Rev. Biol. Trop., 48(4): 765-775, 2000
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The vertical distribution and abundance of gastropods and bivalves from rocky beaches of Cuastecomate Bay, Jalisco. México

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Received 22-II-1999. Corrected 5-V-2000. Accepted 24-V-2000.

Abstract: The vertical distribution and abundance of conspicuous gastropod and bivalve species were studied at five rocky beaches in Cuastecomate Bay, Jalisco. Sampling was done from September, 1993 through March, 1994 with 0.75 m^2 quadrants placed along replicate transect lines (10 m long) in the supralittoral and mesolittoral (upper, middle and lower intertidal) zones. A total of 6 643 mollusks were collected. Gastropods dominated the samples (6 272 individuals, 44 species); the bivalves were less abundant and diverse (371 individuals, five species). Seventeen species comprised 89.8% of all individuals collected. The gastropods *Nodilittorina aspera* and *Nerita scabricosta* were the most abundant with 637.8 and 71.43 individuals/m2, respectively. The most abundant bivalves were *Brachidontes adamsianus* and *Chloromytilus palliopunctatus* with 60.7 and 61.3 individuals/m2 respectively. The abundance of gastropods decreased from the supralittoral to the lower tidal zones while the number of species increased in the same direction. The number of species of bivalves also increased from the supralittoral to the lower intertidal zone; the abundance of individuals was higher at the middle intertidal zone. Affinities between groups of species among sampling stations were identified by computing Pearson's correlation coefficient using abundance values (ind./m^2) and Jaccard's dissimilarity index using species presence or absence in the lower intertidal zone. Affinity among stations was not dependent upon their vicinity but on the high dominance of few species, the occurrence of many secondary species and beach characteristics.

Key words: Gastropods, bivalves, rocky intertidal, Jalisco, vertical distribution.

Gastropods are the most diverse class of mollusks in the tropical Mexican Pacific; the bivalves form the most abundant and the second most diverse class of this region (Hunter 1983). The larger and most important group of these species lives in the intertidal and shallow subtidal zones (Cifuentes-Lemus *et al.* 1990). A recent list of previous investigations on the taxonomic composition of mollusk communities from this region and the localities studied so far is reported by Ríos-Jara *et al.* (1996). In the coast of Jalisco, investigations include the work of González-Villarreal (1977) in Tenacatita Bay; Rodríguez and Ramírez (1982) in Barra de Navidad; Yañez-Rivera (1989) in several rocky beaches of Tenacatita Bay, Chamela Bay and Banderas Bay; Román-Contreras *et al.* (1991) in Chamela Bay; and Holguín-Quiñones and González-Pedraza (1994) in at least 12 beaches along the coastline of Michoacán, Colima and Jalisco. Other research focuses on the population ecology of *Plicopurpura patula pansa*, a commercially important rocky intertidal snail (see Ríos-Jara *et al.* 1994 and

Fonseca-Madrigal 1998 for reviews of this research). Expeditions conducted in the continental platform of Jalisco and Colima report the mollusk fauna found in deeper waters (López-Uriarte 1989, Castillo-Figa 1992, Ríos-Jara *et al.* 1996, Pérez-Peña and Ríos-Jara 1998). Additional information is provided in a few published records mentioned in the literature, which include collations and summation of museum, collections made by Morris (1966) and Keen (1971).

The recent increase in human activities such as tourism and fishing along the shoreline of Jalisco has intensified the exploitation of natural resources. In Cuatecomate Bay, at the southeastern coast of Jalisco, several gastropod and bivalve species have been exploited commercially for many years. Since the intertidal fauna of Jalisco has not been studied well, the present study is important because it will provide a more complete understanding of the vertical distribution patterns of abundance and diversity of most noticeable gastropod and bivalve populations found in the rocky beaches of this region. Special emphasis was devoted to identify possible affinities between groups of species among sampling sites by computing two classification (cluster) analysis, in an effort to understand the relationship between the certain biological, morphological and sedimentological characteristics of the beach and the abundance and species composition found in these beaches, and to make generalizations on this relationship in other similar localities along the tropical Mexican Pacific.

