A comparative survey of reef fishes in Caribbean and Pacific Costa Rica

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Abstract: Fishes from five transects in Manuel Antonio National Park (Pacific) and seven transects in Cahuita National Park (Caribbean), Costa Rica were censused using a rapid visual technique from February to April 1982. Cahuita, with 49 species, had a higher overall species diversity, whereas more individuals were usually seen on the Manuel Antonio transects, where 39 species were counted. Transects with similar habitat complexity showed highest PS values (approximately 60%). Wrasses (Labridae) and damselfish (Pomacentridae) dominated in both the Pacific rock reef and the Caribbean coral reef study areas. Individuals up to 7.5 cm usually dominated on transects, but an increase in size was observed as the habitat complexity increased. Diversity was low at Cahuita in relation to other Caribbean reef areas, probably due to the declining state of the coral reef. The species diversity values at Manuel Antonio are within the range of values found in Central American Pacific estuarine and tidepool studies.

Rock reefs and coral reefs morphologically present very similar habitats of considerable niche diversity harboring a great variety of fish assemblages. Since the structure of a reef is very irregular and complex, most standard methods of fish sampling (nets), are inadequate (Alevizon and Brooks, 1975). Other methods which involve the use of rotenone (Smith, 1973) or explosives (Talbott and Goldman, 1973) are efficient for collections but are frequently incompatible with the goals of areas set aside for conservation purposes. In order to overcome this problem, various visual census techniques have been developed which require no direct collection of fishes (Brock, 1954; Hobson, 1974; Jones and Thompson, 1978; Gladfelter *et al.*, 1980; Sale, 1980). One visual method places transects over the study areas and by repeatedly taking sightings of the abundance of fish species along a transect, an accurate estimation of fish inhabiting the transect area can be determined.

The present study utilizes a rapid visual census technique to estimate the number of fish species, their abundance and size distribution in relation to habitat complexity for a series of transects at two Costa Rican National Parks, Cahuita (Caribbean) and Manuel Antonio (Pacific) during February, March and April 1982.

STUDY AREA

Cahuita National Park is situated 35 km south of Limón on the Caribbean coast of Costa Rica (Fig. 1). Its coral reef extends to 300 m from the shore around Cahuita Point and is 4 km long. The nearshore currents in the area flow from north to south. Risk *et al.* (1980) noted that the reef at Cahuita is in a state of decline probably due to heavy sediment loading in the rivers to the north of the park during heavy rains aand contamination from the port city of Limón. In a study by Wellington (1974), 34 species of coral were found on the Cahuita reef.

Manuel Antonio National Park, on the Pacific coast (Fig. 2), is characterized by rock cliffs interspersed by sand beaches. Although there is no extensive living coral reef at Manuel Antonio there are numerous rock reefs and occasional coral formations.

The transects in both study areas were numbered according to degree of habitat

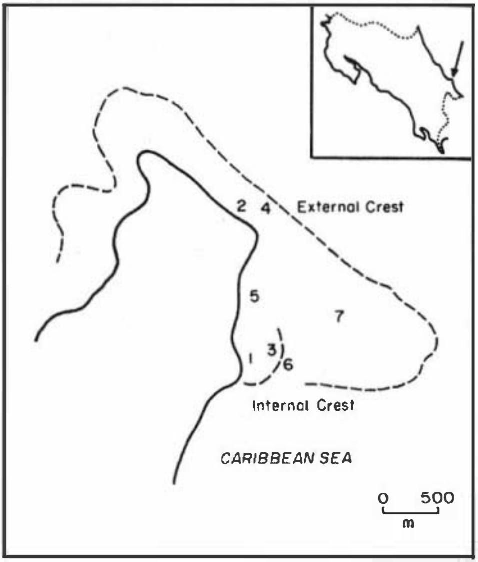

Fig. 1. Transects in Cahuita National Park (Caribbean), Costa Rica.

