DIVERSITY AND STRUCTURE OF THE ICHTHYOLOGIC COMMUNITIES IN THE DIVING SITES IN HOLGUÍN (CUBA)

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ABSTRACT

This study is aimed to determine the diversity and structure of the ichthyologic communities in the coral reefs of Holguín, Cuba. A total of 85 fish species were recorded, including in 32 families and 53 genera. Low species richness and equitability were estimated at different sampling sites throughout the reef system. Cadena de Vita and Canto Chiquito are the sites with the highest number of species 47 and 46 respectively. Cueva 1 and Punta Naranjo were the places with the highest equitability 0.76. Replacement of fish species among the reef sites studied is poor. Canto Azul with Canto Pionero and La Llanita, sharing 29 species. These results reflect a poor state of conservation of the marine fish communities in Holguín.

RESUMEN: Diversidad y estructura de las comunidades ictiológicas en los arrecifes de coral Holguín (Cuba).

Este estudio pretendió determinar la diversidad y estructura de las comunidades ictiológicas en el arrecife de coral de Holguín, Cuba. Un total de 85 especies fueron registradas, incluidas en 32 familias y 53 géneros. La baja riqueza y equitatividad de especies fueron estimada en los diferentes sitios de muestreo del sistema arrecifal. Cadena de Vita y Canto Chiquito son los sitios con el más alto número de especies 47 y 46 respectivamente. Cueva 1 y Punta Naranjo son los lugares con equitatividad mayor 0.76. El remplazamiento de las especies de peces entre los sitios estudiados del arrecife es pobre. Canto Azul con Canto Pionero y La Llanita, mostraron 29 especies. Este resultado refleja un pobre estado de conservación de las comunidades de peces marinos en Holguín.

REZUMAT: Diversitatea și structura comunităților ihtiologice din recifii de corali Holguin (Cuba).

Acest studiu a avut ca scop determinarea diversității și structurii comunităților ihtiologice din recifele de corali din Holguin, Cuba. Au fost înregistrate în total 85 de specii de pești, incluși în 32 de familii și 53 de genuri. O bogăție în specii și o echitabilitate reduse au fost estimate în diferite situri de prelevare în sistemul recifal. Cadena de Vita și Canto Chiquito sunt siturile cu cel mai mare număr de specii 47 și respectiv 46. Cueva 1 și Punta Naranjo au fost locurile cu cea mai mare echitabilitate 0.76. Înlocuirea speciilor de pești printre recifele studiate este redusă. Canto Azul cu Canto Pionero și La Llanita, împărțind 29 de specii. Aceste rezultate reflect o stare precară de conservare a comunităților de pești marini din Holguín.

INTRODUCTION

If more and more world fish stocks were to become systematically overexploited and depleted, then the total marine catch would be expected to decline (Del Monte-Luna and Lluch-Belda, 2016), in this context extensive and intensive fish fauna assessments and monitoring is needed.

The Cuban marine platform is characterized by a wide diversity of marine organisms (Claro, 2006). Fish constitute a group of vital importance in said biota, and the relationship between these and other species of organisms keeps the structure of the different communities stable, which guarantees greater efficiency in the functioning and development of marine ecosystems (González-Sansón and Betancuor, 2003; Caballero et al., 2006). Particularly, in western Cuba, numerous investigations have been carried out related to the issues of structure, composition, and functioning of marine fish communities, as well as other aspects of the ecology of ichthyofauna (Claro and García-Arteaga, 1994; Claro and García-Arteaga, 2001; Chevalier and Cárdenas, 2006). However, in the North Eastern region of Cuba there is little information on the diversity and interaction between marine ichthyologic communities (Reynaldo et al., 2018).

Fish communities show specific organization patterns that can be detected despite the spatial-temporal variability that characterizes them (Ayala-Pérez et al., 2012). Among the emergent properties that characterize them, there are the taxonomic composition, the distribution of their abundances, their diversity (measured as heterogeneity), and equitability, among others (Begon et al., 2006). They also evolve over time and are characterized by their successional stages, within which they maintain structural and functional stability, given by the balance between their components and by environmental constancy (Aviles-Torres et al., 2001). This balance, however, can be affected by external factors, such as anthropic activities, natural environmental changes, or the introduction of species alien to its evolutionary history, known as invasive species (Campos, 2012).

In Cuba, the western portion of the tourist region of Holguín is the most developed area since the 1980s, featuring the highest levels of complexity in the territorial implementation of tourism (La et al., 2012). In this region, the coral reefs display a poor state of conservation, following the proposed methodology by Alcolado and Duran (2011). The investigations carried out by scientific entities in the region have been unpublished rapid inventories within the framework of technical projects, so there is a lack of information on the structure of marine fish communities (Vega et al., 2004). For this reason, it is necessary to determine the diversity and structure of the ichthyologic communities in the coral reefs for tourist use in Holguín, due to the human impact associated pressures, threats and risks.

MATERIAL AND METHODS

Study area and sampling method

From the 17th to the 30th of July, 2015, the coastal sector of Guardalavaca beach was sampled, in the northeastern platform of Cuba, northwest of the province of Holguín (Fig. 1). For this, 16 sampling sites (Figs. 1-4) were selected in the front area of the reef at an average depth of 12 m. Each site was georeferenced with a global positioning system, Garmin X12 GPS. Visual censuses were carried out at each site (Brock, 1954) in six linear transects of 50 m long by two m wide, occupying a total area of 600 m². The species of fish observed and the number of individuals belonging to each of them were recorded. Fish species were identified based on descriptions of Humann and Deloach (2002).

Figure 1: Location of sampling sites.

Figure 2: Sampling site.

Figure 3: Sampling site.

Figure 4: Sampling site.

Data analysis

The richness of ichthyologic species was estimated by the number of species recorded (S). The equity of Pielou (J) measures the proportion of the diversity observed in relation to the maximum diversity expected. The dominance of the species (D) was determined following Magurran (2004). Diversity was estimated from Fisher's alpha index, which is based on a logarithmic model of the distribution of the abundance of the species (Magurran, 1988). Beta diversity or diversity between habitats was estimated by the Whittaker index, which measures the degree of species replacement or biotic change through environmental gradients (Whittaker, 1972). Gamma diversity was obtained following the criteria (Landen, 1996), gamma diversity = average alpha + beta, from the richness of species:

Beta calculation based on species richness (Moreno, 2001):

$$Beta = \sum_j q_j (ST - S_j) \quad (1)$$

where:

$Beta$ = Beta diversity;

q_j = Proportional weight of community j , based on its area or any other measure of relative importance;

ST = Total number of species registered in the set of communities;

S_j = Number of species registered in the community j .