MATERIALS AND METHODS

The southern coastline of Jalisco, México is sculptured with small bays, which ranges in exposure from broadly open to nearly enclosed. One of these bays is Cuastecomate Bay, which is located in the southeastern portion of Jalisco. The bay spreads 2.5 by 1.3 km between Punta Carrizalillo and Punta Cuastecomatito (19°13'29" - 19°14'18" N, 104° 43'45" - 104°45'29" W) and has a surface area of approximately 325 hectares. The shoreline of the bay is mostly composed of rocky beaches, with solid blocks sometimes mixed with fixed or loose boulders and pebbles forming tidal pools. This region has warm-wet climate with the rainy season occurring mostly during the summer. Annual temperature ranges from 32.3°C in September to 20.6°C in January (mean = 27°C). Cumulative monthly precipitation ranges between 587.5 and 967.3 mm. September records the highest precipitation values with 301.7 mm and February the lowest with 1.6 mm (García 1973).

The biota of rocky beaches from the southern coast of Jalisco includes a large variety of species. A checklist of the macrofauna (Annelida, Mollusca, Arthropoda, Echinodermata and Chordata) of Barra de Navidad, a small nearby coastal lagoon located approximately 4 km south of Cuastecomate Bay, is provided by Rodríguez-Cajiga (1993). In the tide pools and towards the middle and lower intertidal zones, a variety of species of macroalgae are found. A floristic list of the macroalgae from the south coast of Jalisco, including Cuastecomate Bay was presented by Enciso-Padilla *et al.* (1995) and Aguila-Ramírez *et al.* (1998).

Sampling was performed during a seven months period (September, 1993 - March, 1994) at five stations in Cuastecomate Bay. Representative types of beaches were selected as sampling stations based on observations of the biological, morphological and sedimentological characteristics of the coastline of the bay. These beaches are all accessible and have lengths of approximately 150 m, variable widths of 20 to 35 m and slopes of 12°-25°. The sampling stations selected are: S-1, La Calechosa; S-2, Bajada del Arroyo; S-3, El Laboratorio 1; S-4, El Laboratorio 2; S-5, Punta Carrizalillos. A preliminary recognition of the supralittoral and mesolittoral zones was first performed; the mesolittoral (intertidal) zone was classified in three zones (upper, middle and lower intertidal zones) according to the natural zonation of invertebrates and algae (Lewis 1964, Bakus 1968, Peres 1982).

The minimum sampling size was estimated using the species-area curve method (Brower and Zar 1984) during preliminary sampling activities in all stations. Samples were taken using quadrants of 0.75 m^2 placed along 10 m transect lines (Elliott 1977). Two transects were placed parallel to the tidal mark on each littoral zone (supralittoral, upper, middle and lower intertidal). Quadrants were randomly placed along each transect. According to the species-area curve, minimum-sampling size was always smaller than 24 m^2 (32 quadrants) in all littoral zones. All littoral zones of each sampling station were sampled once using this sampling size during the study period. Sampling activities were always performed during low tides. All live gastropods and bivalves in the quadrants were counted and identified to species. Only individuals not identified in situ were collected. These organisms were preserved in 70% alcohol and identified in the laboratory. The work of Morris (1966), Keen (1971) and Skoglund (1992) were used for taxonomic identification.

For classification (clustering), the Pearson's coefficient of correlation and the Jaccard's similarity index were computed (Statistica Program SYNTAX 0.5 for Windows) to identify possible affinities between groups of species among sampling stations. The values of abundance of each species (ind./m^2) were used in the Pearson's coefficient of correlation calculations (quantitative analysis) and the information on the presence or absence of species in the sampling stations for the calculation of the Jaccard's dissimilarity index (qualitative analysis). The UPGMA (Unweighted Pair-Group Method using Arithmetic Averages) clustering method was used (González Sansón 1994). Cluster analysis was performed with data from the lower intertidal. This was the most representative zone of the beaches because it always recorded the highest number of species (72.3% of all species collected during the study period). The lower intertidal is also the less perturbed zone because it keeps protected underwater by surf and tidal currents most of the time.

RESULTS

A total of 6 643 mollusks were collected. Gastropods dominated the samples (6 272 individuals, 94.4%); the bivalves were less abundant (371 individuals, 5.6%). Thirty genera and 44 species of gastropods were identified. The species of the genus *Tegula* (*T. globulus* and *T. corteziana*) and *Siphonaria* (*S. palmata* and *S. maura*) were considered as *Tegula* spp. and *Siphonaria* spp. respectively, due to difficulties for their identification in the field. Bivalves were less diverse with five genus and five species. Seventeen species were the most abundant (>10 ind./m^2) and may be considered as dominant, they comprised 89.8% of all individuals collected (Table 1).