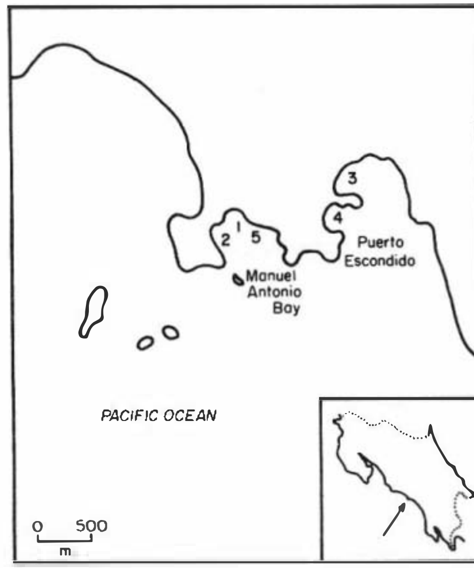

Fig. 2. Transects in Manuel Antonio National Park (Pacific), Costa Rica.

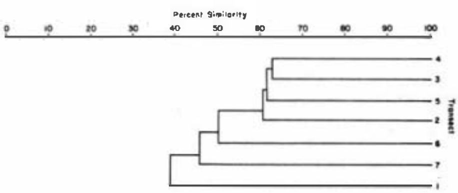

Fig. 3. Overlap in the ichthyofaunal species composition for the seven transects in Cahuita.

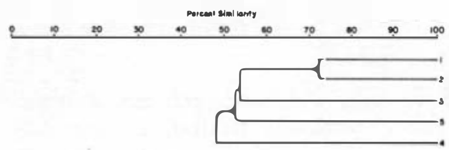

Fig. 4. Overlap in the ichthyofaunal species composition for the five transects in Manuel Antonio.

complexity, Transect 1 being the least complex. Here, habitat complexity refers to an area's topographical irregularity.

Figure 1 indicates the seven different habitats which were sampled at Cahuita:

Transect 1: Located inside the internal reef crest, this area was characterized by loose dead coral rubble free of vegetation. The bottom was flat with a depth from 0.5 to 1.5 m.

Transect 2: Inside of the reef crest of Cahuita point and surrounded by extensive fields of turtle grass (*Thalassia* sp.), this flat area was covered by coral formations up to 0.75 m in height and small patches of the corals *Montastrea* sp., *Porites* spp., and *Millepora* sp.

Transect 3: Inside part of the internal crest, composed of clumps of coral up to 1 m in height covered by numerous small patches of vegetation and algae. The most common corals were *Diploria* sp., *Porites* sp. and *Siderastrea* sp. Between the coral formations were flat areas of sand and coral rubble. Depths ranged from 0.5 to 1.5 m.

Transect 4: Northern part of the reef crest located on the point. There were large coral formations to 2 m in height. There was also much vegetation and small patches of the corals; *Siderastrea radians*, *Millepora* sp., *Agaricia* sp. and *Diploria clivosa*. This area acted as a buttress against the strong incoming current and waves.

Transect 5: This small coral reef in the shallowest part of the lagoon included the following corals; *Acropora* sp., *Siderastrea* sp., *Porites* sp., *Diploria* sp., and *Gorgonia* sp. The surrounding lagoon was of coral rubble, sand beds of *Thalassia* sp. and large blocks of coral. This small reef was from 1 to 2 m in depth.

Transect 6: On the outer side of the internal crest and composed of fields of branching *Acropora* sp. surrounded by areas of *Millepora* sp., *Siderastrea radians, Montastrea cavernosa, Porites astreoides, Agaricia agaricites, Diploria strigosa* and *Montastrea annualus.* This area's irregularity provided a very complex habitat for fishes. The water depth was from 0.5 to 3 m.

Transect 7: This most complex habitat was a reef located between the internal and external crests. It was made up of large branching *Acropora palmata* that extended to heights of 4 m. Also there were large heads of *Diploria strigosa, Siderastrea radians* and *Montastrea cavernosa* and large patches of *Millepora* sp., *Porites astreoides, Dichocoenia stokesii, Colpophyllia* sp., *Porites porites* and *Agaricia agaricites.* The water depth ranged from 0 to 6 m.