For all diversity analyses, bootstrap processing was performed for an $N = 10000$ of the centered type for a 95% confidence interval. The statistical comparison of the ecological indices between sites was carried out using the diversity permutation test, for 9999 randomized matrices (Brower et al., 1997). The roughness of the seabed (cm) was determined following the AGRRA methodology (2000).

Clustering analysis was used to represent the present fish associations, using the Morisita (1959) index as modified by Horn (1966) as a measure of similarity. This specific analysis constitutes one of the most widely used models to quantify the similarity between communities from quantitative data. Of the quantitative models, it has been suggested that it is the most satisfactory (Magurran, 1988). To determine the statistical differences between the groups (70% similarity), an analysis of similarities (ANOSIM) was performed using 10000 permutations, and a SIMPER to establish the contribution of the abundance of the species, which most influenced the dissimilarity between the groups (Clarke, 1993). The statistical package used was Past. 4.0 (Hammer et al., 2001).

RESULTS

A total of 85 fish species were recorded, included in 32 families and 53 genera. The most representative species according to their abundances throughout the ecosystem are *Clepticus parrae* 5,273 individuals, *Chromis cyanea* 3,202 individuals and *Thalassoma bifasciatum* 1,014 individuals (Tabs. 2a and 2b).

The ichthyofauna of the Holguín coral reef area present a low species richness (Fig. 2) and equitability (Fig. 3) with an average of 37 species and 0.60 of equitability for 16 studied sites.

Figure 2: Species richness (S) by dive sites.

Table 1: Ecological indices at Holguín dive sites. The largest values are highlighted in bold. Richness of species Taxa (S), Equity (J), Dominance (D), and Fisher (A).

Index	Acuario	Bigornia	Cadena	Canto Azul	Canto Chiquito	Canto Federico	Canto Izzis	Canto Pionero	Coral Garden	Corona	Cueva 1	Laberinto	Llanita	Punta Naranjo	Poza Azul	Sirena
S	31	37	47	36	46	31	34	38	34	33	40	33	45	43	35	38
J	0.74	0.36	0.54	0.73	0.42	0.70	0.48	0.48	0.55	0.61	0.76	0.55	0.69	0.72	0.76	0.65
D	0.11	0.48	0.19	0.12	0.38	0.15	0.33	0.31	0.26	0.21	0.09	0.24	0.10	0.11	0.11	0.15
A	7.84	6.59	8.39	8.93	8.79	7.47	7.05	6.89	6.78	6.97	10.9	7.06	9.68	11.5	7.76	8.90

The sites with the highest species richness are shown in figure 2, where the following stand out: Cadena de Vita and Canto Chiquito with 47 and 46 species, respectively (Tab. 1). In relation to equity, the highest values were obtained in: Cueva 1 and Poza Azul (0.76), followed by Acuario (0.74), Canto Azul (0.73), and Punta Naranjo (0.72) (Tab. 1). The abundance of the species throughout the reef system is low, highlighting *C. cyanea* 571 ind./100 m² and *C. parrae* 1,219 ind./100 m², as the only species with high abundance, not observing the presence of large groupers or species of fish of bigger size (Tabs. 2a and 2b).

Table 2a: Abundance of the fish species for each sampling site in 100 m².

Species	Acuario	Bigornia	Cadena	Canto Azul	Canto Chiquit	Canto Federico	Canto Izzis	Canto Pionero
<i>Abadeduf saxsatilis</i>	0	0	0	0	16	0	0	16
<i>Acanthostracion polygonia</i>	1	0	0	0	0	0	0	0
<i>Acanthostracion quadricornis</i>	0	0	0	1	0	0	0	0
<i>Acanthurus bahianus</i>	23	21	18	5	5	10	9	0
<i>Acanthurus chirurgus</i>	0	0	0	0	0	0	0	0
<i>Acanthurus coeruleus</i>	19	9	9	15	12	9	13	30
<i>Amblycirrhitus pinos</i>	0	0	0	0	0	0	0	0
<i>Anisotremus virginicus</i>	0	1	0	5	2	1	0	4
<i>Aulostomus maculatus</i>	0	0	3	0	3	0	0	3
<i>Bodianus rufus</i>	0	3	3	1	1	0	1	1
<i>Calamus calamus</i>	0	0	0	0	0	0	0	0
<i>Cantherhines macrocerus</i>	1	0	0	0	0	0	0	0
<i>Cantherhines pullus</i>	0	1	0	0	0	0	0	0
<i>Canthigaster rostrata</i>	3	1	10	0	4	1	0	7
<i>Caranx ruber</i>	0	2	0	0	2	0	0	0
<i>Cephalopholis cruentata</i>	1	4	6	1	3	1	4	4
<i>Cephalopholis fulva</i>	10	8	1	1	4	8	5	4
<i>Chaetodon capistratus</i>	2	4	12	14	7	4	11	8
<i>Chaetodon ocellatus</i>	0	6	2	0	0	0	1	0
<i>Chaetodon sedentarius</i>	0	0	1	0	0	0	0	0
<i>Chaetodon striatus</i>	0	0	0	0	0	0	0	0
<i>Chromis cyanea</i>	96	269	571	148	350	24	467	487
<i>Chromis insolata</i>	0	0	0	1	0	0	0	0
<i>Clepticus parrae</i>	0	1219	701	14	947	104	0	813
<i>Coryphopterus personatus</i>	0	0	15	30	22	0	3	41
<i>Epinephelus flavolimbatus</i>	0	0	0	0	0	0	0	0
<i>Epinephelus guttatus</i>	0	0	0	0	0	0	3	0
<i>Equetus punctatus</i>	0	0	0	0	1	0	0	0
<i>Gramma loreto</i>	0	0	2	17	16	0	6	16
<i>Gramma melacara</i>	0	0	0	0	0	0	0	0
<i>Haemulon aurolineatum</i>	0	0	345	0	1	0	0	0
<i>Haemulon bonariense</i>	0	0	0	0	0	0	1	0
<i>Haemulon carbonarium</i>	0	0	0	0	0	0	0	0
<i>Haemulon flavolineatum</i>	4	31	187	13	10	17	5	28
<i>Haemulon macrostomum</i>	0	0	0	1	0	0	0	2
<i>Haemulon plumieri</i>	1	0	19	2	1	2	1	1
<i>Haemulon sciurus</i>	2	0	1	1	3	16	0	11
<i>Halichoeres bivittatus</i>	0	0	0	0	0	0	0	0
<i>Halichoeres garnoti</i>	10	9	4	2	7	10	13	2
<i>Halichoeres maculipinna</i>	0	0	0	0	0	0	0	0
<i>Holacanthus ciliaris</i>	0	0	0	0	1	0	0	0

Table 2a (continued): Abundance of the fish species for each sampling site in 100 m².