There is a well-defined pattern of vertical distribution of the conspicuous gastropods from Cuastecomate Bay; abundance of individuals decreases from the supralittoral to the lower tidal zones while the number of species increases in the same direction. In the case of bivalves, number of species also increases from the supralittoral to the lower intertidal zone but the abundance of individuals increases from the supralittoral to the middle intertidal zone decreasing again in the lower intertidal (Table 1). Twenty three species were exclusively found in one littoral zone.

The zone with the highest abundance of gastropods was the supralittoral. In this zone, two gastropod species, *Nodilittorina aspera* and *Nerita scabricosta*, were the most abundant with 637.8 and 71.43 ind./m^2, respectively (Table 1). Two bivalve species of the Family Mytilidae were the most abundant in the area of study, *Brachidontes adamsianus* (60.7 ind./m^2 in the middle intertidal) and *Chloromytilus palliopunctatus* (61.3 ind./m^2 in the upper intertidal). Six species of gastropods recorded a wide vertical distribution through the intertidal: *Lottia mesoleuca*, *Mancinella speciosa*, *M. triangularis*, *Mitrella ocellata*, *Planaxis obsoletus* and *Plicopurpura patula pansa*. Two species of bivalves were widely distributed: *Chama squamuligera* from the upper to the lower intertidal zone and *C. palliopunctatus* from the supralittoral to the middle intertidal zone.

TABLE 1

Abundance (ind./m2) and vertical distribution of species

Gastropod species	SL	UI	MI	LI
Astraea unguis (Wood, 1828)				1.8
Bursa corrugata corrugata (Perry, 1811)				1.8
Calyptraea spirata (Forbes, 1852)				1.8
Cantharus elegans (Griffith & Pidgeon, 1834)				2.7
Cantharus sanguinolentus (Duclos, 1833)				3.1
**Columbella fuscata* Sowerby, 1832			13.4	96.4
Columbella sp. Lamarck, 1799			1.8	
**Columbella strombiformis* Lamarck,1822				17.8
Costoanachis nigrofusca (Carpenter, 1857)			3.6	1.8
Crucibulum umbrella (Deshayes, 1830)				3.6
Cypraecassis coarctata Sowerby, 1829			1.8	
Diodora inaequalis Sowerby, 1835			1.8	1.8
Fissurella nigrocincta Carpenter, 1856			2.7	
Fissurella rubropicta Pilsbry, 1890				3.6
Fissurella virescens Sowerby, 1835			5.0	4
Hoffmannola hansi Marcus & Marcus, 1967				5.4
Leucozonia cerata (Wood, 1828)				2.7
**Lottia mesoleuca* (Menke, 1851)		16.1	11.1	3.6
Lottia mitella Menke, 1847			3.6	
Lottia pediculus (Philippi, 1846)			6.3	4.2
Mancinella speciosa Valenciennes, 1832		7.1	1.8	3.0
**Mancinella triangularis* Blainville, 1832		14.3	4.0	4.0
**Melampus tabogensis* C. B. Adams, 1852		10.7		
**Mitrella ocellata* (Gmelin, 1791)		9	10.1	9.0
Mitrella sp. Risso, 1826		1.8		1.8
Nerita funiculata Menke, 1851	9.0			
**Nerita scabricosta* Lamarck, 1822	71.4	26.8		
**Nodilittorina aspera* (Philippi, 1846)	637.8	34.8		
**Nodilittorina modesta* Philippi, 1846	57.6	54.5		
Opeatostoma pseudodon (Burrow, 1815)				3.3
Patella mexicana Broderip & Sowerby, 1829				6.0
Pedipes unisulcatus Cooper, 1866			5.4	
**Planaxis obsoletus* Menke, 1851	30.0	62.8	5.4	
Plicopurpura columellaris Lamarck, 1822		3.4	5.4	
Plicopurpura patula pansa (Gould, 1853)		7.1	2.5	5.0
**Siphonaria* spp. Sowerby, 1824		47.7	10.9	
Stramonita haemastoma (Linnaeus, 1758)			1.8	1.8
**Tectura fascicularis* (Menke, 1851)			13.0	3.6
**Tegula* spp. Lesson, 1835			33.4	34.0
Tridachia diomedea Bergh, 1894				1.8
Trimusculus reticulatus (Sowerby, 1835)			1.8	
Zonaria arabicula (Lamarck, 1811)				1.8
Total number of gastropod species	5	13	22	28
Bivalve species	SL	UI	MI	LI
**Brachidontes adamsianus* Dunker, 1857			60.7	8.5
Chama squamuligera Pilsbry & Lowe, 1932		1.8	8.1	9.8
**Chloromytilus palliopunctatus* Carpenter, 1857	3.57	61.3	9.0	
Isognomon recognitus Mabille, 1895			3.6	7.1
Pteria sterna Gould, 1851				1.8
Total number of bivalve species	1	2	4	4