Figure 2 indicates the five different habitats which were sampled at Manuel Antonio:

Transect 1: This plain area was located near the beach in Manuel Antonio Bay and was characterized by small rocks, pebbles and coral rubble which were covered in some places by algae. The water depth was approximatley 4 m.

Transect 2: Rock reef also in Manuel Antonio Bay. The bottom was of irregular rocks that measured from a few contimeters to 0.3 m in height. In between the rocks there were sandy areas and areas that were sparsely covered by low vegetation.

Transect 3: Rock reef on the calm east side of a small island in Puerto Escondido Bay. Characteristic of this area were the medium-sized rocks that ranged in height from 0.2 to 1 m forming numerous small caves. The water depth ranged from 0.5 to 2 m.

Transect 4: West side of the small island in Puerto Escondido Bay. This transect ran from the island to a rock outcropping in front of the island and the rock outcropping, but the rocks in the channel were generally of medium size. This area was exposed to the waves entering the bay and there was usually a strong current. The water depth was from 0.5 to 6 m.

Transect 5: Inside part of a rock point in Manuel Antonio Bay. There was one large coral head which, along with the rocks, ranged in height from 0.5 to 2 m. During low tide this area was protected from the incoming waves by the rock point, which was underwater at high tide. The water depth was from 0.5 to 5 m.

MATERIAL AND METHODS

One hundred foot transects were permanently identified with plastic jugs secured by cord to the bottom. Fishes were sighted by the junior author equipped with snorkeling gear. Eight sightings of each 100 foot transect were taken irrespective of tidal stage and recorded on an underwater writing pad. Each transect included a field 1 m to either side and from the bottom to the surface. Photographs of fish species that could not be immediately identified were taken with a Nikonos 4A underwater camera. An effort was also made to record the fish species that hid in caves or under coral during the day, since the visual technique is only accurate for diurnal species (Brock, 1982). Therefore, the transect data reflect relative rather than absolute abundance. The use of snorkeling gear tends to reduce the amount of noise associated with SCUBA and also facilitates the fish census in shallower waters (Chapman *et al.,* 1974). It was noted that smaller species seemed to be attracted to the bottom sediment that was raised during sampling. This attraction of smaller fishes may have led to a bias of higher counts of these smaller individuals.

Upon completion of all sightings, each N (number of individual sightings per species per transect area) was divided by 8 and the respective standard deviation was calculated. Individual fish in each sighting were grouped into the following size categories; Group 1, to 7.5 cm; Group 2, 7.5-20 cm; Group 3, 20.5-28 cm; Group 4, 28.5-46 cm; and Group 5 > 46 cm.

For each transect, data on the fish species was analyzed as follows. Species diversity was calculated with an approximate equivalent to the Shannon-Weiner Index:

$$H' = C/N\ (N\log_{10}N - \Sigma n_i \log_{10} n_i),$$

where C equals 2.302585, N is the total number of individuals at a transect area and n_i is the number of individuals in the ith species (Lloyd *et al.,* 1968). High species diversity indicates the presence of a great number of species with individuals evenly distributed among the species. The species diversity is low when few individuals are concentrated among a few species.

The evenness component of diversity (J') is calculated using the equation:

$$J' = H'/\ln S,$$

where H' is the Shannon-Weiner Index calculated above, S is the number of species, and lnS is the maximum possible diversity as defined by Pielou (1966). An even distribution of individuals among species implies high diversity. A maximum evenness value of 1 for an area occurs when all species are represented by equal numbers of individuals.

Finally, in order to extract more information from the trends of the two indices, the percent contribution of the two most abundant species (D) at each transect area was summed.

In order to measure the species composition similarity between the transects, a percent similarity value was calculated by the formula:

$$PS = 100\ (1.0 - 0.5\ \Sigma|P_{ia} - P_{ib}|),$$

where P_{ia} is the number of individuals in the ith species in Transect a divided by the total number of individuals in Transect a, and P_{ib} is the same for sample b. Percent similarity ranges from 0, when two areas being compared have no species in common, to 100, when the two areas have identical species and amounts of individuals (Haedrich, 1975).

Dendrograms of the transects in Cahuita and Manuel Antonio were constructed using methods developed by Sokal and Michener (1958) for a better visual presentation of the similarity in species composition between the transects.

