	32	18		0.56	B	16.2	30.3	22.39	2.51
<i>Columbella sonsonatensis</i> (Mörch, 1860)	38	7	4	3	1	5	18		0.30	B	6.36	17.73	10.32	3.06
<i>Cosmioconcha palmeri</i> (Dall, 1913)	20	7	3	2	7		1		0.16	F	6.71	10.99	8.75	1.11
<i>Anachis nigrofusca</i> Carpenter, 1857	643	58	36	381	80	72	13	3	4.99	B	2.68	17.67	7.13	1.04
<i>Anachis spadicea</i> (Philippi, 1846)	1		1						0.01	R	5.25	5.25	5.25	
<i>Decipifus lyrta</i> (Baker, Hanna & Strong, 1938)	6	1	1	4					0.05	R	7.34	8.77	7.95	0.49
<i>Mitrella ocellata</i> (Gmelin, 1791)	1001	32	9	273	47	81	432	127	7.77	B	4.92	13.06	10.35	1.24
<i>Mitrella xenia</i> (Dall, 1919)	499	13	3	5	8	11	416	43	3.87	B	4.14	14.86	8.4	1.61
<i>Nassarina heleana</i> Keen, 1971	1		1						0.01	R				
<i>Steironepion piperata</i> (E. A. Smith, 1882)	1		1						0.01	R	4.57	4.57	4.57	
<i>Parvanachis dalli</i> (Bartsch, 1931)	368	74	2	3	43	242	2	2	2.86	B	3.18	7.35	5.57	0.6
<i>Parvanachis guerreoensis</i> (Strong & Hertlein, 1937)	8	1				7			0.06	R	9.74	11.93	10.99	0.67
<i>Parvanachis pygmaea</i> (Sowerby, 1832)	2	1		1					0.02	R	4.62	4.62	4.62	
<i>Glyptanachis hilli</i> (Pilsbry & Lowe, 1932)	1		1						0.01	R	7.18	7.18	7.18	
<i>Anachis gaskoini</i> Carpenter, 1857	1			1					0.01	R	7.32	7.32	7.32	
<i>Anachis scalarina</i> (G. B. Sowerby I, 1832)	1					1			0.01	R	6.18	6.18	6.18	
MELONGENIDAE														
<i>Melongena patula</i> (Broderip & Sowerby 1829)	10		4			4	2		0.08	F	25.86	30.11	28.18	1.7
NASSARIIDAE														
<i>Nasarius gayii</i> (Kiener, 1834)	1					1			0.01	R	6.32	6.32	6.32	
FASCIOLARIIDAE														
<i>Leucozonia cerata</i> (Wood, 1828)	88	15	2	8	4	30	22	7	0.68	B	7.9	69.13	23.78	10.66
<i>Opeatostoma pseudodon</i> (Burrow, 1815)	79	1	4	19	3	4	48		0.61	B	12.33	45.57	23.21	5.55
OLIVIDAE														
<i>Olivella dama</i> (Wood, 1828)	1			1					0.01	R	7.37	7.37	7.37	
MITRIDAE														
<i>Mitra tristis</i> Broderip, 1836	45	7	2	4	31	1			0.35	F	3.51	16.2	10.03	2.77
<i>Mitra rubicola</i> Reeve, 1844	13	4				9			0.10	R	8.27	27.18	15.08	6.05
CANCELARIIDAE														
<i>Admete viridula</i> (Fabricius, 1780)	2	1			1				0.02	R	4.85	11.41	8.13	4.63