SL: supralittoral, UI: upper intertidal, MI: middle intertidal, LI: lower intertidal. * indicate most abundant species (>10 ind./m^2)

Information used for cluster analysis is shown in Table 2. Thirty two species collected in the lower intertidal of all sampling stations were considered for this analysis. Station S-5 (Punta Carrizalillo) registered the highest number of species (18) while station S-4 (El Laboratorio 2) registered the lowest number of these species (11). Thirteen species were collected only at one station. The abundance of all these species was always relatively low (<20.5 ind./m^2) except for *Columbella fuscata* and *Tegula* spp. at station S-5 (Punta Carrizalillo) which registered 96.4 and 64 ind./m^2, respectively.

According to the cluster analysis for present vs. absent species (Jaccard´s similarity index), there are three groups of stations (Figure 1). The first group includes station S-1, with six or seven species in common with each of the other stations. This group recorded a dissimilarity value near to 0.7. The second group includes stations S-2 and S-5, with nine species in

TABLE 2

Abundance (ind./m^2) of species collected in the lower intertidal of five sampling stations from Cuastecomate Bay.

Species	Sampling stations				
	S-1	S-2	S-3	S-4	S-5
Astraea unguis				1.8	
Bursa corrugata corrugata		1.8			
Calyptraea spirata					1.8
Cantharus elegans			1.8		1.8
Cantharus sanguinolentus				1.8	3.57
Columbella fuscata		3.57			96.4
Columbella strombiformis	17.8				
Costoanachis nigrofusca	1.8				
Crucibulum umbrella					1.8
Diodora inaequalis					1.8
Fissurella rubropicta	3.57				
Fissurella virescens	5.0	3.57	3.57	4.0	1.8
Hoffmannola hansi	5.4				
Leucozonia cerata			1.8	3.57	
Lottia mesoleuca		5.4	3.57		
Lottia pediculus	1.8	12.5	3.57		
Mancinella speciosa		1.8	1.8		3.57
Mancinella triangularis	4.5	1.8	3.57	3.0	7.0
Mitrella ocellata		6.5	3.57		17.0
Mitrella sp.			1.8		1.8
Opeatostoma pseudodon	4.0		1.8	1.8	
Patella mexicana		6.0			
Plicopurpura patula pansa	6.0		7.0	1.8	1.8
Stramonita haemastoma	1.8		1.8	1.8	
Tectura fascicularis		17.4	1.8	2.7	5.0
Tegula spp.	3.57	20.0	4.0	3.57	64.0
Tridachia diomedea	1.8				
Zonaria arabicula					1.8
Brachidontes adamsianus	20.5		7.0		3.57
Chama squamuligera	19.0	6.7	5.4	5.36	3.0
Isognomon recognitus	12.5	2.7			9.0
Pteria sterna	1.8				
Total species	16	13	16	11	18

S-1: La Calechosa, S-2: Bajada del Arroyo, S-3: El Laboratorio 1, S-4: El Laboratorio 2, S-5: Punta Carrizalillos.