RESULTS AND DISCUSSION

At Cahuita National Park, a total of 7,582 individual sightings were made represente by 49 species and 21 different families (Tabl 1). The most speciose families were th butterflyfishes, Chaetodontidae (6 spp.), th grunts, Pomadasyidae (7 spp.) and the dam selfishes, Pomacentridae (5 spp.). The bluehea wrasse, *Thalassoma bifasciatum* (1148) and th three spot damselfish, *Stegastes planifron* (1156) were the two most abundant specie and were observed on all transects.

TABLE 1

List of families and species and total number of invididual sightings at Cahuita National Park (Caribbean), Costa Rica

Acanthuridae	
Acanthurus bahianus	278
Acanthurus coeruleus	397
Apogonidae	
Apogon maculatus	20
Blenniidae	
Ophioblennius atlanticus	75
Carangidae	
Caranx bartholomaei	41
Caranx fusus	1
Chaetodontidae	
Chaetodon capistratus	4
Chaetodon ocellatus	63
Chaetodon striatus	26
Holocanthus ciliaris	6
Holocanthus tricolor	1
Pamacanthus paru	3
Clinidae	
Acanthemblemaria sp.	4
Diodontidae	
Diodon histrix	1
Holocentridae	
Holocentrus rufus	119
Myripristis jacobus	51
Kyphosidae	
Kyphosus incisor	144
Labridae	
Bodianus rufus	79
Halichoeres bivittatus	76
Thalassoma bifasciatum	1148
Lutjanidae	
Lutjanus apodus	54
Lutjanus griseus	1
Lutjanus mahogoni	52
Ocyurus chrysurus	5
Mullidae	
Mulloidichthys martinicus	1
Pseudupeneus maculatus	17
Pepheridae	
Pempheris schomburgki	28
Pomacentridae	
Abudefduf saxatilis	647
Chromis multilineata	1
Micropathodon chrysurus	372
Stegastes partitus	6
Stegastes planifrons	1156

Pomadasyidae	
Anisotremus virginieus	9
Haemulon flavolineatum	394
Haemulon macrostomum	860
Haemulon parrai	114
Haemulon plumieri	80
Haemulon sciurus	15
Haemulon sp.	334
Priacanthidae	
Priacanthus cruentatus	63
Scaridae	
Scarus croicensis	460
Scarus taeniopterus	53
Sparisoma rubripinne	172
Sparisoma viride	97
Sciaenidae	
Odontoscion dentex	25
Scorpaenidae	
Scorpaena plumieri	2
Serranidae	
Epinephelus cruentatus	1
Epinephelus fulvus	18
Sphyraenidae	
Shyraena barracuda	8

TABLE 2

List of families and species and total number of individual sightings at Manuel Antonio National Park (Pacific), Costa Rica

Acanthuridae	
Acanthurus xanthopterus	22
Balistidae	
Pseudobalistes naufragium	8
Blenniidae	
Ophioblennius	38
Plagiotremus azaleus	48
Carangidae	
Caranx hippos	18
Caranx stellatus	1
Chaetodontidae	
Chaetodon humeralis	19
Johnrandallia nigrorostris	8
Chromidae	
Chromis atrilobata	12
Cirrhitidae	
Cirrhitus rivulatus	37
Grammistidae	
Rypticus bicolor	1
Holocentridae	
Adioryx suborbitalis	59
Myripristis leiognathos	47
Kyphosidae	
Kyphosus sp.	101
Labridae	
Bodianus diplotaenia	37
Halichoeres dispilus	431
Halichoeres nicholsi	40
Pseudojulis notospilus	816
Thalassoma lucasanum	480
Lutjanidae	
Lutjanus argentiventris	56
Monocanthidae	
Sufflamen verres	13
Mugilidae	
Mugil curema	88
Pomacanthidae	
Holocanthus passer	6
Pomacanthus zonipectus	6
Pomacentridae	
Abudefduf concolor	57
Abudefdulf saxatilis	1159
Microspathodon bairdii	37
Microspathodon dorsalis	610
Stegastes acapulcoensis	474
Stegastes sp.	1160
Pomadasyidae	
Anisotremus taeniatus	5
Haemulon sexfasciatum	61
Haemulon steindachneri	329
Scaridae	
Scarus perrico	62
Serranidae	
Epinephelus labriformis	49
Epinephelus panamensis	25
Sparidae	
Calamus brachysomus	1
Teatraodontidae	
Arothron meleagris	4
Sphoeroides annulatus	2