<i>Holacanthus tricolor</i>	2	5	12	3	1	1	4	1
<i>Holocentrus adscensionis</i>	0	1	2	0	0	1	0	0
<i>Holocentrus rufus</i>	2	0	21	5	5	3	3	22
<i>Hypoplectrus gummigutta</i>	0	0	1	0	1	1	0	0
<i>Hypoplectrus guttavarium</i>	0	0	1	1	1	0	0	1
<i>Hypoplectrus indigo</i>	0	0	2	0	0	0	1	1
<i>Hypoplectrus nigricans</i>	0	0	1	0	0	0	0	0
<i>Hypoplectrus puella</i>	0	4	8	1	8	1	7	4
<i>Lactophrys triqueter</i>	1	1	0	0	2	2	1	0
<i>Lutjanus analis</i>	0	0	0	0	0	3	0	0
<i>Lutjanus apodus</i>	4	2	2	8	0	0	1	1
<i>Lutjanus griseus</i>	0	0	0	0	0	0	0	0
<i>Lutjanus jocu</i>	0	0	0	0	1	0	0	0
<i>Lutjanus mahogoni</i>	0	0	3	11	1	0	0	32
<i>Lutjanus synagris</i>	0	0	0	0	0	0	0	0
<i>Microspathodon chrysurus</i>	2	0	0	2	0	0	0	2
<i>Mulloidichthys martinicus</i>	0	3	12	2	2	0	3	8
<i>Mycteroperca bonaci</i>	0	0	0	0	1	0	0	0
<i>Myripristis jacobus</i>	27	0	0	9	0	0	0	0
<i>Neoniphon marianus</i>	0	3	3	0	2	0	0	0
<i>Ocyurus chrysurus</i>	0	0	3	2	8	13	0	3
<i>Pomacanthus arcuatus</i>	0	1	3	0	0	0	0	0
<i>Pomacanthus paru</i>	0	0	0	0	0	0	0	0
<i>Prognathodes aculeatus</i>	0	1	1	1	0	3	1	0
<i>Pseudopeneus maculatus</i>	0	1	1	0	3	0	0	0
<i>Pterois volitans</i>	0	1	0	0	6	0	0	0
<i>Sargocentron vexillarium</i>	0	0	0	0	0	0	0	0
<i>Scarus iserti</i>	7	53	116	26	31	10	9	57
<i>Scarus taeniopterus</i>	75	43	74	41	68	27	71	5
<i>Scarus vetula</i>	2	0	1	1	1	0	0	0
<i>Serranus tigrinus</i>	0	3	0	0	0	5	1	0
<i>Sparisoma atomarium</i>	0	2	14	0	16	0	1	0
<i>Sparisoma aurofrenatum</i>	25	21	24	28	23	24	39	18
<i>Sparisoma chrysopteron</i>	0	0	0	0	0	0	0	0
<i>Sparisoma rubripinne</i>	1	0	0	0	0	0	0	0
<i>Sparisoma viride</i>	7	3	7	1	3	3	6	20
<i>Stegastes adustus</i>	1	0	0	0	0	0	0	0
<i>Stegastes diencaeus</i>	28	6	2	0	3	1	5	13
<i>Stegastes leucostictus</i>	1	0	0	0	0	0	0	2
<i>Stegastes partitus</i>	23	4	6	30	0	17	5	1
<i>Stegastes planifrons</i>	3	5	6	0	6	0	1	4
<i>Stegastes variabilis</i>	0	2	7	0	9	1	2	2
<i>Synodus synodus</i>	0	0	1	0	0	0	0	0
<i>Thalassoma bifasciatum</i>	17	37	17	49	13	143	161	20
Average abundance	4.71	21.05	26.6	5.8	19.21	5.48	10.17	19.94
Total species number	31	37	47	36	46	31	34	38

Table 2b: Abundance of the fish species for each sampling site in 100 m².