Table 2. Continued / Continuación

CONIDAE										
<i>Conus brunneus</i> Wood, 1828	1	1							0.01	
<i>Conus purpurascens</i> G. B. Sowerby I, 1833	1	1							0.01	R 40.11 40.11 40.11
<i>Conus gladiator</i> Broderip, 1833	16	6	3			3	4		0.12	F 8.16 25.96 15.84 6.56
<i>Conus nux</i> Broderip, 1833	38	5	4		5	24			0.30	F 9.51 24.03 16.58 4.09
<i>Conus princeps</i> Linnaeus, 1758	1				1				0.01	R 31.6 31.6 31.6
TURRIDAE										
<i>Pilsbryspira garciacubasi</i> Shasky, 1971	5	4		1					0.04	R 12.7 14.38 13.52 0.78
<i>Crassispira cerithoidea</i> (Carpenter, 1857)	1	1							0.01	R 9.26 9.26 9.26
Subclass Pulmonata										
SIPHONARIIDAE										
<i>Siphonaria gigas</i> G. B. Sowerby I, 1825	15	5		8			2		0.12	F 8.62 19.37 13.09 3.61
<i>Siphonaria maura</i> Sowerby I, 1835	784	564	4	64	35	81	14	22	6.09	B 3.62 19.52 9.67 2.69
<i>Siphonaria palmata</i> Carpenter, 1857	387	302	5	21	24	34		1	3.00	B 3.78 16.74 8.71 2.09
<i>Williamia peltoides</i> (Carpenter, 1864)	1	1							0.01	R 5.51 5.51 5.51

N= Number of organisms analyzed, 1= Majahua, 2= Tlacopanocha, 3= Parque de la Reina, 4= Muelle, 5= Manzanillo, 6= La Angosta y 7= Pie de la Cuesta, RAB sp= relative abundance of each species, Gd= Geographical distribution (B= Broad, F= Frequent, R= Restricted), Min= Minimum, Max= Maximum, Avg= Average Sd= Standard deviation

Table 3. Relative abundance and distribution of the families of Gastropods (Subclasses Prosobranchia and Pulmonata) associated with the rocky intertidal zone of the MPR 32, Guerrero, Mexico / Abundancia relativa y distribución de las familias de gasterópodos (Subclases Prosobranchia y Pulmonata) asociada a la zona intermareal rocoso de la RMP 32, Guerrero, México

Families	All sites	Sampling sites						
		1	2	3	4	5	6	7
FISSURELLIDAE	3.44	0.04	1.32	0.25	0.64	2.56	0.07	29.86
LOTTIIDAE	9.02	4.85	3.67	8.36	20.80	2.03	14.46	10.48
TROCHIDAE	8.89	3.35	29.41	21.74		1.35	0.03	0.31
TURBINIDAE	0.18	0.55	1.32	0.05				
NERITIDAE	1.02	2.36	1.76	0.15	0.12	2.03		0.39
LITTORINIDAE	2.49	4.34	12.5	1.56	1.03	0.67	0.30	3.86
RISSOIDAE	0.51	0.04	0.29	1.33	1.62	0.07	0.03	
CERITHIIDAE	0.14	0.08		0.36	0.38			4.64
PLANAXIDAE	1.19	2.53	0.14	0.49	1.42		0.19	
EPITONIIDAE	0.01			0.05	0.38			
HIPPONICIDAE	0.22	0.68	0.29			0.60		
CALYPTRAEIDAE	3.92	9.20	10.73	0.46	1.80	12.36	0.61	0.55
NATICIDAE	0.007	0.04						
TRIVIIDAE	0.02	0.04				0.15		
CYPRAEIDAE	0.49	0.38	3.08	0.38	0.64	0.98	0.03	
OVULIDAE	0.18	0.21	0.44	0.02		1.13		
CYMANTHIDAE	0.007	0.04						
MURICIDAE	29.04	12.59	13.97	35.48	23.51	15.15	44.50	33.49
BUCCINIDAE	1.48	3.35	1.91	0.25	0.90	4.75	0.76	
COLUMBELLIDAE	26.1	15.26	15	25.99	33.72	39.74	35.45	14.02
MELONGENIDAE	0.07		0.58			0.30	0.07	
NASSARIIDAE	0.007					0.07		
FASCIOLARIIDAE	1.29	0.68	0.88	0.69	0.90	2.56	2.67	0.55
OLIVIDAE	0.007			0.02				
MITRIDAE	0.45	0.47	0.58	0.10	4	0.75		
CANCELLARIIDAE	0.01	0.04			0.12			
CONIDAE	0.43	0.51	1.02		0.77	2.03	0.15	
TURRIDAE	0.04	0.21		0.25				
SIPHONARIIDAE	9.21	37.48	1.32	2.39	7.62	8.67	0.61	1.81
Species richness	108	74	65	54	46	57	37	30
Total families	29	25	20	21	18	20	15	11
Total abundance	12.881	2.326	680	3.886	774	1.326	2.620	1.269
Relative abundance (%)	100	18.05	5.27	30.17	6.0	10.29	20.34	9.85