TABLE 3

Percent of each size group at each transect

Transect	1	2	3	4	5
Cahuita					
1	100	0	-	-	-
2	54	33	13	-	-
3	78	19	2	-	-
4	67	12	9	8	3
5	61	24	13	2	-
6	45	45	8	2	-
7	38	38	21	7	2
Manuel Antonio					
1	99	-	-	-	-
2	89	4	6	1	-
3	59	20	20	1	-
4	19	36	39	6	-
5	46	42	11	1	-

At Manuel Antonio National Park, a somewhat lesser number of individuals were sighted (6427), undoubtedly due to fewer transects. Thirty-nine species were recorded and distributed among 21 families (Table 2). The dominant families were the wrasses, Labridae (5 spp.) and again the promacentrids (6 spp.). The two most abundant species were nearly identical in total number of sightings as those of Cahuita; the sergeant major, *Abudefduf saxatilis* (1159) and the damselfish, *Stegastes* sp. (1160), both of the family Pomacentridae.

Table 3 shows the percent of individual sightings within each of the previously detailed size categories. The transects are ordered from the least complex habitat (1) on, in increasing complexity. In both Cahuita and Manuel Antonio, the least complex habitat was exclusively inhabited by small individuals (to 7.5 cm), mainly wrasses (Labridae) and damselfish (Pomacentridae). In all other transect areas, there was a similar distribution of fishes throughout the different size categories, but with the greatest concentration usually in the smallest size category 1.

On the basis of mean number of individuals and species at Cahuita (Table 4), Transect 6, which has the second most complex habitat, contained the most species (34) and mean number of individuals (361.6). The species diversity and evenness for Transect 6 was lower than expected for the complexity of this area's habitat. But the two most dominant species, *Haemulon macrostomum* and *S. planifrons,* constituted 35% of all the fishes seen on this transect, therefore resulting in lower species diversity and evenness values. Transect 1 had the smallest number of species (6) and individuals (N= 6.1). This may be directly related to the low habitat complexity which provided little cover for fish. The high dominance value (71.4) indicates the success of two dominant species (*S. planifrons* and *Scarus croicensis*) in exploiting this area. Transects 5 and 7 had similar mean numbers of fishes and species which could be correlated with their similar species diversity and evenness values. Both Transects 5 and 7 have numerous coral species, are surrounded by deeper water, and are not located on a reef crest. An overall trend in increasing or decreasing species diversity, species richness, mean number of individuals or evenness cannot be seen as the transects increase in habitat complexity. The mean species diversity value of 2.861 calculated for Cahuita transects can be compared with those computed for fish on a coral patch reef in the Virgin Islands where H' was 3.3 (Smith and Tyler, 1972) and 3.4 n the entire Caribbean (Backus *et al.,* 1970). For Florida reef fish assemblages H' was 4.290 to 4.529 (Jones and Thompson, 1978). The lower species diversity value calculated for Cahuita is probably attributable to the overall deterioration of the reef as cited in the literature.

TABLE 4

Mean fish abundance (N/8) and index calculations for each transect

Transect	Mean	S.D.	H'	SR	J'	D
Cahuita						
1	6.1	± 7.60	1.424	6	0.79	71.4
2	59.3	± 25.30	2.490	21	0.82	32.9
3	142.5	± 63.94	2.358	25	0.73	34.4
4	159.5	± 76.15	2.367	27	0.72	43.7
5	105.7	± 44.37	2.591	25	0.81	35.9
6	361.6	±141.55	2.535	34	0.72	34.8
7	113.3	± 39.54	2.713	30	0.80	29.7
Manuel Antonio						
1	157.3	± 92.05	2.110	18	0.73	44.2
2	159.6	± 90.05	2.145	19	0.73	36.9
3	213.1	± 92.34	2.487	30	0.73	38.9
4	119.6	± 68.18	2.140	27	0.65	49.6
5	179.5	± 85.75	2.396	29	0.71	41.1

H' = Shannon-Weiner diversity index (based on N and SR).
SR = number of species observed on transect.
J' = evenness component of diversity (based on H' and SR).
D = percent dominance of the two most common species.