Species	Coral Garden	Crona	Cueva 1	Laberinto	Llanita	Punta Naranjo	Pza Azul	Sirena
<i>Abadeduf saxsatilis</i>	2	0	0	0	0	10	0	0
<i>Acanthostracion polygonia</i>	0	0	0	0	0	0	0	0
<i>Acanthostracion quadricornis</i>	0	0	0	0	0	0	0	0
<i>Acanthurus bahianus</i>	15	4	1	5	7	3	14	7
<i>Acanthurus chirurgus</i>	1	0	0	0	0	22	0	0
<i>Acanthurus coeruleus</i>	16	27	22	7	24	0	11	24
<i>Amblycirrhitus pinos</i>	0	0	0	0	0	0	0	1
<i>Anisotremus virginicus</i>	0	6	5	300	1	6	0	0
<i>Aulostomus maculatus</i>	0	0	1	0	0	0	1	0
<i>Bodianus rufus</i>	3	0	0	0	3	0	0	2
<i>Calamus calamus</i>	0	0	0	1	0	0	0	0
<i>Cantherhines macrocerus</i>	0	0	0	0	0	0	0	0
<i>Cantherhines pullus</i>	0	0	0	0	0	0	0	0
<i>Canthigaster rostrata</i>	3	0	1	0	2	0	0	0
<i>Caranx ruber</i>	0	2	0	1	1	2	2	1
<i>Cephalopholis cruentata</i>	2	1	2	1	7	1	1	0
<i>Cephalopholis fulva</i>	12	0	2	1	15	3	5	0
<i>Chaetodon capistratus</i>	3	11	1	5	8	5	8	13
<i>Chaetodon ocellatus</i>	0	0	0	0	0	2	1	3
<i>Chaetodon sedentarius</i>	0	0	0	0	0	0	0	0
<i>Chaetodon striatus</i>	0	3	0	0	0	0	0	0
<i>Chromis cyanea</i>	117	132	80	63	155	60	116	67
<i>Chromis insolata</i>	0	0	1	0	0	0	0	0
<i>Clepticus parrae</i>	470	317	20	33	119	133	183	200
<i>Coryphopterus personatus</i>	0	0	10	0	106	30	0	0
<i>Epinephelus flavolimbatus</i>	0	0	0	0	3	0	0	0
<i>Epinephelus guttatus</i>	0	0	0	0	0	0	0	0
<i>Equetus punctatus</i>	0	0	0	0	1	0	0	0
<i>Gramma loreto</i>	0	12	15	0	8	9	0	1
<i>Gramma melacara</i>	0	2	0	0	0	0	0	0
<i>Haemulon aurolineatum</i>	0	0	0	0	0	0	0	0
<i>Haemulon bonariense</i>	0	0	0	0	0	0	0	0
<i>Haemulon carbonarium</i>	0	0	0	201	0	0	4	0
<i>Haemulon flavolineatum</i>	2	6	40	0	13	2	13	4
<i>Haemulon macrostomum</i>	0	0	0	1	22	0	0	2
<i>Haemulon plumieri</i>	0	0	2	0	3	0	6	2
<i>Haemulon sciurus</i>	2	3	3	0	3	2	8	1
<i>Halichoeres bivittatus</i>	0	0	0	0	0	12	7	0
<i>Halichoeres garnoti</i>	14	4	10	7	3	5	14	1
<i>Halichoeres maculipinna</i>	1	0	0	0	0	0	0	0
<i>Holacanthus ciliaris</i>	0	0	1	0	0	0	0	1

Table 2b (continued): Abundance of the fish species for each sampling site in 100 m².

<i>Holacanthus tricolor</i>	3	2	2	4	3	2	6	2
<i>Holocentrus adscensionis</i>	1	0	1	2	1	0	9	1
<i>Holocentrus rufus</i>	0	3	9	0	5	2	16	3
<i>Hypoplectrus gummigutta</i>	2	0	0	0	0	0	0	0
<i>Hypoplectrus guttavarium</i>	0	0	0	0	0	1	0	0
<i>Hypoplectrus indigo</i>	1	2	1	0	0	1	0	1
<i>Hypoplectrus nigricans</i>	0	0	0	0	0	1	0	0
<i>Hypoplectrus puella</i>	0	3	3	1	7	3	1	1
<i>Lactophrys triqueter</i>	0	0	0	0	0	0	0	1
<i>Lutjanus analis</i>	0	0	0	0	0	0	0	0
<i>Lutjanus apodus</i>	0	6	6	2	4	2	18	2
<i>Lutjanus griseus</i>	0	0	0	0	1	0	0	0
<i>Lutjanus jocu</i>	0	0	0	0	0	0	0	1
<i>Lutjanus mahogoni</i>	0	1	2	0	2	1	6	0
<i>Lutjanus synagris</i>	0	0	0	2	0	0	0	0
<i>Microspathodon chrysurus</i>	3	0	0	0	1	0	0	2
<i>Mulloidichthys martinicus</i>	0	4	2	1	1	1	21	0
<i>Mycteroperca bonaci</i>	0	0	0	0	0	0	0	0
<i>Myripristis jacobus</i>	1	1	2	0	2	0	0	7
<i>Neoniphon marianus</i>	1	5	10	1	7	0	3	1
<i>Ocyurus chrysurus</i>	0	0	3	3	136	1	9	61
<i>Pomacanthus arcuatus</i>	0	1	2	0	1	1	0	0
<i>Pomacanthus paru</i>	0	0	2	0	0	0	0	0
<i>Prognathodes aculeatus</i>	0	1	0	1	2	0	0	0
<i>Pseudopeneus maculatus</i>	0	0	0	0	0	1	1	0
<i>Pterois volitans</i>	0	0	0	0	1	1	0	0
<i>Sargocentron vexillarium</i>	0	0	0	0	0	1	0	0
<i>Scarus iserti</i>	24	27	6	12	41	36	39	10
<i>Scarus taeniopterus</i>	56	47	72	40	82	22	54	83
<i>Scarus vetula</i>	9	1	5	3	2	0	4	8
<i>Serranus tigrinus</i>	4	0	0	0	0	0	0	0
<i>Sparisoma atomarium</i>	0	0	12	0	0	0	0	0
<i>Sparisoma aurofrenatum</i>	26	20	22	14	22	24	27	26
<i>Sparisoma chrysopteron</i>	0	0	1	0	0	0	0	0
<i>Sparisoma rubripinne</i>	0	0	0	0	0	1	0	2
<i>Sparisoma viride</i>	11	12	1	4	7	16	14	8
<i>Stegastes adustus</i>	0	0	0	0	0	0	0	0
<i>Stegastes diencaeus</i>	16	0	0	1	1	11	4	2
<i>Stegastes leucostictus</i>	1	0	0	1	0	2	0	0
<i>Stegastes partitus</i>	18	23	30	4	7	4	22	14
<i>Stegastes planifrons</i>	3	2	2	6	0	4	0	1
<i>Stegastes variabilis</i>	2	0	0	2	1	2	5	0
<i>Synodus synodus</i>	0	0	0	0	1	1	0	0
<i>Thalassoma bifasciatum</i>	166	92	0	16	157	24	42	60
Average abundance	11.89	9.21	4.85	8.77	11.75	5.56	8.17	7.37
Total species number	34	33	40	33	45	43	35	38

Figure 3: Statistical variability of the equitability of Pielou (J), between sites.

Equal letters represent that there are no statistical differences and different letters that there are differences ($p \leq 0.0001$).

Dominance (Fig. 4). Bigornia and Canto Chiquito were the sites with the highest dominance and statistical variability ($p \leq 0.0001$) (Tab. 1). The species that most influenced in the dominance at these sites were *C. cyanea* and *C. parrae* respectively. These sites were characterized by a low species richness (40 and 47 species, respectively).

Figure 4: Statistical variability of Dominance (D), between sites. Equal letters represent that there are no statistical differences and different letters that there are differences ($p \leq 0.0001$).

