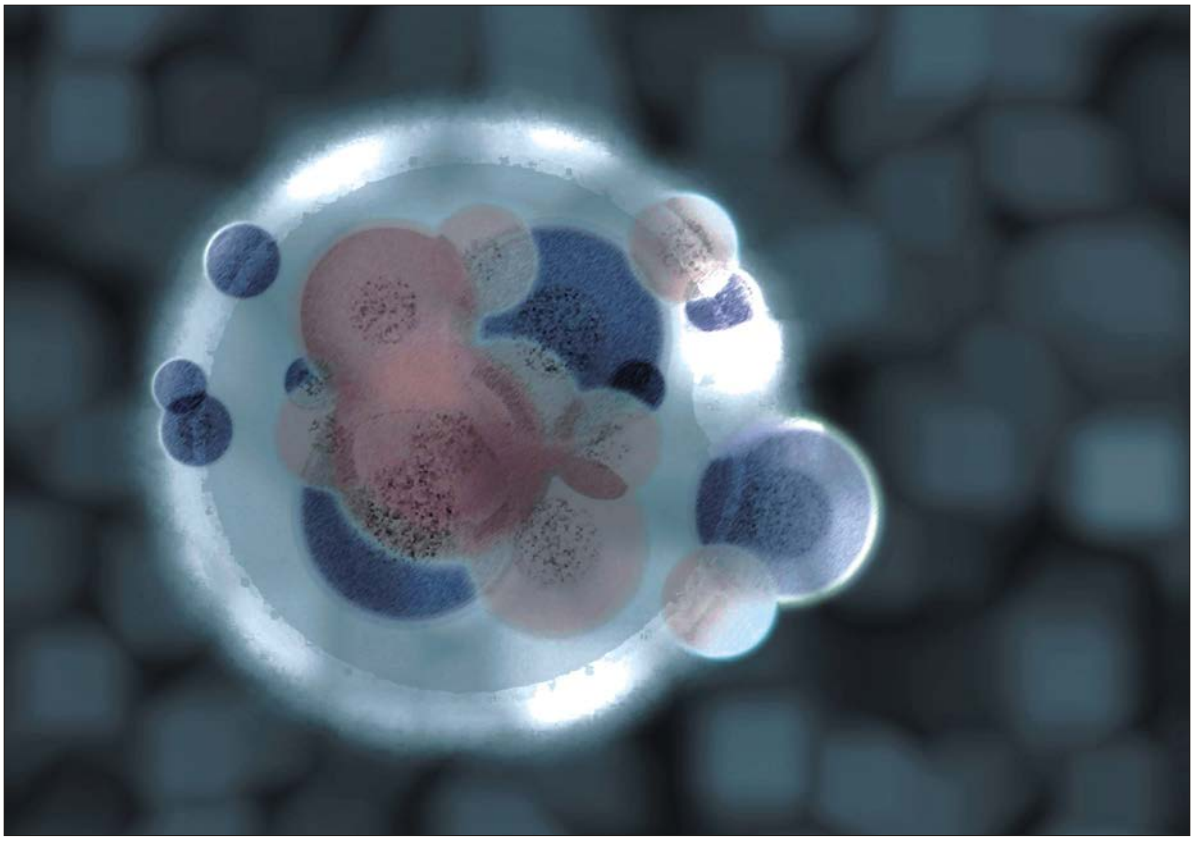

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Structure of Reef Fish Communities in the Littoral of Colima, Mexico

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Abstract: This research was made in three coral reef of Colima State, México (La Boquita, Club de Yates and Punta Carrizales) which are treated by coastal development, marine pollution and human smugglers of ornate fish. The main goal was to obtain species richness, estimation of fish relative abundance and others ecological indices of reef fish assemblages in order to provide baseline to future changes. The fish census was obtained through underwater observation during the year 2004. A total of 4,627 organisms were recorded in a surface area of 3,100 square meter of the three selected areas. Forty six species belonging to 23-families were detected. Most species-rich families were Pomacentridae (5 species) followed by Lutjanidae and Labridae (4 species) and Acanthuridae, Carangidae, Haemulidae (3 species). Of this species recorded in La Boquita most abundant were *Thalassoma lucasanum* (30%), 22% belongs to *Stegastes acapulcoensis* and 19% to *Chromis atrilobata*. In Carrizales the most abundance species belongs to *Haemulon maculicauda* with 14.8% and *Stegastes acapulcoensis* with 18% By last, Club de Yates, 17% belong to *Prionurus punctatus* and *Haemulon maculicauda* with 14%. The density organism per square meter was higher in the Club de Yates with 1.8 organisms, Carrizales with 1.5 and minor in La Boquita with 1.26 organisms. The values of diversity index and equity also were estimated. They fluctuate between 0.84 in La Boquita and 0.94 in Club de Yates. These results indicate changes of reef fish assemblages between sites in the littoral of Colima derive by physical and biological factors. It is important to take conservation measurement to protect this ecosystem in Colima.

Key words: Reef fish, coral reef, abundance indices

INTRODUCTION

The coral reefs have the greater concentration and diversity of fish species on the ocean. Unfortunately, little is known about his dynamics, community structure and its requirements for microhabitats. The changes in the absolute and relative abundance of the ictical components of rocky reefs could have deep effects on the ability of these local communities to recover by themselves in case by future disturbances. The diversity of species has the capacity to increase the resilience of the ecosystem to support environmental adverse effects[1]. The coast of the Colima State is characterized to have a narrow continental shelf. This fact reduces the fishing potential comparing with other places. Nevertheless, their subtropical climate and the coastal configuration with multiple estuaries and coastal lagoons cause it to be a rich coast in diversity of marine species of ichthyologic fauna. There are rocky promontories and steep slabs that affect the diversity of fish species. This important diversity little has been studied for two fundamental reasons: 1) much of this one is small and lacks commercial value and 2) its study and collects is difficult with traditional arts of fishing.

The coastal development, mainly in the bays of Manzanillo and Santiago, has been intense in the last decades. This fact has modified the coast by means of harbor works, channels, ports and tourism development on the coast, is why its environmental impact could be of irreversible consequences. Its effects on the coastal ecological systems have been negative, an example can be mentioned: the destruction of mangrove in the Cuyutlán, San Pedrito and Juluapan lagoons that could hit the rocky reef communities since it has happened in other places[2]. Not controlling these changes on the coast could exceed the limits of tolerance of the organisms in coral reefs. Factors combined with the fishing that already affects these ecosystems.