At Manuel Antonio, Transect 3 (Table 4) had the greatest mean number of individuals (213.1), number of species (30) and species diversity (2.487), while Transect 1 had the lowest species diversity due undoubtedly, in part, to the low mean number of species (18). The two most dominant species on Transect 4, *Stegastes* sp. and *Microspathodon dorsalis,* contributed to the highest D value (50%). Transects 3 and 4 are both located in Puerto Escondido and around the same island except that Transect 3 is located on the calm protected side of the island and Transect 4 is located on the rough unprotected side. Therefore, the calmer water apparently allows for the development of a richer fish community. The mean species diversity of 2.627 calculated for the transects in Manuel Antonio is comparable with other Central American Pacific fish community studies. In El Salvador, Phillips (1981) reported that H'diversity ranged from 0.60 to 2.46 in a coastal mangrove embayment. In an estuarine environment in Costa Rica, León (1973) found H' values from 2.295 to 2.771 in the Gulf of Nicoya, while at a later date, Bartels *et al.* (1983) gave values from 0.671 to 3.163 for the same estuary. Also, in a Costa Rican Pacific coast tidepool study, Weaver (1970) found a fairly low species diversity (mean H' = 1.1-1.4 for three sites).

The dendrograms of the overlap in ichthyofaunal composition for the seven transects in Cahuita National Park (Figure 3) visually demonstrate that Transects 2, 3, 4 and 5 have similar fish compositions due to their tighter clustering. Transects 6 and 7 may represent a loose cluster and 1 is the least similar to all others. Figure 4 illustrates the same for the five transects in Manuel Antonio. Again from the dendrogram one can see that transects that have similar habitats have similar species compositions. Transects 3, 4 and 5 which have more complex habitats are loosely grouped while Transects 1 and 2 which do not have such complex habitats are associated at a higher level of similarity.

In summary, the transects in the coral reef at Cahuita had higher species diversity and evenness values than those calculated for the rock reefs in Manuel Antonio. However, more fish were seen in the transects of Manuel Antonio. The greater topographical variability of the reef in Cahuita could be the reason why Cahuita had a higher species diversity value. The percent similarity values demonstrated that similar habitats tend to have similar species compositions. The most outstanding conclusion of this fish census is the relatively low species diversity encountered at Cahuita which supports evidence indicating the declining state of Cahuita's coral reef.

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RESUMEN

De febrero a mayo de 1982 se hizo un censo de los peces por medio de una técnica rápida visual en el Parque Nacional Manuel Antonio (Pacífico) y en el Parque Nacional de Cahuita (Caribe), Costa Rica. Los peces se obtuvieron a través de cinco transectos en el Pacífico y siete en el Caribe.

Cahuita, con 49 especies, mostró una diversidad media de especies más alta mientras que en Manuel Antonio, con un menor número de especies (39), registró un mayor número de individuos. Los transectos con una complejidad de habitat semejante mostraron valores más altos de PS (aproximadamente 60%) Los lábridos y los promacéntridos dominaron en ambas áreas de arrecife rocoso del Pacífico y de coralino del Caribe. Generalmente dominaron en los transectos los individuos hasta de 7.5 cm. Conforme aumentó la complejidad de un transecto aumentó el número de peces grandes. La diversidad del arrecife de Cahuita fue baja en relación con otros arrecifes del Caribe debido probablemente al estado deteriorado en que se encuentra éste. Los valores de diversidad de especies en Manuel Antonio están dentro del ámbito de valores encontrado en estudios realizados en estuarios y en charcos de la zona entre mareas del litoral Pacífico de Centroamérica.

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