1= Majahua, 2= Tlacopanocha, 3= Parque de la Reina, 4= Muelle, 5= Manzanillo, 6= La Angosta and 7= Pie de la Cuesta

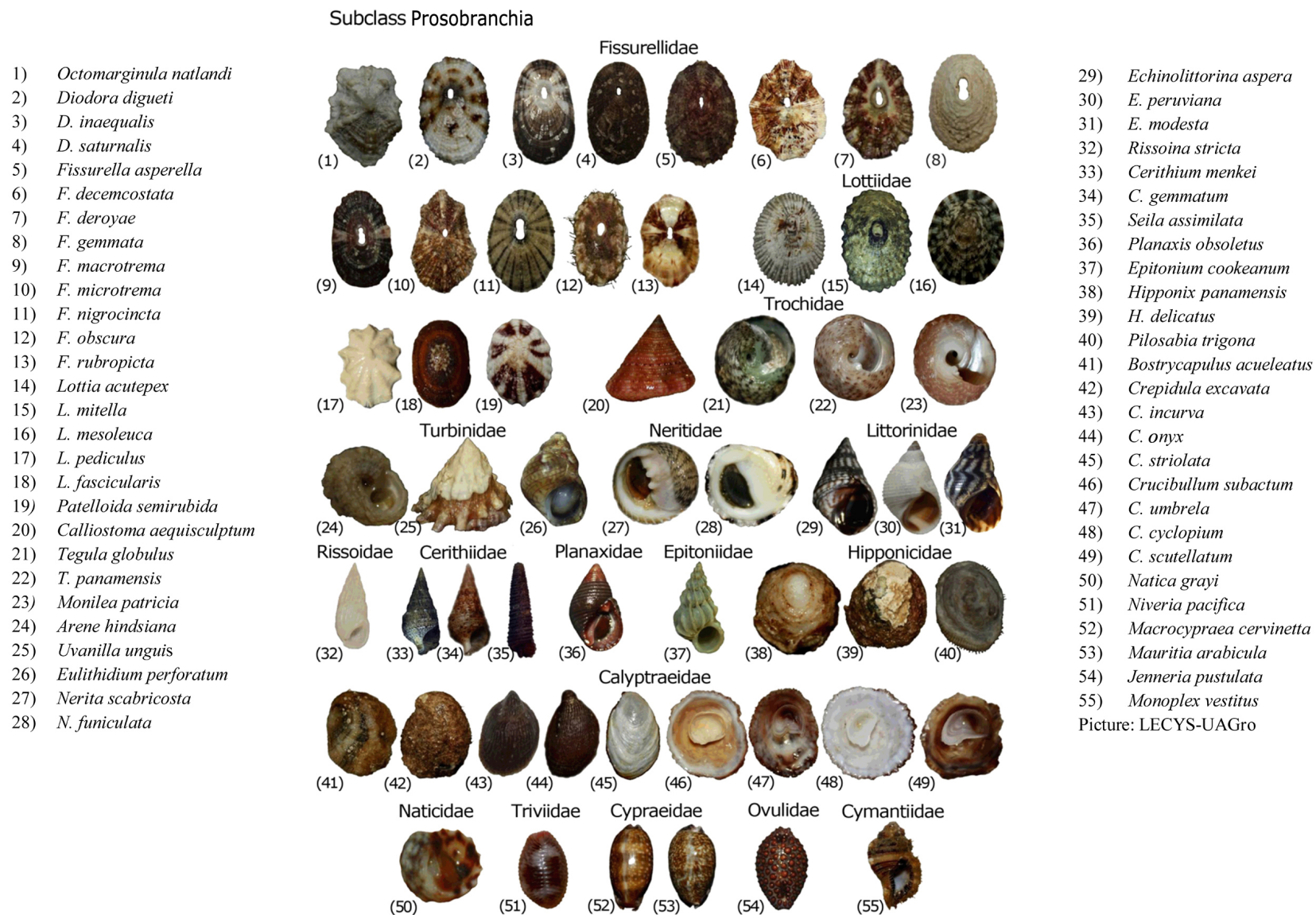
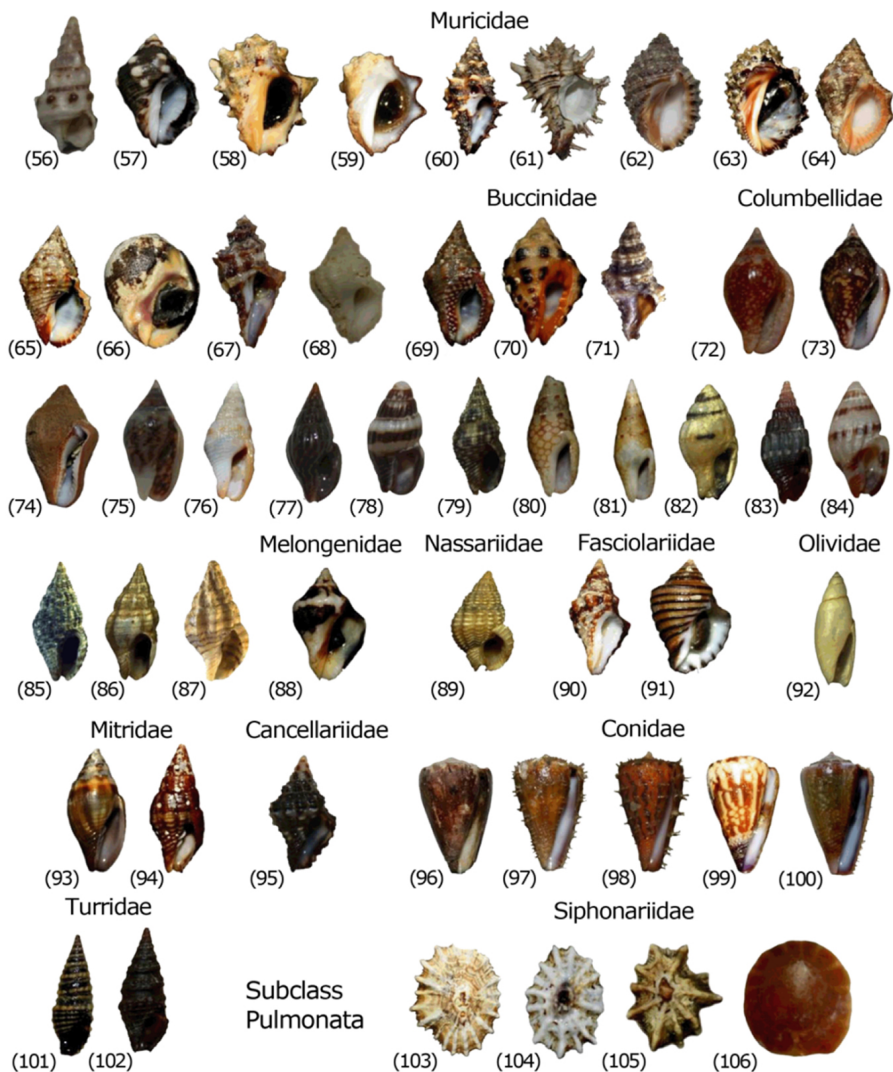


Figure 2. Species richness of the Pulmonata and Prosobranchia subclasses, associated to the rocky intertidal zone of the MPR 32, Guerrero, Mexico / Riqueza de especies de las subclases Pulmonata y Prosobranchia, asociadas a la zona intermareal rocosa de la RMP 32, Guerrero, México