The objective of this study was to characterize the structure of the communities of fish in terms of composition of species, diversity, equity, index of

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dominance, density, relative abundance, biomass and ichthyotrophical categories in three different sites in the coast of Colima as basic study to evaluate possible adverse effects on these ecosystems by projects of coastal development in the zone.

MATERIALS AND METHODS

This study was made on two important coral reefs of Colima State coast and one rocky reef. Colima State is located on the southern coast of the Mexican Pacific Ocean, between 103°19.3' to 104°41.6' of West Longitude and between 18°41.2' to 19°31.3' North Latitude (Fig. 1). Manzanillo is located at the Northwest of the Colima State, between 19°27'29" North Latitude and 104°37'110" West longitude (Fig. 1). The predominant climate is warm sub-humid with rains in summer and autumn and dry in winter and spring, the annual average temperature is 31.4°C; the relative humidity oscillates between the 70 and 79%, with an annual average precipitation of 985,3 mm[3].

The selection of the samplings places was made according its relevance as coral reef area and the tourist attractiveness (La Boquita and Punta Carrizales). A rocky reef without coral (Club de Yates) was selected with comparative aims.

In these reefs three species of coral stand out: Pocillopora capitata, Porites lutea and *Sipbonorgia* sp. La Boquita and Carrizales reefs have an oval form, with their greater axis, of approximately 200 m parallel to the coast and with their smaller axis of approximately 50 m, perpendicular to the coast (with a surface, also approximated, of 10,000 m^2). They have an average depth of three meters. The coral reef Punta Carrizales has the form of a small horseshoe where the ends count on coral and the intermediate part is sandy plains. Its length in both ends is 400x50 m approximately (with 20,000 m^2 each of surface) with an average depth of five meters. Both coral reefs are oriented north to south and separated by 3 km approximately. The level of human disturbance is significantly greater in La Boquita than in Carrizales. These disturbances, in La Boquita, include the destruction of the habitat by the anchors of the boats and the permanence of a tunny anchored net near this reef. This tunny net captures between 80 and 135 tons annually corresponding to 56 species[4]. Mainly pelagic species of the Carangid genus and others of carnivorous habits. The rocky reef of the Club de Yates consists of a rock promontory with a depth of 10 m, it does not have coral and it maintains a more intense wave dynamics than the places of La Boquita and Carrizales.

The information about the structure of rocky reef fish is difficult to obtain due to the diversity, fauna mobility and variety of microhabitats in the complex rocky substrate[5]. The applicability and limitations of several used techniques to estimate the abundance and structure of fishes in the reef have been reviewed by several authors[6-13]. The techniques include the use of fishing arts (nets, traps and hooks), poisons, explosives and censuses by visual observations. The visual observations by

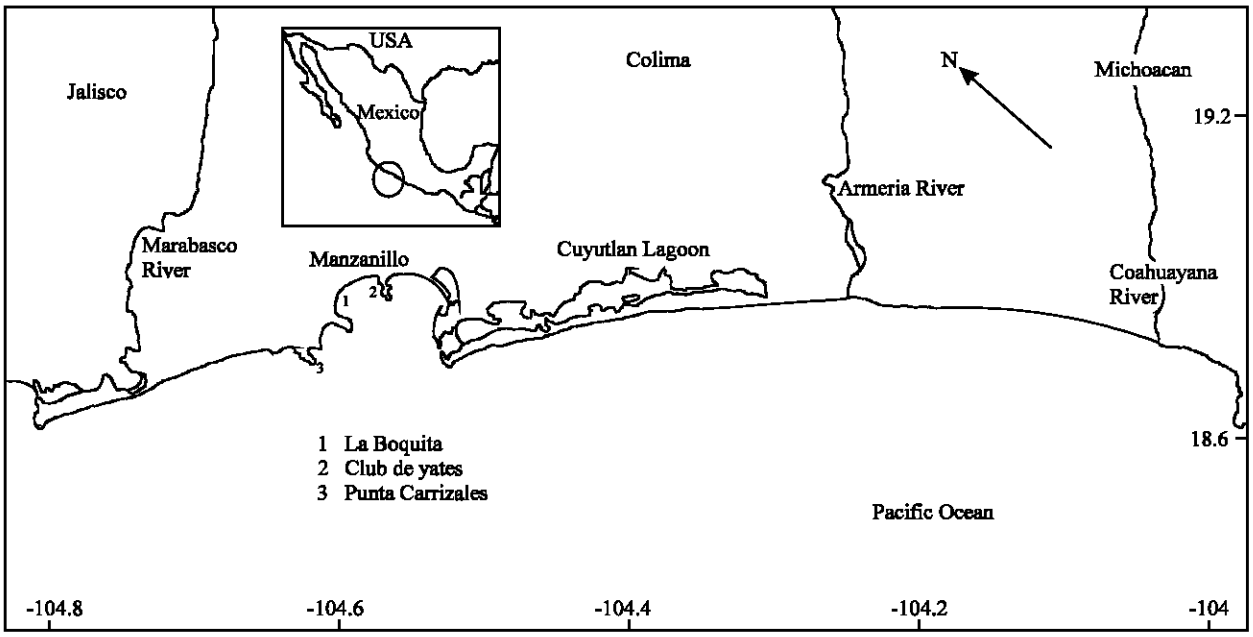

Fig. 1: Geographic location of study areas on Colima, Mexico

means of the independent diving are the commonest used method in structure studies of rocky reef fish[14,15]. It has the advantage of a nondestructive method for quantitative evaluation that can be repetitive without damage.

Monthly sampling campaigns were made in the three selected areas (from 23/04/2004 until 22/10/2004). In each area, immersions with independent diving gear were done making submarine visual censuses between a depth of 2 to 10 m. All of them were done during the day between 09:00 and 13:00 hours with an approximately duration of 8 to 12 min by transect. The length of the transects was 25 m, chosen randomly. Two observers maintained a vision of four meters wide covering an approximated surface of 100 m^2. All those fish that were o passed by that area were counted. Information of each species and number of individuals was obtained being made the identification *in situ*. The species that had doubts were photographed for their later identification.

The count provided information on the percentage of frequency of sightings (%FA considered like the percentage that the species was registered for all transects), abundance (number of individuals) and density (the number of individuals by m^2). The relative abundance calculated by the rate between the number of organisms of each species and the total of individuals of all the species multiplied percent. The density of organisms was obtained dividing the total number of individuals between the total sampled surfaces. The Simpson diversity index was used (DSp) because it is more sensitive to changes in the abundance of most species of a community and the Shannon index (H') that is more sensitive to the changes in the abundance of rare species of a community[16] was used too. They were calculated by means of the expressions:

$$Dsp = 1 - \lambda \qquad \lambda = \sum n_i (n_i - 1) / N (N-1)$$

$$H' = \sum p_i \log \qquad p_i p_i = n_i / N$$

Where:

n_i = Number of individuals of species

N = The total number of observed individuals.