Fisher's alpha diversity (Fig. 5). The highest values were recorded in Punta Naranjo (11.49) and Cueva 1 (10.94), which presented the highest number of species with the highest densities (Tabs. 1 and 2). The rest of the sites have few ichthyologic species with significant densities. The species with the highest densities in both sites were *C. parrae*, *C. cyanea*, *S. taeniopterus*, and *S. aurofrenatum* (Tab. 2). These sites did not show statistical differences between them, but with the other collection sites ($p \leq 0.0001$) (Fig. 5). The lowest diversities were recorded in Bigornia, Coral Garden, Canto Pionero, and Corona (Tab. 1) and in turn the sites with the highest statistical variability for this ecological index ($p \leq 0.0001$).

Figure 5: Statistical variability of Fisher alpha diversity, between sites.

Equal letters represent that there are no statistical differences and different letters that there are differences ($p \leq 0.0001$).

Beta diversity. Wittaker's global Beta diversity index was (1.26). The sites with the least replacement of species were Acuario with Bigornia (0.41), Cadena de Vita (0.41), Canto Chiquito (0.42), Laberinto (0.40), and Punta Naranjo (0.43).

The species not shared between Acuario with the aforementioned sites were *Acanthostracion polygonia*, *Anisotremus virginicus*, *Cantherhines macrocerus*, *Caranx ruber*, *C. parrae*, *H. puella*, *Microspathodon chrysurus*, *Mulloidichthys martinicus*, *Myripristis jacobus*, *Sparisoma rubripinne*, *Stegastes adustus*, and *Stegastes variabilis*.

Other sites that shared fewer species were Canto Azul with Coral Garden 0.40 highlighting *Abudefduf saxatilis*, *A. quadricornis*, and *Acanthurus chirurgus*.

Table 3a: Beta diversity in the ichthyologic communities in the contemplative diving sites in Holguín, Cuba.

Sites	Acuario	Bigornia	Cadena	Canto Azul	Canto Chiquito	Canto Federico	Canto Izzis	Canto Pionero
Acuario	0	0.41	0.41	0.34	0.42	0.32	0.35	0.33
Bigornia	0.41	0	0.26	0.39	0.30	0.26	0.23	0.36
Cadena	0.41	0.26	0	0.27	0.20	0.30	0.25	0.22
Canto Azul	0.34	0.39	0.27	0	0.31	0.31	0.31	0.18
Canto Chiquito	0.42	0.30	0.20	0.31	0	0.32	0.35	0.23
Canto Federico	0.32	0.26	0.30	0.31	0.32	0	0.29	0.30
Canto Izzis	0.35	0.23	0.25	0.31	0.35	0.29	0	0.27
Canto Pionero	0.33	0.36	0.22	0.18	0.23	0.30	0.27	0
Coral Garden	0.29	0.32	0.33	0.40	0.37	0.29	0.38	0.30
Corona	0.37	0.31	0.30	0.24	0.36	0.37	0.34	0.32
Cueva 1	0.38	0.35	0.21	0.23	0.27	0.35	0.35	0.25
Laberinto	0.40	0.25	0.35	0.33	0.39	0.31	0.37	0.32
Llanita	0.36	0.26	0.21	0.18	0.25	0.28	0.34	0.22
Punta Naranja	0.43	0.32	0.24	0.34	0.30	0.40	0.35	0.23
Pza Azul	0.36	0.27	0.21	0.29	0.28	0.27	0.33	0.28
Sirena	0.30	0.36	0.31	0.29	0.33	0.36	0.33	0.31

Table 3b: Beta diversity in the ichthyologic communities in the contemplative diving sites in Holguín, Cuba.

Sites	Coral Garden	Corona	Cueva 1	Laberinto	Llanita	Punta Naranja	Pza Azul	Sirena
Acuario	0.29	0.37	0.38	0.40	0.36	0.43	0.36	0.30
Bigornia	0.32	0.31	0.35	0.25	0.26	0.32	0.27	0.36
Cadena	0.33	0.30	0.21	0.35	0.21	0.24	0.21	0.31
Canto Azul	0.40	0.24	0.23	0.33	0.18	0.34	0.29	0.29
Canto Chiquito	0.37	0.36	0.27	0.39	0.25	0.30	0.28	0.33
Canto Federico	0.29	0.37	0.35	0.31	0.28	0.40	0.27	0.36
Canto Izzis	0.38	0.34	0.35	0.37	0.34	0.35	0.33	0.33
Canto Pionero	0.30	0.32	0.25	0.32	0.22	0.23	0.28	0.31
Coral Garden	0	0.37	0.37	0.34	0.34	0.40	0.36	0.33
Corona	0.37	0	0.23	0.30	0.25	0.31	0.29	0.29
Cueva 1	0.37	0.23	0	0.36	0.24	0.34	0.28	0.30
Laberinto	0.34	0.30	0.36	0	0.28	0.36	0.23	0.35
Llanita	0.34	0.25	0.24	0.28	0	0.29	0.25	0.27
Punta Naranja	0.40	0.31	0.34	0.36	0.29	0	0.28	0.38
Pza Azul	0.36	0.29	0.28	0.23	0.25	0.28	0	0.38
Sirena	0.33	0.29	0.30	0.35	0.27	0.38	0.28	0

Punta Naranjo was the other site that shared fewer species with Canto Federico and Coral Garden 0.40. The species with the lowest replacement were *A. coeruleus*, *C. rostrata*, *C. ruber*, *C. ocellatus*, *C. personatus*, *G. loreto*, *H. bivittatus*, *H. adscensionis*, *H. gummigutta*, *H. nigricans*, *L. apodus*, *L. mahogoni*, *M. martinicus*, *P. arcuatus*, and *P. maculatus*. The places that presented a higher degree of species replacement were Canto Azul, with Canto Pionero and La Llanita, sharing 29 species with abundance between one to 813 individuals 100 m² (Tabs. 2a and 2b).

Gamma diversity. A value of 87.93% was obtained in this research for the community complex.

Ichthyologic similarity (Fig. 8). The analysis of the similarity between the studied sites regarding the densities of the ichthyologic species allowed to establish four groups. The first made up of Laberinto and less similarity 18%. The second group with Canto Federico and La Llanita, with 74% similarity. The third structured with the highest number of sites and similarities above 80%. The fourth group constituted by Canto Azul and Canto Izzi 82%, Cueva 1 and Acuario with 84% (Fig. 6). The obtained cophenetic correlation was 92%.