- 56) *Aspella hastula*
- 57) *Acanthais brevidentata*
- 58) *Vasula speciosa*
- 59) *Acanthais triangularis*
- 60) *Murexsul zeteki*
- 61) *Hexaplex princeps*
- 62) *Plicopurpura columellaris*
- 63) *P. pansa*
- 64) *Stramonita biserialis*
- 65) *Trachypollia lugubris*
- 66) *Vasula melones*
- 67) *Vitularia salebrosa*
- 68) *Coralliophila parva*
- 69) *Gemophos sanguinolentus*
- 70) *Engina tabogaensis*
- 71) *E. pulcra*
- 72) *Columbella auromexicana*
- 73) *C. fuscata*
- 74) *C. major*
- 75) *C. sonsonatensis*
- 76) *Cosmioconcha palmeri*
- 77) *Anachis nigrofusca*
- 78) *A. spadicea*
- 79) *Decipifus lyrta*
- 80) *Mitrella ocellata*
- 81) *M. xenia*



- 82) *Parvanachis dalli*
- 83) *P. guerreorensis*
- 84) *P. pygmaea*
- 85) *Gilptanachis hilli*
- 86) *Anachis gaskoini*
- 87) *A. scalarina*
- 88) *Melongena patula*
- 89) *Nasarius gayii*
- 90) *Leucozonia cerata*
- 91) *Opeatostoma pseudodon*
- 92) *Olivella dama*
- 93) *Mitra tristis*
- 94) *M. rubicola*
- 95) *Admete viridula*
- 96) *Comus brunneus*
- 97) *C. gladiator*
- 98) *C. princeps*
- 99) *C. nux*
- 100) *C. purpurascens*
- 101) *Pilsbryspira garciacubasi*
- 102) *Crassispira cerithoidea*
- 103) *Siphonaria gigas*
- 104) *S. maura*
- 105) *S. palmata*
- 106) *Williamia peltoides*

Picture: LECYS-UAGro

Figure 3. Species richness of the Pulmonata and Prosobranchia subclasses, associated to the rocky intertidal zone of the MPR 32, Guerrero, Mexico / Riqueza de especies de las subclases Pulmonata y Prosobranchia, asociadas a la zona intermareal rocosa del la RMP 32, Guerrero, México

The higher relative abundance per site was registered in Parque de la Reina (30.17%), followed by La Angosta (20.34%). Sites that showed lower values in relative abundance are Muelle (6%) and Tlacopanocha (5.27%).

In the MPR 32, the species registered with high relative abundance was *Acanthais triangularis* (Blainville, 1832) (12.74%), followed by *Tegula globulus* (Carpenter, 1857) (8.75%), *Mitrella ocellata* (Gmelin, 1791) (7.77%), *Stramonita biserialis* (Blainville, 1832) (6%), *Siphonaria maura* Sowerby I, 1825 (6.08%) and *Columbella fuscata* G. B. Sowerby I, 1832 (5.38%). 21 species had greater or equal to 1% relative abundance. Together these 21 species accounted for 86.83% of the total abundance found in the MPR 32. The 0.31% of the total abundance is represented by 28 species; these species are represented by an organism. Only 5 sites these species (7 in Majahua, 10 in Tlacopanocha, 4 in Parque de la Reina, 3 in Muelle and 4 in Manzanillo) were found (Table 2).

The most abundant species recorded in Majahua were *S. maura* (24.24%) and *Siphonaria palmata* Carpenter, 1857 (12.98%) in Tlacopanocha, *T. globulus* (29.26%) and *Echinolittorina aspera* (Philippi 1846) (10.29%), in Parque de la Reina, *T. globulus* (21.69%) and *A. triangularis* (18.63%), in Muelle, *Anachis nigrofusca* Carpenter, 1857 (0.33%) and *C. fuscata* (9.30%), in Manzanillo, *Parvanachis dalli* (Bartsch, 1931) (18.25%) and *Bostrycapulus acueleatus* (Gmelin, 1791) (6.48%), In La Angosta, *A. triangularis* (17.25%) and *A. nigrofusca* with (16.48%) and in Pie de la Cuesta, *Fissurella nigrocineta* Carpenter, 1856 (17.73%) and *Fissurella gemmata* Menke, 1847 (12.13%).