Also the possible maximum value (DSmax) of the Simpson diversity index was estimated according:

$$Dsmax = [(s - 1)/s] * [N/(N - 1)]$$

Where, s = number of observed species (Hmax = - ln (1/s) for Shannon index).

Later, with this information, the equity of community (uniformity) or relative diversity was calculated (like Eq = DSp/Dsmax) with the purpose of considering how heterogenous is the fish community in the rocky reef of each one of the studied localities. In order to consider the similarity between the communities of fish in the selected areas, the Percentage of Similarity (PS) was used (like: PS = $\sum$ [the inferior value of the relative abundance of each species in both communities]). This index takes into account the proportionality from the relative abundance between the communities. Also the Morisita-Horn index was used to consider the similarity of fish communities between places[17]. It's main characteristic is it's robustness when differences between species diversity or sample sizes exist. Basically it talks about the probability that an individual randomly chooses for each one of the two communities belonging to the same species[18]. It's calculated like:

$$I_M = 2 \sum X_i Y_i [(I_1 + I_2) N_1 N_2]$$

Where, X_i and N_1 are the number of individuals of species I and the total number of individuals in community 1. Also, Y_i and N_2 are the number of individuals of species I and the total number of individuals in community 2. Using the same annotation for I_1 and I_2 these are defined as:

$$I_1 = \sum X_i [(X_1 - 1) / N_1 (N_1 - 1)$$

and

$$I_2 = \sum Y_i [(Y_1 - 1) / N_2 (N_2 - 1)$$

The value of the Morisita Index is 0 (no similarity) to 1 (identical) and has the desirable characteristics of not being influenced by the sample size[19]. In the same way, the dominance index was applied. This index refers to the numerical abundance of the species and its influence on the community nature according to the formula[20]:

$$I.D. = 100 X Y_1 + Y_2 / Y$$

Where, Y_1 is the number of individuals of the most dominant species; Y_2 is the second species with greater number of individuals; Y is total number of individuals of all the species. The lengths were considered using validated techniques[21]. This information was used to estimate the total biomass using the length-weight relationship reported for 18 species of fish with commercial value in this region[22]. The observation of the conduct of the fish was done using reports about this subject[23]. A trophic classification of the fish was done: herbivores, planktivore, microinvertivore, macroinvertivore and piscivore. At the same time they were divided in as first order consumers (planktivore, herbivores and microinvertivore); second order

consumers (macroinvertivore, including some herbivores) and third order consumers (piscivore and macroinvertivore)[24]. The feeding behavior was characterized by bottom, average water and surface water.

In order to evaluate the differences between the considered abundance indices in the sampling sites, an analysis of variance under the randomized complete blocks design was made, with a significance level $\alpha = 0.05$. Using abundance indices as a variable and the three sites of sampling like treatments whereas the detected species constituted the blocks of the design. Previously the collected data were standardized.

RESULTS

A total of 4,627 organisms were counted in a total surface of 3,100 m^2. In La Boquita there were 1,646 individuals belongs to 20 families, 1,538 individuals were counted in Carrizales divided in 22 families. In Club de Yates 1,443 individuals pertaining to 18 families were observed.

Altogether 47 species corresponding to 23 families were detected (Table 1). Of these, the family with the greater number of species was Pomacentridae with five species, followed by the families Lutjanidae and Labridae with four species each and Acanthuridae, Carangidae and Haemulidae with three identified species for each.

Only 23 species were observed in the three sites, an amount that corresponds to 50% of the total observed species. In addition 11 (23.9%) species were observed only in one place.

The most abundant of the observed species in La Boquita was *Thalassoma lucasanum* (30%) followed by *Stegastes acapulcoensis* (24%) and *Chromis atrilobata* (19%). In Carrizales the most abundant species correspond to *Stegastes acapulcoensis* with 18.9% and *Haemulon maculicauda* with 14.8%. Finally, in Club de Yates 17.7% correspond to *Prionurus punctatus* and *Haemulon maculicauda* with 14.7% (Table 2).

The comparison of the three selected sites show that the number of species was greater in Carrizales with 39 species and Club de Yates with 38 species and smaller in La Boquita with 31 species. Also the density of organisms by square meter was greater in Club de Yates with 1.8 organisms, Carrizales with 1.5 and smaller in La Boquita with 1.26 organisms by square meter (Table 3).

The diversity is an important characteristic in the reef fish communities and generally is associated with other properties of the ecosystem. The values of the Simpson diversity index varied from 0.81 in La Boquita to 0.91 in Club de Yates and Carrizales. There were very similar values for the Shannon index. The obtained values for equity between the localities fluctuated from 0.84 in La Boquita to 0.94 in the Club de Yates, showing more uniformity the Club de Yates and Carrizales compared with La Boquita (Table 3).

The greater dominance index for La Boquita (52.8) suggests a greater effect of the *Stegastes acapulcoensis* and *Chromis atrilobata* species on the fish species of the coral reef in this place. In case of Club de Yates and Carrizales, the dominant effect of the most abundant species is smaller.

The results about the Morisita community similarity coefficient and PS indicate that differences between the communities of the studied sites exist. We can see greater similarity indices for La Boquita and Carrizales (0.58) and lower similarity between La Boquita and Club de Yates (0.15). The percentage of similarity presented the same behavior as far as the comparison of sites (Table 4). The analysis of variance (ANOVA) to compare the abundance indices between sampled places shows that significant differences exist among them ($F = 8.72$, $p = 0.00027$).

As far as the present biomass during the period of this study, only those species of fish which the information of the length-weight relationship was available were considered (Table 5). For example, the average biomass calculated in La Boquita was of 69 g m^{-2}, where nine species of commercial fish were identified, for the Club de Yates the average biomass was 2,064 g m^{-2} for 16 commercial species and for Carrizales it was 613 g m^{-2} for 16 species.

In the considered biomass *Prionurus punctatus* emphasizes with 23,271.6 g/100 m^2 in the Club de Yates; *Anisotremus interruptus* with 2,063.3 g/100 m^2 in Carrizales and *Lutjanus viridis* in La Boquita with 1,082.1 g/100 m^2.