The statistical comparison between the four groups established in this research analysis of similarity allowed obtaining a value of the level of significance $p = 0.95$, and a strength of the factors on the samples $R = 0.02$, with no statistical differences between the four groups. Similar results were obtained in independent analysis between each of the groups.

Figure 8: Dendrogram of similarity % of the study sites from the density of species for 100 m², Cophenetic correlation = 0.92.

The species that contributed the most to 80% dissimilarity were *C. parrae* 35.11%, *C. cyanea* 16.46%, *T. bifasciatum* 7.22%, *A. virginicus* 4.49%, *H. carbonarium* 2.90%, *S. taeniopterus* 2.87%, *O. chrysurus* 2.76%, *H. flavolineatum* 2.57%, *C. personatus* 2.53%, *H. aurolineatum* 2.50%. The roughness of the bottom averaged 21.9 cm, with the highest value in Canto Pionero (41.9 cm), and the lowest in Canto Federico (8.5 cm).

The Guardalavaca Holguín coral reef displays a richness of species with an average value of 37.56 species. The average abundances of herbivorous fish (parrots and barbers), and carnivores (snappers, groupers, and grunts) were extremely low (25 and seven individuals in 100 m², respectively (Tabs. 2a and 2b). The general equity in all the studied sites is poor with values between 0.36 and 0.76. Dominance presented values between 0.10 and 0.48. An average Fisher's alpha diversity of 8.24 was obtained. These results allow to infer a poor state of conservation of the fish communities that inhabit this coastal sector.

These environments are characterized by a higher habitat heterogeneity with the dominance of coral species *Agaricia agaricites* 38.7 ind./10 m², *Millepora alcicornis* 27.3 ind./10 m², *Siderastrea siderea* 25.8 ind./10 m², and *Stephanocoenia intercepa* 27.3 ind./10 m² (Busutil et al., 2015). The families Scaridae and Haemulidae were those that contributed in a greater number of species in both sampling sites, highlighting the *Scarus taeniopterus* species as the most abundant. Species richness is an ecological index that allows defining these sites with the best environmental conditions to support a greater number of taxa, among them greater availability of food and number of refuges stand out (Moreno, 2001).

Diversity is strongly linked to the concept of equity; more ecologically equitable fish communities are more diverse. Diversity has a minimum value when abundance is concentrated in a single species, while the others remain with a single individual, while also having a maximum value when all species are equally common (Moreno, 2001).

The Pielou equity index showed significant differences between the protected marine areas of Guanahacabibes and the Arrecifes Xcalak National Park ($F = 25.19$, $p < 0.001$). Presenting the marine area of Mexico higher values (0.75 ± 0.05) than the area of Cuba (0.62 ± 0.06) (Cobián-Rojas et al., 2018).

Results similar to those obtained in the Guanahacabibes area 0.62 were obtained in La Llanita and Canto Federico 0.69 respectively, Sirena 0.65 and Corona 0.61. Equity values close to those obtained in the Arrecifes Xcalak 0.75, National Park were determined in Cueva 1 and Poza Azul 0.76, Acuario 0.74, Canto Azul 0.73, and Punta Naranjo 0.73. The rest of the sites not mentioned presented lower values and statistical differences were obtained between the sites with the highest equity values and those with the lowest equity ($p = 0.0001$).

Ichthyologic similarity. The analysis of similarity between the different sampled sites in relation to the density of the fish, allowed to establish to Laberinto as the site with the least similarity. Bigornia, Canto Chiquito, Coral Garden and Corona as the sites with the greatest ichthyologic similarity. Sites that shared the highest species composition. No statistical differences were detected between the four groups established for 70% similarity. This result shows that the contribution of the densities between the sites was not significant. It obtained a value of 92% of the cophenetic correlation, allowing to establish a high correlation between the distances of the simulated matrix and the real one. This high correlation value allows us to infer a good representation of the individual distances between the sites located in the dendrogram of similarity (Gotelli and Ellison, 2004).

DISCUSSION

Species richness. The number of species is the most used measure-to-measure biodiversity in different ecosystems, since it reflects different aspects of ecology (Gaston, 1996; Moreno, 2000). The sites that presented the highest number of species were Cadena de Vita with 47 species distributed in 27 genera, 16 families and Canto Chiquito with 46 species distributed in 31 genera, 19 families. Species richness is an ecological index that allows for defining these sites with the best environmental conditions to support a greater number of taxa, among them greater availability of food and number of refuges stand out (Moreno, 2001).

Species richness is associated with local environmental factors and biotic interactions (Llorente and Morrone, 2001). Acuario, Corona and Coral Garden, were sites of less richness. In these latter sites, two commercial fishing bases (Guardalavaca and Puerto de Vita fishing base) carry out the fishing activity, both made up of approximately 60 vessels (Puga et al., 2018). Where different fishing gear is used, highlighting the nets of 100 m long and palanques of 100 hooks (Baisre, 2018). During the samplings, the occasional presence of people exercising the activity with pneumatic rifles in the work area was verified. This type of fishery is exerted selectively on the large predators and herbivores of the reef (Aguilar, 2005; Aguilar and González, 2007). Underwater fishermen report an average annual catch of approximately 995 kg in this coastal sector. Baisre (2018) found that 74% of the fishing sites in Cuba are overexploited and 5% have collapsed. The overfishing has been strongly correlated with ecological collapse in marine ecosystems, such as the absence of large predators, a characteristic present in the 16 monitored sites (Harborne et al., 2017).

Froese et al. (1998) suggested that the fishing exploitation of multispecies communities has an effect of change in the relative abundance in the different functional fish groups. He stated that the greatest expected effect is the succession of large groupers by small-sized and short-lived herbivorous species. In Cuba, there are more than 60 years of over-exploitation of fishing, establishing a significant decrease from the 90s in all fishing sites, with a reduction of 40% in 21 of the most commercially important species (Baisre, 2018). However, there are dissimilar factors that could be influencing the current condition of the sites with less richness, such as recruitment, climate change and the characteristics of the habitat, and food availability, among others (González and Aguilar, 2000). Another aspect that is considered is the selective fishing carried out in these sites on the ichthyologic communities.