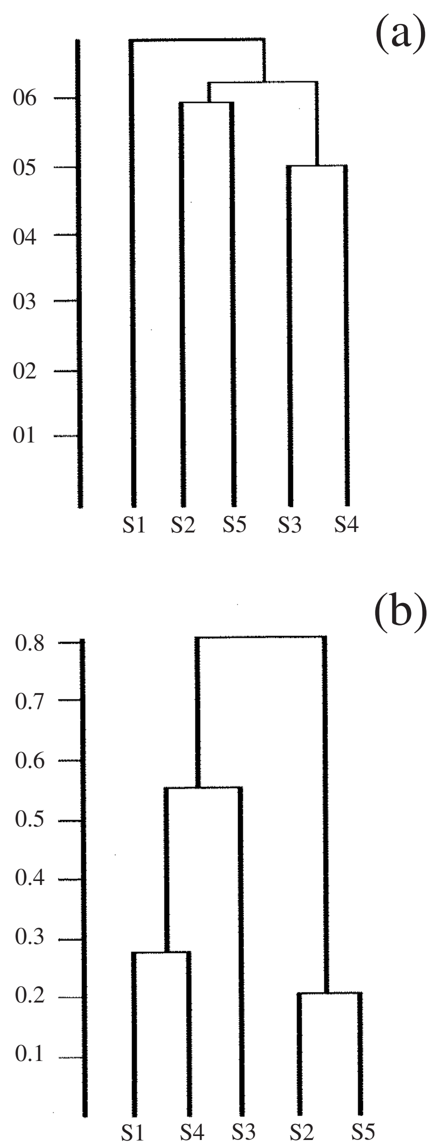

Fig. 1. Dendrograms showing cluster analysis for the lower intertidal data of sampling stations using (a) Jaccard´s Index of Similarity and (b) Pearson´s Coefficient of correlation. See text and Table II for names and location of sampling stations S1 to S5 in Cuatecomate Bay.

common and a value <0.6. The third group includes stations S-3 and S-4, also with nine species in common but higher affinity (dissimilarity value <0.5). The Pearson's coefficient of correlation (quantitative analysis) recognized three groups of stations (Figure 1). The first group includes stations S-1 and S-4 and it is defined by the bivalve *Chama squamuligera*, which were the most abundant in S-4 and the second most abundant in station S-1. This group has seven species in common and a Pearson's coefficient value <0.3. The second group includes station S3. The second group was formed of station S3. This was the only protected station and all species found in their lower intertidal were also found in the other stations. The group is characterized by the high number of species with relatively low abundances. The two most abundant of these species may define the group, the gastropod *Plicopurpura patula pansa* and the bivalve *Brachidontes adamsianus*. The third group is comprised of stations S-2 and S-5 and it is defined by the gastropods *Columbella fuscata* and *Tegula* spp., which were the most abundant in both stations. This group recorded the highest affinity (<0.2) of all groups.

DISCUSSION

The great abundance and variety of species found in Cuastecomate Bay indicate the importance of gastropods and bivalves in the rocky intertidal communities of the southern coastline of Jalisco. Both gastropods and bivalves form an assemblage dominated by a small number of species. This dominance was most remarkable in the lower intertidal, where three out of thirty two species found in this intertidal zone (*Columbella fuscata*, *Tegula globulus* and *T. corteziana*) comprised 50.5% of all individuals. Many species were rare in the samples (*e.g.* species with only one individual collected during the study period).

Most species of mollusks are commonly associated with particular patches of habitat (i.e. rock cracks, crevices and holes, tide pools), which may vary in abundance and availability in the rocky shores (Williams and Morritt 1995, Underwood and Chapman 1996). Species restricted to the upper zones of the beaches of Cuastecomate Bay (*e.g. Nodilittorina aspera*, *N. modesta*, *Nerita scabricosta* and *N. funiculata*) were mostly aggregated in the moisten and shaded microhabitats of rock crevices or beneath the rocks. These aggregations are well protected from high temperatures and desiccation, the two most restrictive physical factors during the long periods of exposure in the upper littoral levels. Many gastropods and bivalves avoid exposed areas of the rocks where the wave action and the sunlight are important restrictive factors (Santés-Alvarez and Hernández 1983, Williams and Morritt 1995). Adaptations to the upper tidal levels include the ability of *Siphonaria* spp., which are cap-shaped pulmonate limpets, quite common on bare rocks during low tides, to make use of atmospheric oxygen using a functional lung (Keen 1971, Liu 1994). On the other hand, several species had a wider vertical distribution. For example, the limpet *Lottia mesoleuca* and the snails *Mancinella speciosa*, *M. triangularis* and *Mitrella ocellata*, were found in the upper, middle and lower intertidal zones. Marked differences in vertical distribution of species or their absence in some littoral levels closely relate to the transient nature of the littoral environment, which changes from nearly terrestrial to completely marine conditions. Environmental cues that govern distribution of these species were not evaluated, but we predict that they respond to features of the habitat, which are very variable across the shore. In some cases, individuals of the same species were found scattered at distances of a few to tens of meters, closely related to the availability of pools or other suitable microhabitats during the low tide. Other species were similarly associated with small patches of anemones and mussels (*Brachidontes* sp. and *Chloromytilus* sp.). Vertical distribution of some predator snails in the rocky intertidal may also be related to the relative vertical position of its prey (Sleder 1981, Ríos-Jara 1983). Several other factors (*e.g.* mating, feeding and competence relationships) may be important regulating factors. In addition, many snails move around on a daily basis, thereby regularly changing patterns of distribution (Chapman and Underwood 1994, Underwood and Chapman 1996).