Table 1: List of fish species and frequencies found in three reefs in Manzanillo, Colima

		% Frequency		
Species	Common name	La Boquita (N =1646)	Club de Yates (N =1443)	Punta Carrizales (N =1538)
Acanthuridae				
Acanthurus nigricans	Cirujano cola blanca	8	50	NP
Acanthurus xanthopterus	Barbero	NP	25	NP
Prionurus punctatus	Calandria	38	100	50
Balistidae				
Sufflamen verres	Cochino	8	63	60

Table 1: Continue

Species	Common name	% Frequency		
		La Boquita (N =1646)	Club de Yates (N =1443)	Punta Carrizales (N =1538)
Bleuniidae				
Ophioblennius steindachneri	Cachudito Mono	23	NP	40
Carangidae				
Caranx caballus	Cocinero	NP	10	20
Caranx caninus	Jurel	NP	10	20
Caranx sexfasciatus	Ojo de Perra	NP	NP	10
Chaetodontidae				
Chaetodon Humeralis	Mariposa Triplebanda	23	88	60
Johnrandallia nigrirostris	Mariposa Limón	31	50	60
Cirrhitidae				
Cirrhitis rivulatus	Halcón Gigante	NP	NP	10
Cirrhitichthys oxicephalus	Halcón de Coral	31	NP	60
Diodontidae				
Diodon holocanthus	Pez Erizo	23	100	50
Diodon hystrix	Puercoespín	NP	50	NP
Haemulidae				
Anisotremus interruptus	Bacoco	NP	50	30
Haemulon maculicauda	Rasposa	31	100	60
Haemulon sexfaciatus	Guzga	8	25	NP
Holocentridae				
Myripristis leiognathus	Soldado	15	100	70
Sargocentron suborbitalis	Ardilla	23	75	60
Kyphosidae				
Kyphosus elegans	Chopa	NP	NP	20
Fistulariidae				
Fistularia Commersonni	Trompeta	31	63	70
Labridae				
Bodianus diplotaenia	Vieja	31	88	40
Halichoeres chierchiae	Señorita	64	100	80
Thalassoma lucasanum	Vieja Arco iris	27	NP	90
Thalassoma grammaticum	Viejita Crepúsculo	NP	13	NP
Labrisomidae				
Malacoctenus zonifer	Trambollo del Pozo	NP	NP	10
Lutjanidae				
Lutjanus argentiventris	Pargo Alazán	NP	75	70
Lutjanus novemfasciatus	Pargo Mulato	NP	63	40
Lutjanus gntattus	Pargo Lunarejo	NP	25	NP
Lutjanus viridis	Pargo Rayado	31	25	70
Mullidae				
Mulloidichthys dentatus	Chivo	30	63	60
Muraenidae				
Gymnothorax nnchilatus	Morena Ondulada	NP	NP	10
Gymnothorax casteneus	Morena Castaña	NP	NP	10
Ophichthidae				
Myrichthys tigrinus	Tieso	8	25	10
Ostraciidae				
Ostracion meleagris	Pez Cofre	15	38	40
Pomacanthidae				
Holacanthus passer	Muñeca Rey	23	63	80
Pomacentridae				
Abudefduf troschelii	Pintaño	38	48	70
Chromis atrilobata	Cola de Tijera	38	25	50
Microspathodon dorsalis	Jaqueta Gigante	90	56	60
Stegastes acapulcoensis	Castañeta indiga	92	100	100
Stegastes flavilatus	Castañeta Azul	70	100	80
Tetraodontidae				
Arothron meleagris	Botete Negro	90	63	60
Sphoeroides annulatus	Botete Anillado	23	63	NP
Sciaenidae				
Pareqnes viola	Corvinilla	3	50	40
Serranidae				
Epinephelus labriformis	Cabrilla	46	75	80
Epinephelus panameusis	Cabrilla Panameña	23	63	30
Serranus psittacinus	Serrano Rayado	NP	13	NP

NP= No presence

Table 2: Relative abundance of fish species by areas in Manzanillo, Colima

		Relative abundance		
Species	Common name	La boquita	C. de yates	Punta carrizales
Acanthurus nigricans	Cimjano	0.059	3.58	0.0
Acanthurus xanthopterus	Barbero	0.0	0.89	0.0
Prionurus punctatus	Calandria	0.47	17.8	1.75
Sufflamen verres	Puerco Negro	0.06	1.10	1.23
Ophioblennius steindachneri	Cachudito Mono	0.59	0.0	0.52
Caranx caballus	Cocinero	0.0	0.27	3.31
Caranx caninus	Jurel	0.0	0.13	0.26
Caranx sexfasciatus	Ojo de Perra	0.0	0.0	0.06
Chaetodon Humeralis	Triple banda	0.53	1.58	0.71
Johurandallia nigrirostris	Mariposa Limón	0.47	0.55	0.58
Cirrhitis rivulatus	Halcón Gigante	0.0	0.0	0.13
Cirrhitichthys oxicephalus	Halcón de Coral	1.36	0.0	1.30
Diodon holocanthus	Pez Erizo	0.47	9.66	1.04
Diodon hystrix	Pez Erizo Pinto	0.0	1.44	0.0
Anisotremus interruptus	Bacoco	0.0	0.55	5.91
Haemulon maculicauda	Rasposa	0.47	14.83	14.88
Haemulon sexfaciatus	Guzga	0.11	3.93	0.0
Myripristis leiognathus	Soldado	0.41	6.69	2.40
Sargocentron suborbitalis	Ardilla	0.17	1.03	1.43
Kyphosus elegans	Chopa	0.0	0.0	0.65
Fistularia Commersonni	Trompeta	0.82	0.48	0.84
Bodianus diplotaenia	Vieja	0.65	2.55	1.23
Halichoeres chierchiae	Señorita	3.1	2.48	1.95
Thalassoma lucasanum	Vieja Arco iris	29.5	0.0	5.20
Thalassoma grammaticum	Viejita Crepúsculo	0.0	0.34	0.0
Malacoctenus zonifer	Trambollo del Pozo	0.0	0.0	0.01
Lutjanus argentiventris	Pargo Alazán	0.0	3.52	1.43
Lutjanus novemfasciatus	Mulato	0.0	0.82	0.39
Lutjanus guttatus	Lunarejo	0.0	0.48	0.0
Lutjanus viridis	Rayado	3.9	0.41	7.67
Mulloidichthys dentatus	Chivo	5.6	1.58	7.93
Gymnothorax undulatus	Morena ondulada	0.0	0.0	0.06
Gymnothorax castaneus	Morena Castaña	0.0	0.0	0.06
Myrichthys tigrinus	Tieso	0.06	0.26	0.06
Ostracion meleagris	Pez Cofre	0.23	0.34	0.32
Holacanthus passer	Muñeca Rey	0.47	0.89	1.49
Abudefduf troschelii	Pintaño	0.35	5.38	2.79
Chromis atrilobata	Cola de Tijera	18.5	0.82	4.87
Microspathodon dorsalis	Jaqueta Gigante	1.95	1.17	1.17
Stegastes acapulcoensis	Castañeta indiga	24.4	5.79	18.98
Stegastes flavilatus	Castañeta Azul	3.07	4.00	2.66
Arothron meleagris	Botete Negro	0.059	0.62	1.17
Sphoeroides annulatus	Botete Anillado	0.1	0.48	0.0
Pareqnes viola	Corvinilla	0.59	0.55	0.39
Epinephelus labriformis	Cabrilla	0.9	1.86	1.82
Epinephelus panamensis	Cabrilla Panameña	0.5	0.76	1.10
Serranus psittacinus	Serrano Rayado	0.	0.13	0.0
Total %N		100%	100%	100%