Blaber (1985) found a relationship between the increase in fish richness and the variety of the habitat and the latitudinal changes, in Southeast Africa. Greater species richness may be associated with the high complexity of the relief, which provides abundant refuges and food for fish in Cuba (Cobián et al., 2018), as it has been confirmed by other authors in other regions (Núñez-Lara et al., 2005). Although, in this study the roughness of the bottom of the highest value was obtained in Canto Pionero site with 41.9 cm and a richness of 41 species, followed by Punta Naranjo 33 cm and a richness of 50 species and Acuario with 31 cm and 35 species. Indicating that greater roughness does not necessarily imply favourable ecological conditions in a coral reef. If it is considered that dead corals also increase the relief of the bottom (McField and Richards, 2007). A marked deterioration in the health status of Caribbean coral reefs has been observed, caused by anthropogenic stressors and climate change (Mumby et al., 2014; Graham et al., 2015).

The fish communities present in two marine protected areas, one in Guanahacabibes (Cuba) and the other in the Arrecifes Xcalak National Park (Mexico), these did not present statistical differences for the number of fish species. Presenting the Guanahacabibes area with a higher richness value (43 species) than the Arrecifes Xcalak National Park, (35 species) (Cobián-Rojas et al., 2018). Martínez-Iglesias and Serpa (1997), point out the significantly

reduced abundance of fish present in Punta Francés, Isla de la Juventud, Cuba. The abundance of herbivorous fish in Cayo Levisa is also extremely low. These authors recorded 77 species of fish, the most abundant being *S. taeniopterus*, *C. cyanea*, *T. bifasciatum*, *S. partitus* and *G. loreto* (De la Guardia et al., 2005). Similar values obtained by Cobián-Rojas et al. (2018), were obtained in the different study stations of this work. Anthropogenic disturbance in the marine environment can influence the richness of ichthyologic species, being considered as the stress that excludes species at high trophic levels and does not prevent competitive exclusion by superior competitors (Paine, 1966; Huston, 1979; Connell, 1983).

Ichthyologic equity. Equity refers to the equitability in the abundances of the different species; and it is typically evaluated taking into account the number of dominant species in relation to the number of rare or not common species (Magurran, 2004; Moreno et al., 2011). The more species there are in a site, as well as the more homogeneous their distribution, the greater its diversity. The highest equitabilities were obtained in Cueva 1, Poza Azul, Acuario, Canto Azul and Punta Naranjo. Communities with greater equity indicate that they present are stable between the actions of the local biota and abiotic elements, competition, predation and immigration to other locations (Sonco, 2013). The species that most contributed to this ecological index in the aforementioned sites were: *A. bahianus*, *A. coeruleus*, *C. fulva*, *C. cyanea*, *H. garnoti*, *H. tricolor*, *S. taeniopterus*, *S. aurofrenatum*, and *S. partitus*. The abundances of these species were extremely low. This result may be indicating that there is a balanced pressure from legal and poaching at sites with close values of the equity index. This result is indicating that there is a balanced pressure of legal and poaching in sites with close values of the equity index (Cobián-Rojas et al., 2018).

Ichthyologic dominance. This index is inverse to the concept of community equity, since it takes into account the most important species without considering the rest of the species, being less sensitive to the richness of the species (Krebs, 1996; Magurran, 2004). Dominance is strongly influenced by the importance of the most dominant or common species (Magurran, 1988; Moreno, 2001), therefore they are more sensitive to changes in equitability (Feinsinger, 2003). The species that most influenced the sites of greatest dominance were *C. cyanea* and *C. parrae*. This last species was also the most abundant in the Guanahacabibes National Park (Cobián-Rojas et al., 2018). Bigornia and Canto Chiquito were the sites with the highest dominance, due to the fact that they are located on the reef slope (wall edge). This habitat favors a high dominance of a few species (*C. parrae*, *C. cyanea*, and *S. partitus*), which makes the equity lower and, therefore, the diversity index as well (Cobián-Rojas et al., 2018). The same behavior was observed in the reef slope of the Bahía de Cochinos (Cuba) (Chevalier and Cárdenas, 2006).

These two species present high densities in different dive sites in Cuba, such as in the coral reefs of María la Gorda, Guanahacabibes National Park (Cobián and Chevalier, 2009), registering densities for both species of 84.79 and 109.3 ind./100 m². Values lower than those obtained in this study for Bigornia, Cadena de Vita, Canto Chiquito, Canto Pionero, Coral Garden, Corona, Llanita, and Poza Azul (Tab. 2).

Fisher's alpha diversity. Punta Naranjo and Cueva 1 were the sites with the highest Fisher alpha diversity. They are the sites with the highest number of species and the highest densities. Presenting statistical differences with the places of less diversity. Highlighting the species *C. parrae*, *C. cyanea*, *S. taeniopterus*, and *S. aurofrenatum* with the highest abundances. Species diversity is an important indicator in the study of community ecology and conservation biology. A direct relationship has been established between alpha diversity and the functioning of ecosystems, such as productivity and stability (MacLaurin and Sterelny,

2008). Analysing this ecological index, Punta Naranjo and Cueva 1 constitute the most conserved sites in terms of ichthyologic communities. Bigornia, Coral Garden, Canto Pionero, and Corona places with less diversity. Indicating that the ichthyologic communities that inhabit these places have a poor state of conservation. The diversity is a characteristic that can be measured in marine ecosystems, such as productivity, density, and biomass (Alcolado, 1998). The diversity index reflects the complexity and structure of the system under study (Rodríguez-Zaragoza et al., 2011). The sites with low diversity are the product of fishing in this area, being more intense in the months of September to December, these sites are more accessible to fishermen (Baisre, 2018). Areas in Cuba exposed to intensive fishing and pollution, such as those along the Northwest coast, exhibit reduced coral density and ichthyology diversity (Duran et al., 2018).