The increase in the number of invertebrate species in the lower intertidal of rocky beaches have been directly related to a higher heterogeneity of the substratum and microhabitats (Williams 1994). The variety and abundance of algae increase substratum heterogeneity and provide shelter and food for many intertidal invertebrates. In rocky beaches, tide pools are important shelter sites for gastropods and bivalves. For example, in the lower intertidal *Tridachia diomedea*, a non-shelled opistobranch was collected in a tide pool associated to mats of the green algae *Bryopsis* and *Enteromorpha*, probably feeding on them.

Comparison with previous studies on mollusks conducted in the rocky intertidal of several localities of Jalisco and Colima shows differences in the number of species recorded (Table 3). Perhaps the most important factors to consider when comparing these studies are: (i) the sampling method, (ii), the surf exposure of the beach (*e.g.* protected, semi-exposed, exposed), and (iii) the study period. Obviously, the direct search of mollusks gives larger numbers of species and probably of individuals than the transects and quadrants method. Species composition vary with surf exposure of the beach while collections conducted throughout a year cycle may record species not found when collecting for a shorter period of the year (Williams 1993).

Results of studies shown in Table 3 indicate that the number of species collected by searching directly in the rocky intertidal was always larger than numbers obtained with transects and quadrants. Differences in species found in these localities are therefore related to sampling method. The direct search of organisms is a less restrictive and easier method of collection in the rocky intertidal. This method gives good qualitative results in terms of the variety of species obtained; the use of transects and quadrants is more useful when one is interested in quantitative data. Surf exposure is probably the most important factor determining shore populations and influencing their distribution (Lewis 1964). When comparing studies, which used the direct

TABLE 3

Comparison of several studies on mollusks conducted in the rocky intertidal of localities of Jalisco and Colima, México.

Locality	Surf exposure	Sampling method and period	Class	Number of species	Reference
El Tamarindo Beach, Tenacatita Bay, Jalisco.	P	DS (?)	Gastropoda	94	González-Villarreal 1977
Barra de Navidad, Jalisco (coastal lagoon)	P	DS (?)	Gastropoda	67	Rodríguez & Ramírez 1982
			Bivalvia	39	
Santiago Beach, Santiago Bay, Colima	S-E	DS (1Y)	Gastropoda	51	Sánchez-González 1989
La Boquita Beach, Santiago Bay, Colima	P	DS (1Y)	Gastropoda	63	Sánchez-González 1989
La Boquita Beach, Santiago Bay, Colima	P	DS (1Y)	Gastropoda	63	Sánchez-González 1989
La Audiencia Beach, Santiago Bay, Colima	S-E	DS (1Y)	Gastropoda	67	Sánchez-González 1989
La Manzanilla Beach, Tenacatita Bay, Jalisco	S-E	T&Q (1Y)	Gastropoda	41	Yañez-Rivera 1989
La Virgencita Beach, Chamela Bay, Jalisco	P	T&Q (1Y)	Gastropoda	52	Yañez-Rivera 1989
Los Arcos Beach, Banderas Bay, Jalisco.	S-E	T&Q (1Y)	Gastropoda	45	Yañez-Rivera 1989
La Calechosa Beach, Cuastecomate Bay, Jalisco	P	T&Q (_Y)	Gastropoda	12	Present study
			Bivalvia	4	
Bajada del Arroyo Beach, Cuastecomate Bay, Jalisco	S-E	T&Q (_Y)	Gastropoda	11	Present study
			Bivalvia	2	
El Laboratorio 1 Beach, Cuastecomate Bay, Jalisco	E	T&Q (_Y)	Gastropoda	14	Present study
			Bivalvia	2	
El Laboratorio 2 Beach, Cuastecomate Bay, Jalisco	S-E	T&Q (_Y)	Gastropoda	10	Present study
			Bivalvia	1	
Punta Carrizalillos Beach, Cuastecomate Bay, Jalisco	S-E	T&Q (_Y)	Gastropoda	15	Present study
			Bivalvia	3	