Table 3: Species richness, density, diversity (Simpson y Shannon), equity and dominance indices in reef fishes on Santiago Bay, Colima

Places	Species richness	Density (fish m^{-2})	Diversity index DSp	Diversity index (H')	Equity index	Dominance index
La Boquita	31	1.26	0.81	2.11	0.61	52.8
C. de Yates	38	1.80	0.91	2.92	0.80	32.5
Carrizales	39	1.53	0.91	2.91	0.79	33.8

Table 4: Reef fish similarity between areas using Morisita and Percent of Similarity indices

Places	Shared species	Morisita index	Similarity percentage
La Boquita-Punta Carrizales	28	0.58	0.52
La Boquita-Club deYates	28	0.15	0.23
Club de Yates-Punta Carrizales	30	0.55	0.50

The trophic classification of the observed species shows that more than 36% of the total species have an opportunistic nutritional habit and the rest are specialist in their nutritional habits. In general, 18 species of the 47 observed species, are consumers of first order (38% herbivore and planktivore); 17 are consumers of second

Table 5: Calculated biomass per 100 square meters of commercial fish in the reefs: La Boquita (Bq), Club de Yates (CY) and Punta Carrizales (Ca) in the littoral de Colima, México

Species	Length-weight relationship*	Average length (cm)			Calculate average weight (g)			Number of fish per 100 m^2			Average biomass (g/100 m^2)		
		Bq	CY	Ca	Bq	CY	Ca	Bq	CY	Ca	Bq	CY	Ca
Acanthurus xanthopterus (Barbero)	$Pt = 0.097 \times Ls^{2.79}$ r = 0.990	0	20.3 *(±6.6)*	0	0	431.2	0	0	6.5	0	0	700.7	0
Prionurus punctatus (Calandria)	$Pt = 0.0095 \times Ls^{3.50}$ r = 0.920	11.5 (±4.8)	23.3 (±5.7)	17.8 (±6.0)	48.9	580.0	226.0	0.6	32.3	2.7	30.1	23271.6	610.2
Stuffamen verres (Puerco Negro)	$Pt = 0.17 \times Ls^{2.51}$ r = 0.900	25.0 (±0.0)	20.0 (±5.3)	18.7 (±5.1)	548.6	313.3	264.7	0.1	2.0	1.9	42.2	626.6	537.3
Caranx caballus (Cocinero)	$Pt = 0.078 \times Ls^{2.04}$ r = 0.930	0	15.0 (±0.0)	11.2 (±5.3)	0	19.5	10.7	0	0.5	5.1	0	9.8	24.5
Caranx caninus (Jurel)	$Pt = 0.04 \times Ls^{2.90}$ r = 0.990	0	7.5 (±0.0)	17.5 (±5.0)	0	13.7	161.0	0	0.3	0.4	0	3.4	64.4
Caranx sexfasciatus (Ojo de perra)	$Pt = 0.112 \times Ls^{2.55}$ r = 0.990	0	0	25.0 (±0.0)	0	0	411.1	0	0	0.1	0	0	41.1
Anisotremus interruptus (Bacoco)	$Pt = 0.067 \times Ls^{2.822}$ r = 0.960	0	14.0 (±2.6)	21.0 (±4.9)	0	114.9	360.8	0	1.0	9.1	0	114.9	2821.0
Haemulon maculicauda (Rasposa)	$Pt = 0.17 \times Ls^{2.39}$ r = 0.850	10.3 (±3.8)	13.8 (±4.9)	13.8 (±2.7)	44.7	90.1	90.1	0.6	26.9	22.9	21.5	2547.8	2063.3
Haemulon sexfaciatus (Guzca)	$Pt = 0.106 \times Ls^{2.63}$ r = 0.980	15.0 (±0.0)	20.0 (±5.0)	0	131.3	279.9	0	0.2	7.1	0	20.2	1791.2	0
Myripristis leiognathus (Soldado)	$Pt = 0.046 \times Ls^{2.93}$ r = 0,730	12.8 (±3.6)	13.6 (±3.7)	10.7 (±3.7)	80.7	96.3	47.7	0.5	12.1	3.7	13.1	1167.6	176.5
Kyphosus elegans (Chopa)	$Pt = 0.01 \times Ls^{3.62}$ r = 0,920	0	0	20.0 (±5.2)	0	0	512.5	0	0	1.0	0	0	512.5
Fistularia Commersonni (Trompeta)	$Pt = 0.015 \times Ls^{2.31}$ r = 0.893	21.4 (±6.3)	32.1 (±4.8)	32.8 (±7.5)	17.7	45.3	47.6	1.1	0.9	1.3	19.1	39.6	68.1
Lutjanus argentiventris (Pargo Alazan)	$Pe = 0.049 \times Ls^{2.82}$ r = 0.970	0	19.3 (±0.0)	18.6 (±4.9)	0	219.0	186.3	0	6.4	2.2	0	1396.1	409.9
Lutjanus novemfasciatus (Pargo Mulato)	$Pt = 0.027 \times Ls^{2.943}$ r = 0.977	0	17.5 (±4.5)	16.6 (±4.0)	0	122.9	105.2	0	1.5	0.6	0	184.4	63.1
Lutjanus gutattus (Pargo Lunarejo)	$Pt = 0.07 \times Ls^{2.68}$ r = 0.980	0	16.4 (±3.7)	0	0	126.1	0	0	0.9	0	0	110.3	0
Lutjanus viridis (Pargo Rayado)	$Pt = 0.057 \times Ls^{2.87}$ r = 0.890	12.6 (±3.5)	15.0 (±0.0)	82.0 (±3.2)	13.2	135.2	91.7	5.2	0.8	11.8	422.6	101.4	1082.1
Mulloidichthys dentatus (Chivo)	$Pt = 0.029 \times Ls^{2.99}$ r = 0.970	7.7 (±3.9)	14.0 *14.2* (±2.5)	(±2.2)	12.9	77.5	80.8	7.3	2.9	12.2	36.5	63.3	985.8
Epinephelus labriformis (Cabrilla)	$t = 0.047 \times Ls^{2.82}$ r = 0.940	9.0 (±3.1)	18.6 (±7.3)	16.3 (±6.7)	23.0	178.6	125.3	0.8	3.4	2.8	21.8	907.2	350.8

*From: Espino-Barr *et al.*[22]; r = correlation coefficient

order (36% microinvertivore, macroinvertivore) and 12 species are consumers of the third order (25% piscivore). Most of the species have a nutritional behavior related to the substrate of the reef (82%). Only six species use others habitats in addition to rocky reefs to look for food (Table 6).