12 families of the subclass Prosobranchia presented broad distribution, 8 with frequent distribution and 8 with restricted distribution. The Siphonaridae family, which belongs to the subclass Pulmonata also found with broad distribution. Subclass Prosobranchia, 23 species were found with broad distribution, with frequent distribution 27 and 54 with restricted distribution. In the subclass Pulmonata 2 species were found with broad distribution, 1 species with frequent distribution and 1 with restricted distribution.

Macrocyprea cervineta (Kiener, 1843) had the greatest size in length with 84.48 mm (min= 7.97; 37.82 ± 24.12), followed by *Leucozonia cerata* (Wood, 1828) to 69.13 mm (min= 07.9; 23.78 ± 10.66) and *Crucibulum umbrella* (Deshayes, 1830) to 65.85 mm (min= 8.39; 38.29 ± 10.99). The species that presented the smallest sizes on in length were *Natica grayi* (Philippi, 1852) with 2.32 mm and *Eulithidium perforatum* (Philippi, 1848) with 3.12 mm (Table 2).

The value of diversity index H' for the MPR 32, was 4.87 bits individual⁻¹, while the value of J' was 0.72 (Table 4).

Table 4. Estimated values of H' and J' for the RMP 32, and for each sampling site / Valores de H' y J' estimado para el MPR 32, y para cada sitio de muestreo

Sampling site	H'	J'
Majahua	4.309	0.687
Tlacopanocha	4.479	0.736
Parque de la Reina	3.672	0.641
Muelle	4.285	0.776
Manzanillo	4.665	0.807
La Angosta	3.616	0.689
Pie de la Cuesta	3.659	0.761
General	4.873	0.720

DISCUSSION

The Gastropoda class is well represented in the rocky intertidal zone of the MPR 32. The species richness of the Gastropoda Class along the Mexican Pacific, outside the state of Guerrero, is lower compared to the results of this research (Ortiz-Arellano & Flores-Campaña 2008, Ríos-Jara *et al.* 2009, Landa-Jaime *et al.* 2013, Flores-Rodríguez *et al.* 2014), as well as in other sites located in the state of Guerrero (Flores-Rodríguez *et al.* 2012, Flores-Garza *et al.* 2010, 2011, Torreblanca 2010, 2012, Torreblanca-Ramírez *et al.* 2012). Only Salcedo *et al.* (1988) reported 118 species of subclass Prosobranchia, but they sampled in the intertidal and subtidal sites with sandy and rocky substrate.

The species richness corresponds to that expected in the rocky intertidal zone located in a tropical area. Differences in species richness from the rocky intertidal zone of the state of Guerrero, is attributed to greater sampling effort, the characteristics of easy access to the sites, and careful sampling of the area. Furthermore, sampling was conducted at sites that vary in the type of substrate and wave exposure.

The highest species richness was found on sites that have low stability of the substrate. Sites that have stable substrate and the impact of the waves is direct had lower species richness. The relationship between species richness, diversity and complexity of the substrate has been treated by classical works such as Brusca (1980), which mentions that there is a direct correlation between the stability of the beaches and the type of species. Spight (1977) found a higher species richness in substrates formed by pebbles, compared with cliffs. Flores-Rodríguez *et al.* (2012), analyzing the biodiversity of molluscs distributed in 9 sites on the coast of the state of Guerrero reported that species richness is associated with habitat stability and intensity of the waves. Unstable substrates formed by

boulders and with less intensity of the waves, showed higher species richness.

Fissurellidae, Lottiidae, Muricidae, Columbelloidea and Calyptraeidae were reported as families with higher species richness by Flores-Rodríguez *et al.* (2014), Flores-Garza *et al.* (2010), Torreblanca (2010), Flores-Garza *et al.* (2011), Torreblanca *et al.* (2012) and Torreblanca-Ramírez *et al.* (2012). The same result was found in this research. Moreover, in this study, family Siphonariidae subclass Pulmonata is reported as a family well represented in the MPR 32.