DS: Direct Search method, T&Q: Transects and Quadrants method, P: Protected, S-E: Semi-exposed, E: Exposed. The sampling period of each study is between brackets: (1Y): one year, (_Y): approximately half a year, (?): not especified.

search method, the number of species collected in localities protected from wave action tends to be larger. Similarly, studies with longer sampling periods recorded larger numbers of species.

The marked discrepancy in the number of species collected in the semi-exposed beaches of Cuastecomate Bay (Bajada del Arroyo, El Laboratorio 2 and Punta Carrizalillos) to other semi-exposed rocky beaches of southern Jalisco (Yáñez-Rivera 1989) may be attributed to differences in sampling period; Yañez-Rivera collected during the four seasons of the year while collections during present study covered only seven months of the year (no collections were conducted during the summer). Protected beaches generally recorded a larger number of species, suggesting that wave exposure may be restrictive to some species of mollusks. In Cuastecomate Bay, several species were more common in localities where wave action was more intense, particularly *Patella mexicana* and *Plicopurpura patula pansa*, and species of *Fissurella*, *Siphonaria*, *Trimusculus*, *Calyptraea*, *Crucibulum*, *Lottia* and *Tectura*, and most bivalves found in the bay.

Cluster analysis. The high dominance of few species of gastropods and bivalves in Custecomate Bay constrained the sampling stations clustering in space and caused that the affinity among stations was not dependent upon their vicinity but on the occurrence of secondary species and the characteristics of the beaches. For example, stations S-2 and S-5 are relatively distant of each other; S-2 is located in the north shore inside the bay while S-5 is the only station outside the bay. These stations, however, have similar morphology and surf exposure (both semi-exposed). They recorded high affinity with a dominance of *Columbella fuscata* and *Tegula* spp. Sampling stations S-3 and S-4 also have similar characteristics. These are the most exposed beaches of the bay (although S4 was considered as semi-exposed), with intense wave activity and slopes of 20°-25°. Several mollusks with wide apertures and strong hydrodynamic shells indicative of high resistant to surf and tidal currents were abundant in these beaches (*e.g. Fissurella virescens*, *Plicopurpura patula pansa*, *Mancinella triangularis*, *Stramonita haemastoma*, *Tectura fascicularis*, *Chama squamuligera*). The group formed by stations S-2 and S-5 include semi-exposed beaches with smoother slopes (near to 12° in S2 and 20° in S5), both beaches have more homogeneous topography formed of rock beds with small water retaining cracks and crevices intercalated with relatively flat sandy areas. These beaches recorded nine species in common. Some of these species were found in sandy substratum under the rocks (*e.g. Columbella fuscata*, *Mitrella ocellata* and *Tegula* spp.) but others were mostly found on the rock bed in more exposed situations (*e.g. Fissurella virescens*, *Chama squamuligera*, *Isognomon recognitus*). Station S-1 (La Calechosa Beach) is the only protected beach sampled during present study. This station have a very irregular topography (slope=14°) with rock boulders, tide pools and stones creating a variety of habitats. This beach recorded the highest number of gastropod and bivalve species, which include organisms with different life habits probably related to the ample variety of types of habitats found here. The species of the genera *Opeatostoma*, *Leucozonia*, *Diodora*, *Fissurella*, *Lottia*, *Plicopurpura*, *Stramonita*, *Brachidontes*, *Chama*, *Isognomon*, *Chloromytilus* and *Pteria* were mostly found on the rocks while those species of *Columbella*, *Mitrella* and *Tegula* were buried in the sand under rocks. The two only opistobranch species found in the present study were in the tide pools of this beach. This station formed a separated group with a relatively low affinity to all other stations probably related to the high number of secondary species and the variety of habitats.