According to the trophic categories, in La Boquita 45% of the species are herbivore (first order consumer) and a smaller percentage are third order consumers (13%). In the case of Club de Yates the most of consumers are second order consumers (39%). In Carrizales a greater uniformity between the trophic categories with respect to the other sites exists.

DISCUSSION

The amount of present species provides information on the richness of the coral reef and gives us a biodiversity indicator. This is interesting when comparing the obtained results in these places with other localities.

Table 6: Trophic structure of reef fishes (Categories and trophic level: Primary Consumer: H, Herbivore; P, Planktivore; Secondary Consumer: Mi Microinvertivore; Ma, Macroinvertivore; Third Consumer: F, Piscivore. Feed areas: S, surface ; M, middle water; B, bottom)

Species and trophic category	Feeding behavior	Feeding Zone	Feeding area
Consumidor primario			
Acanthurus nigricans	H	B	
Acanthurus xanthopterus	H	B	
Prionurus punctatus	H	B	
Ophioblennius steindachneri	H	B	
Chaetodon Humeralis	Mi, H	B	
Johurandallia nigrirostris	Mi, H	B	
Kyphosus elegans	H	M, S	
Thalassoma lncasanum	P, Mi	B, M	
Abudefduf troschelii	P	M, S	
Thalassoma grammaticum	P, Mi	B, M	
Malacoctenus zonifer	Mi	B	
Holacanthus passer	H	B	
Chromis atrilobata	P	M	
Stegastes acapulcoeusis	H	B	
Stegastes flavilatus	H	B	
Arothron meleagris	Mi, H	B	
Sphoeroides anuulatus	Mi, H	B	
Microspathodon dorsalis	H	B	
Consumidor secundario			
Sufflamen verres	P, Ma	B	
Cirrhitis rivulatus	Mi	B	
Cirrhitichthys oxicephalus	Mi	B	
Diodon holocanthus	Ma	B	Out side
Diodon hystrix	Ma	B	Out side
Anisotremus interruptus	Ma	B	
Haemulon maculicauda	Ma	B	
Haemulon sexfaciatus	Ma	B	
Myripristis leiognathus	Ma	B	
Sargocentron suborbitalis	Ma	B	
Bodianus diplotaenia	Ma, Mi	B	
Halichoeres chierchiae	Ma	B	
Myrichthys tigrinus	Ma	B	
Ostracion meleagris	Mi	B	
Pareques viola	Mi	B	
Serranus psittacinus	Mi	B	
Mulloidichthys dentatus	Mi	B	
Consumidor tercer orden			
Caranx caballus	F	S, M	Out side
Caranx caninus	F	S, M	Out side
Caranx sexfasciatus	F	S, M	Out side
Fistularia Commersonni	F, Ma	M	Out side
Lutjanus argentiventris	F, Ma	B, M	
Lutjanus novemfasciatus	F, Ma	B, M	
Lutjanus gntattus	F, Ma	B, M	
Lutjanus viridis	F, Ma	B, M	
Gymnothorax nnchulatus	F, Ma	B	
Gymnothorax casteueus	F, Ma	B	
Epiuephelus labriformis	F, Ma	B	
Epiuephelus panameusis	F, Ma	B	

Fourty seven species of rocky reef fish are reported, this does not mean that these are the unique ones since by the study methodology (visual observations) species exist with nocturnal habits and other that are criptic and are not easily observed. On the other hand, the diversity of fish species also is correlated with the size of the reef[25]. The three selected sites are relatively small areas (between 10,000 to 40,000 m^2 of coralline reefs including rocky bottoms). Results of similar studies in reference to the number of species of fish are presented in Table 7.

Table 7: Species number of reef fish in others studies in the Mexican Pacific Ocean

Locality	Species
California Gulf	271 [43]
Parque Nacional de Huatulco, Oaxaca	51 [30]
Bahía de Tenacatita, Jalisco	49 [28]
Bahía Banderas, Jalisco	78 [27]
Bahía de la Paz, Baja California Sur	10 [44]
Isla Cerralvo, Baja California Sur	90 [45]
Litoral de Colima	68 [46]
Bahía Santiago, Colima	47 [This study]

The geographic differences of the structure of fishes are complicated to explain. There are physical, biological and habitat factors different in each one of the localities. The families which contribute with more species are coincident with other studies made in Mexico[26-28] and in other areas of the world[29]. From these species the most important it was *Pomacentridae*.

The dominant species in La Boquita were *Stegastes acapulcoensis*, *Chromis atrilobata* and *Thalassoma lucasanum*. They were coincident with those obtained for a reef in Huatulco, Oaxaca[30] and for the Bay of Tenacatita, Jalisco[28]. Nevertheless the species dominance was different for Carrizales reef, where *Haemulon maculicauda* and *Stegastes acapulcoensis* were more abundant. The rocky reef Club de Yates does not have coral presence, which implies that only a small percentage (6.3%) of the species found in the three sites could have forced association with alive coral reefs although in long term the presence of coral is important in the recruitment of these species[31]. In the Club de Yates area, the density of organisms by square meter was greater than the other sites, this fact could be attribute to a greater exhibition to the surge and the water movement[29,32-36].

With regard to the ecological indices, the values of species richness, density, diversity, equity were lower in the zone of La Boquita and could be associated to the degradation of the habitat by direct anthropogenic actions and to the operation of an adjacent fish tunny net since 1987. This fact has caused the increase in the dominance of a small group of species as indicate the values of the index. As well as the number of commercial species in La Boquita and the average lengths and weights of them were, in general terms, smaller than in the other two localities. Club de Yates and Carrizales are remoter of anthropogenic actions that could hit them adversely.