Muricidae and Columbelloidea was determined as the most abundant families in the rocky intertidal of the MPR 32. Similar results are reported by Torreblanca *et al.* (2012) and Torreblanca-Ramírez *et al.* (2012), to Acapulco. Flores (2004), for the state of Guerrero reported to Lottiidae and Siphonariidae families as the most abundant. Furthermore, this research shows for the first time the Trochidae family as one of the most abundant for the rocky intertidal zone of the MPR 32 for the first time.

The subclass Prosobranchia subclass, families Fissurellidae, Lottiidae, Calyptraeidae, Muricidae and Columbelloidea and Pulmonata subclass the Siphonariidae family, were identified as the best represented in species richness, abundance and distribution so they are considered as representative Families for the rocky intertidal zone of the MPR 32.

Species that this investigation found as the most abundant, are similar to those reported by other research conducted in the MPR 32 (Flores-Garza *et al.* 2010, 2011; Torreblanca *et al.* 2012 and Torreblanca-Ramírez *et al.* 2012). Furthermore, the present investigation reports *F. gemmata*, *F. nigrocincta*, *Lottia mesoleuca* (Menke, 1851), *Lottia pediculus* (Philippi, 1846) and *Plicopurpura pansa* (Gould, 1853).

The abundances for 28 species were represented by a single organism, and 6 species for 2, these species are considered rare for the rocky intertidal zone of the MPR 32. The rare species found only in the sites whose characteristic wave exposure is low to medium. Rare species were not found at stations with high exposure to waves.

Rare species are those having less resistance to environmental stress. Alcolado (2001) mentions that the higher correspondence of the values of environmental variables, with ranges favorable for physiological life, the greater the number of potential species that occurs in a given habitat and the less frequent and smaller the fluctuations in these variables, the greater the opportunities for each of the species to exploit to the maximum the available resources and increase their populations. However, molluscs species richness or heterogeneity, comparatively reflect the degree of stress, equity and the level of environmental forecasting. Therefore, the ecology

is based on the identity of the species or its dominance (generalist species, widely distributed, abundant populations of larger sizes and greater support for environmental variations), and sometimes in the census of absent species (species specialists, more sensitive, their populations are smaller, have less resistance to environmental variations).

In relation to geographical distribution of species, *L. mesoleuca*, *L. pediculus*, *L. fascicularis*, *C. umbrella*, *V. speciosa*, *A. triangularis*, *P. pansa*, *S. biserialis*, *T. lugubris*, *Engina tabogaensis* Bartsch, 1931, *C. fuscata*, *A. nigrofusca*, *M. ocellata*, *M. xenia*, *P. dalli*, *S. maura* and *S. palmata* are the representative species of the rocky intertidal zone MPR 32, these species were present at the 7 sites.

Species that have been reported with the greater size in the MPR 32 are *C. umbrella* and *M. cervinetta* (Flores-Garza *et al.* 2011, Torreblanca *et al.* 2012 and Torreblanca-Ramírez *et al.* 2012). This research found similar results, and also reports *L. cerata* as a species with larger size. *N. grayi* and *Jenneria pustulata* (Lightfoot, 1786) have been reported in the MPR 32 as the smaller species (Flores-Garza *et al.* 2011, Torreblanca *et al.* 2012, Torreblanca-Ramírez *et al.* 2012). This research also found *N. grayi* as one species with the smallest size in length.

The values of diversity and evenness for molluscs, which have been reported by other studies conducted in sites located in the MPR 32 are high and similar to those found in the present study (Flores-Garza *et al.* 2011, Torreblanca *et al.* 2012 and Torreblanca-Ramírez *et al.* 2012). Finally, the values of diversity and uniformity found in the study area correspond to that of a tropical zone and are evidence that the region studied is a highly diverse area and it corresponds to benthic ecosystems with high stability.

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