According to Pearson's correlation analysis (Fig. 1), three groups can be determined. The first group was formed of stations S1 and S4, and was defined by the bivalve *Chama squamuligera*. This bivalve was the most abundant species in both stations. Stations S1 and S4 shared seven species in common; these were the most sheltered of all sampling stations. Abundance of these seven species was very similar among stations, except for *Opeatostoma pseudodon*. Gastropods and bivalves of this group were mostly found either on bare rocks or on rocks with barnacles. Many individuals were also nested in the rock crevices and holes during low tides. Five species were found only in these two beaches (*Collumbella strombiformis*, *Fissurella rubropicta*, *Hoffmannola hansi*, *Tridachia diomedea* and *Pteria sterna*). The second group was formed of station S3. This was the only station considered as exposed. Although this group may be defined by the gastropod *Plicopurpura patula pansa* and the bivalve *Brachidontes adamsianus*, all species in this group were also found in other beaches. Station 3 recorded a relatively high number of species in the lower intertidal (16). A third group was formed of stations S2 and S5, two semi-exposed beaches. This group was defined by the snail *Tegula* spp, which was very abundant in both stations. These stations shared nine species in common but numbers of individuals among stations were quite different. Several of the most abundant species of this group were common in the sandy substratum under the rocks (*e.g. Columbella fuscata*, *Mitrella ocellata, Tegula* spp.), while other less abundant species were mostly found exposed on the rocks.

More studies are needed, especially ones which utilize similar methodologies in different habitats. Research designed to examine the effect of environmental factors, such as desiccation, heating and wave action, must be carried further. Direct field observations of mollusks behavior at the rocky intertidal under different wave exposure conditions would add to our understanding of their distribution and abundance in these beaches. Do rocky shore structures serve as refuge from wave action for numerous mollusks or only for some species? What physiological and morphological characteristics predominate in exposed and protected beaches? For example, several studies suggest that shells of mollusks may be thicker and stronger in exposed intertidal rocky-shores (Kitching 1976, Giraldo-López and Gómez-Schouben 1999). However, the variation of the shell shape with wave action is typical for each species. Does this apply to the mollusks species of Cuastecomate Bay? These are just some of the questions that future research should explore in the localities of present study. They are approachable with creative field designs or laboratory observational studies.

ACKNOWLEDGMENTS

We wish to thank Daniel Kosonoy for invaluable help during sampling activities. Martín Pérez-Peña, Alejandro Muñoz-Urias and Ildefonso Enciso-Padilla provided assistant in the use of the computer programs for cluster analysis at the Departamento de Ecología of the Universidad de Guadalajara.

RESUMEN

Se presenta la distribución y abundancia de las especies conspicuas de gastrópodos y bivalvos encontradas en cinco playas rocosas de la Bahía Cuatecomate, Jalisco. El muestreo se realizó desde septiembre de 1993 hasta marzo de 1994 usando cuadrantes de 0.75 m2 colocados a lo largo de líneas de transectos (longitud = 10 m) en réplica, en las zonas supralitoral y mesolitoral (intermareal superior, medio e inferior). Se recolectó 6 643 moluscos. Los gastrópodos dominaron las muestras (6 272 individuos, 44 especies), los bivalvos fueron menos abundantes y diversos (371 individuos, cinco especies). Diecisiete especies representaron el 89.8% de todos los individuos recolectados. Los gastrópodos *Nodilittorina aspera* y *Nerita scabricosta* fueron los más abundantes con 637.8 y 71.43 individuos/m^2, respectivamente. Los bivalvos más abundantes fueron *Brachidontes adamsianus* y *Chloromytilus palliopunctatus* con 60.7 y 61.3 individuos/m^2, respectivamente. La abundancia de gastrópodos disminuyó desde el supralitoral hacia las zonas inferiores mientras que el número de especies aumentó en esa misma dirección. El número de especies de bivalvos también aumentó desde el supralitoral hacia la zona intermareal inferior; la abundancia de individuos fue mayor en la zona intermareal media. La afinidad entre grupos de especies de diferentes estaciones de muestreo fue identificada calculando el coeficiente de correlación de Pearson usando los valores de abundancia (ind./m^2), y el índice de disimilaridad de Jaccard usando la información sobre presencia o ausencia de las especies en la zona intermareal inferior. La afinidad entre estaciones no dependió de su cercanía sino de la alta dominancia de algunas especies, de la abundancia relativa de las especies secundarias y de las características propias de cada playa.

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