The communities under similar conditions in a geographic region indicate that they were dominated by the same species. Nevertheless, the dominance index shows there exists differences between La Boquita and the other studied places in spite to having similar conditions.

The abundance index probably is underestimating because many individuals could not be seen from the selected transects. Thus, the calculations to establish absolute density could be unsuitable nevertheless provide information to establish a relative abundance more than can be quantitatively useful to compare habitats. The data presented here do not show the possible seasonal variations that could affect the communities of fish in the reef. Although these variations in the coasts of Colima are not very marked, little is known of these changes and the stability of communities of reef fish, according the consulted literature[23].

The fish communities similarity indices applied for the selected sites show different values among them, being greater, this difference, between La Boquita and Carrizales may be because they are ambient with coral reef. The analysis of variance (ANOVA) shows there exists significant differences between these ($\alpha = 0,05$). If we considered similarity criterion that establishes that two faunas are similar if they have more than 66% of similarity[37]. Then the three studied sites are not statistically similar but, nevertheless, they share a great number of species.

The analysis of the trophic activity gives us an idea of the ecological importance of the rocky reef fauna. Most of the small fish are planktivore, whereas the great fish tend to be piscivore, therefore the biomass tends to be mainly in the greater carnivores. Most of the reef fish usually are opportunistic, that is, can change their feeding habits according to the occasion appears to them[38]. By the previous thing also it is difficult to categorizer the present species in an order in individual. Differences in the composition of the trophic categories in the three observed sites exist. In La Boquita the consumers of first order are more abundant (herbivores) and those of third order imply only 13% of the total observed species. However in the Club de Yates and Carrizales the third order consumers were increased in 24 and 28%, respectively. Some authors mentions that the fishing can promote the abundance of herbivores and diminution of carnivores[39]. The trophic behavior of most observed fish is more related to the bottom of the reef than the water column. Only a small percentage of fish are fed outside on the reef.

Abundance and density are factors that can be affected by the fishing activity. In the case of La Boquita fishing activity through the use of a tunny net, sportfishing, line and harpoon exists. For the other two areas (Club de Yates and Carrizales) the fishing activity is minimum. Is well-known that the average length of most species is small, this fact reduces their biomass, mainly of those species of carnivorous fish (rock fish, sawhorses and jacks)[40]. Numerous studies have demonstrated that the fishing on coral reefs affects the increase of abundance and diversity of small species such as pez arcoiris, piñatos and others. Nevertheless, it also influences loss of species of elevated trophic levels[41,42].

In addition the deterioration of the coral reef is more evident in La Boquita that in Carrizales, probably, because La Boquita is nearest to the beach and it is an immediate access to a greater number of people. While in Carrizales the access is only by sea and is more distant from population centers. These considerations can be due to the smaller density (1.26 orgamisms by square meter) in contrast to the other selected sites where a greater density exists. The values of equity greater to 0.90 indicate that it is a highly heterogeneous community[18].

CONCLUSIONS

Only 47 species corresponding to 23 families were detected. The family with greater richness of species was Pomacentridae (5 species) followed by Lutjanidae and Labridae (4 species) and Acanthuridae, Carangidae and Haemulidae (three species). The organism's density by square meter was greater in Club de Yates with 1.8 organisms per square meter, Carrizales with 1.5 and La Boquita with 1.26 organisms per square meter. The difference in density could be attributed to the fact that in Club de Yates there is a greater water movement and surge. The similarity indicators show that the communities of reef fish are different in the three selected sites although they share a great number of similar species.

In the case of La Boquita these indicators (richness of species, diversity, equity) were smaller comparatively than other two sites. La Boquita shows a greater deterioration of the environment in general, in contrast to the other two sites, according to smaller values of the ecological indicators like density of organisms by square meter, minors length averages, minor diversity and shortage of carnivorous fish. It is important to revalue the ecological impact of the tunny net that works adjacent to La Boquita reef, since apparently this is causing deterioration in the communities of fish of that reef. The biomass in Club de Yates with 23271.6 g/100 m^2 (230 g m^{-2}) emphasizes *Prionorus punctatus*; *Anisotremus interruptus* with 2821 g/100 m^2 (28.2 g m^{-2}) Carrizales and the *Lutjanus viridis* with 422.6 g/100 m^2 (4.8 g m^{-2}) in La Boquita.

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REFERENCES

1. Naeem, S., 1998. Species redundancy and ecosystem reliability. Conservation Biol., 12: 39-45.
2. Mumby, P., A. Edwads, E. Arias-Gonzalez, K. Lindeman and P. Blacwell *et al.*, 2004. Mangroves enhance the biomass of coral reef fish communities in the Caribbean. Nature, 427: 533-536.
3. Ortiz-Guerra, J., 1989. Coastal development of Manzanillo, Colima municipality: Diagnosis and perspective. Professional Thesis, Faculty of Marine Sciences, University of Colima, pp: 112.
4. Granados-MontesOca, N., 2000. Evaluation of a fishing art: Tunny net located in Miramar, Colima. Investigation Report, Administration of Marine Resources, Faculty of Marine Sciences, University of Colima, pp: 75.
5. Russell, B., F. Talbot, G. Anderson and B. Goldman, 1978. Collection and Sampling of Reef Fishes. In D.R. Stoddart and R.E. Johannes (Eds.), Coral Reefs: Research Methods, UNESCO, Paris, pp: 329-345.
6. Sale, P., 1980. The ecology of fishes on coral reefs. Oceanogr. Marine Biol. Ann. Rev., 18: 367-421
7. Sale, P. and W. Douglas, 1981. Precision and accuracy of visual census technique for fish assemblages on coral patch reefs. J. Environ. Biol. Fishes, 6: 333-339.
8. Brock, R., 1982. A critique of the visual census method for assessing coral reef fish populations. Bull. Marine Sci., 32: 269-276.
9. DeMartini, E. and D. Roberts, 1982. An empirical test of biases in the rapid visual technique for species-time censuses of reef fish assemblages. J. Marine Biol., 70: 129-134.
10. Sale, P. and B. Sharp, 1983. Correction for bias in visual transect censuses of coral reef fishes. Coral Reefs, 2: 37-42.
11. Kimmel, J., 1985. A new species-time method for visual assessment of fishes and its comparison with established methods. J. Environ. Biol. Fishes, 12: 23-32.
12. Sanderson, S. and A. Solonsky, 1986. Comparison of a rapid visual and a strip transect technique for censoring reef fish assemblages. Bull. Marine Sci., 39: 119-129.
13. Bortone, S. and J. Kimmel, 1991. Environmental Assessment and Monitoring of Artificial Habitats. In Seaman, W. Jr. and L.M. Sprague (Eds.), Artificial Habitat for Marine and Fresh Water Fisheries, Academic Press, New York, pp: 177-236.
14. Parker, R., 1990. Tagging studies and diver observations of fish populations on live-bottom reefs of the U.S. Southeastern coast. Bull. Marine Sci., 46: 749-760.
15. Bohnsak and Bannerot, 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Technical Report NMFS 41, pp: 15.
16. Solow, A., 1993. A simple test for change in community structure. J. Anim. Ecol., 62: 191-193.
17. Krebs, C., 1998. Ecological Methodology. Benjamin Cunimings, Menlo Park, California
18. Brower, J., J. Zar and von Ende, 1998. Field and Laboratory Methods for General Ecology. WCB/McGraw-Hill Publ. Iowa.
19. Wolda, H., 1981. Similiarity indices, sample size and diversity. Oecologia, 50: 296-302.
20. McNaughton, S., 1968. Structure and function in California grassland. J. Ecol., 49: 962-972.
21. Labrosse, P., 2002. Underwater visual fish census surveys: Proper use and implementation. Reef Resources Assessment Tools, pp: 44.
22. Espino-Barr, E., M. Cruz-Romero and A. García-Boa, 2003. Marine fish with commercial value of the Colima coast, Mexico. National commission for the knowledge and use of the biodiversity. National Institute of Fishing. Regional Center of Fishing Investigation in Manzanillo, SAGARPA, Mexico, pp: 106.
23. Bohnsack, J., A. Castillo and M. Bello, 2002. Resource survey of Looe Key National Marine Sanctuary 1983. NOAA Technical Memorandum NMFS-SEFSC-478, pp: 326.
24. Yáñez-Arancibia, A., 1978. Taxonomía, ecología y estructura de las comunidades de peces en las lagunas costeras con bocas efímeras del Pacífico de México. Centro Ciencias del Mar y Limnología, UNAM, Publicación Especial, 2: 306.
25. Galzin, R., S. Planes, V. Dufour and B. Salvat, 1994. Variation in diversity of coral reef fish between French Polynesia atolls. Coral Reefs, 13: 175-180.
26. Pérez-España, H., F. Galván-Magaña and L. Abitia-Cárdenas, 1996. Temporary and space variations in the community structure of rocky reef fish of the Southwest of the California Gulf, Mexico. CICIMAR-IPN, Marine Sci., 22 : 273-294.

27. Solís-Gil, C., 1996. Diversity and abundance of the populations of existing adornment fish of in Bahia de Banderas. National institute of Pesca-SEMARNAT.
28. Pérez-España, H. and M. Saucedo-Lozano, 2000. Structure of the reef fish community in Tenacatita, Jalisco. I National Coralline Reef Congress Veracruz, México.
29. Willams, D., 1982. Patterns in the distribution of fish communities across the central Great Barrier Reef. Coral Reefs, 1: 35-43.
30. Barrientos-Villalobos, J., E. Leyte-Morales and A. Palma-Ruiz, 2000. Diversity and abundance of ictiófauna of coralline reefs of the National Park Huatulco, Oaxaca. I National Coralline Reef Congress, Veracruz, Veracruz, México.
31. Jones, G., M. McCormick, M. Srinvasan and J. Tagle, 2004. Coral decline threatens fish biodiversity in marine reserves. Proc. Natl. Acad. Sci., 101: 8251-8253.
32. Lecchini, D., M. Adjeroud, M. Pratchett, L. Cadoret and R Galzin, 2003. Spatial structure of coral reef fish communities in the Ryukyo Islands, Southern Japan. Oceanologica Acta, 26: 537-547.
33. Galzin, R., 1987. Structure of fish communities of French Polynesia coral reefs. Marine Ecol., Progress Series, 41: 129-136.
34. Adjeroud, M., Y. Letourneur, M. Porcher and B. Salvat, 1998. Factors influencing spatial distribution of fish communities on a fringing reef at Mauritius, S.W. Indian Ocean. Environ. Biol. Fish., 53: 169-182.
35. Bellwood, D. and P. Wainwright, 2002. Locomotion in labrid fishes: Implications for habitat use cross-shelf biogeography on the Great Barrier Reef. Coral Reefs, 20: 130-150.
36. Fulton, C., D. Bellwood and P. Wainwrigth, 2001. The relationship between swimming ability and habitat use in wrasses (Labridae). J. Marine Biol., 139: 25-33.
37. Sánchez, O. and G. Lopez, 1988. A theoretical analysis of some indices of similarity as applied to biogeography. Folia Entomológica Mexicana, 75: 119-145.
38. Hamelin-Vivien, M., 1981. Trophic relationship of the reef fishes in Tulear (Madagascar). Oceanologica Acta, 4: 365-374.
39. McClanahan, T., 1997. Primary succession of coral-reef algae: Differing patterns on fished versus unfished reefs. J. Exp. Marine Biol. Ecol., 218: 77-102.
40. Jennings, S. and N. Poluning, 1996. Effects of fishing effort and catch rate upon structure and biomass of Fijian reef fish communities. J. Applied Ecol., 33: 400-412.
41. Russ, G. and A. Alcala, 1989. Effects of intense fishing pressure on an assemblage of coral reef fishes. Marine Ecology Progress Series, 132: 1-9.
42. McClanahan, T., 1997. Effects of fishing and ref. structure on East Africa coral reefs. Proceeding of the Eight Coral Reef Symposium, Smithsonian Tropical Research Institute, Panama City, Panama, pp: 1533-1538.
43. Thomson, D., 1999. Reef Fishes of the Sea of Cortez. The rocky-shore fishes of the Gulf of California. The University of Arizona Press, Tucson, pp: 302.
44. Sánchez-Ortiz, C., J. Arreola-Robles, O. Aburto-Oropeza and O. Cortés-Hernández, 1997. Reef fish in the region of La Paz, BCS. En Urban R. y M. Ramírez (Ed.), The Bay of La Paz, Investigation and Conservation. UABCS-CICIMAR-SCRIPPS.
45. Jiménez-Gutierrez, S. and J. Elorduy-Garay, 1999. Abundance and structure of the associations of rocky reef fish in the zone of Cerralvo Island, BCS, Mexico. I International Symposium on the Cortés Sea, Hermosillo, Sonora.
46. Pérez-Vivar, T., 1995. Systematic and biogeography of fish of the coast of Colima, Mexico. Professional Thesis, Faculty of Biological Sciences, Universidad Autónoma de Guadalajara, pp: 102.