Marine ecosystems with greater diversity will have better functioning and resilience (Hughes et al., 2003). The main causes of the loss of diversity are habitat destruction, overexploitation, pollution, climate change, and invasive species (Gutiérrez, 2006; Santos and Tellería, 2006; Capote et al., 2012). In the case of invasive species, the ichthyologic communities that inhabit these sites have been strongly affected by the presence of the lionfish (*Pterois volitans*), a generalist predator (Reynaldo et al., 2019). Other possible causes of the low fish diversity in the studied sites and the lower densities in the fish communities in the tourism sector of Holguín could be strongly influenced by the tourism and navigation activities themselves (Esslemont, 1999; Roupheal and Inglis, 2000; Zakai and Chadwick-Furman, 2002). As well as legal and illegal extractive and fishing activities (Padilla, 2000; Pikitch et al., 2004). These factors generate a pattern of chronic and constant stress that does not allow the recovery of fish communities (Buddemeier et al., 2004).

Close relationships have been determined between Fisher's alpha diversity and latitude, climate, biological productivity, habitat heterogeneity, habitat complexity, disturbance, and geographic distances (Fischer, 1960, 1961; Pianka, 1966; Stehli et al., 1969; Brown and Gibson, 1983; Stevens, 1989; Ricklefs, 1990). The theory of environmental heterogeneity supports the idea that heterogeneous environments allow them to be colonized by a greater number of species, thereby increasing diversity (Badii and Landeros, 2007). The fishing constitutes the fundamental factor of the reduced ecological diversity of the ichthyological communities in the Guardalavaca reef, Holguín. Overfishing is one of the interventions of man that most alter the diversity of fish in Caribbean coral reefs, by removing herbivorous and carnivorous fish (Bellwood et al., 2004).

In Punta Frances marine park in Cuba, a reduction in the diversity in the ichthyologic communities was obtained as a result of illegal and commercial fishing. Reducing mainly the predatory families, Lutjanidae and Serranidae, as well as the species of the genus *Mycteroperca* (Angulo et al., 2007). Individuals of *S. coelestinus*, and *S. guacamaia*, important grazers of macroalgae, were present in Northwest Cuba up until the 1970 (Aguilar and Gonzalez-Sanson, 2007), species not recorded in this study. But they have been targeted by fishers in recent decades. Their current scarcity has put the region at risk of remaining in a coral-depleted alternative stable state (Steneck et al., 2014).

Abundant fishing areas in the Caribbean Sea are overexploited, including Cuba. These practices have changed the structure of fish communities of Caribbean coral reefs, reducing the abundance of predatory fishes (Valdivia et al., 2017). It is estimated that about 74% of Cuban fisheries are overexploited, 20% are fully exploited, and 5% have collapsed (Baisre, 2018). Groupers and snappers, which aggregate on a few, predictable spawning sites, are especially prone to uncontrolled fishing (Claro et al., 2009). Commercial catches of the Nassau grouper, *E. striatus*, have declined by 98% (Jones et al., 2004; Baisre, 2018).

Beta (β) diversity. Beta diversity is a measure of the change of species between different types of communities or habitats; as such, it corresponds to the spatial contiguity of different communities or habitats (Magurran, 2004). Halffter et al. (2005), defines Beta diversity as the degree of change or replacement in the composition of species between different communities of a landscape. In the present study, the communities that presented a greater replacement of species had a greater geographic distribution; Canto Azul is located from Canto Pionero at a distance of 16 km and from La Llanita at 18 km. This result allows inducing that despite being geographically, remote communities show high ecological similarities. Acuario was the site that had the least replacement of species with the Bigornia, Cadena de Vita, Canto Chiquito, Laberinto and Punta Naranjo sites. Like Canto Azul with Coral Garden. In addition to Punta Naranjo with Canto Federico and Coral Garden.

There are species that share the same natural resource between different sites and others that interact negatively with other species to obtain this limited resource. This resource can be food or shelter, modifying the structure, dynamics and productivity of the communities (Badii and Landeros, 2007). Fish communities that share a greater number of species are susceptible to interspecific competition. Competition between species is the driving force in the structure of communities, involving as a factor increasing levels of diversity in a given area (Badii and Landeros, 2007). The increase in temperature has an obvious direct effect on the displacement of the geographical limits of many ichthyological species (Southward and Boalch, 1994; Southward et al., 1995; Alcock, 2003). During this research sampling activities, elevated temperatures between 30 and 32°C were obtained. There is an increase in these temperatures in the last five years (INSMET, 2020). This is a possible cause of the replacement of the species between the different sites studied.

Gamma diversity. The gamma diversity is the number of species in the set of sites or communities that make up a landscape (Forman and Gordon, 1986). Whittaker (1972) defined it as the species richness of a set of communities that make up a landscape, resulting from both alpha and beta diversities. The result obtained in this research allows us to establish that alpha diversity comprises 42.71% and beta diversity 57.29% of the gamma diversity of the studied marine ichthyologic communities. All communities are structured mainly at the ecological level by the degree of differentiation between them or the degree of replacement of species through environmental gradients (Moreno, 2001). In this way, we can define that those communities with a greater replacement of species are the ones that should be more conserved, being Canto Azul, Canto Pionero, and La Llanita.

The fish species that most influenced the dissimilarity between Laberinto and the different sites were: *C. parrae*, *C. cyanea*, *T. bifasciatum*, *A. virginicus*, *H. carbonarium*, *S. taeniopterus*, *O. chrysurus*, *H. flavolineatum*, *C. personatus*, and *H. aurolineatum*. The species that contributed the most to group III similarity with the highest number of sites were: *A. bahianus*, *A. coeruleus*, *C. fulva*, *C. capistratus*, *C. cyanea*, *C. parrae*, *H. flavolineatum*, *H. garnoti*, *H. tricolor*, *S. iserti*, *S. taeniopterus*, *S. aurofrenatum*, *S. viride*, and *T. bifasciatum*. These species are specialized herbivores that constitute key elements in the structure and composition of fish communities in coral reefs; controllers of the overgrowth of algae on the coral reef (Williams and Polunin, 2001). The group IV made up of four sites had a greater contribution of the similarity of the species mentioned above in addition to *C. cruentata*, *H. plumieri*, *H. rufus*, *L. apodus*, and *S. partitus*.

Key fish in the control and growth of vegetation cover on the seabed (Williams and Polunin, 2001). The structure of ichthyologic communities includes ecological interactions that produce patterns (spatial, temporal, cyclical, and ordered) of distribution and abundance (Kikkawa, 1986). The number of interconnections in a community depends mainly on the interacting species. Among these interconnections, the interspecific competition, the trophic, and symbiotic interrelationship nested in trophic networks stand out. Increasing the complexity increases the stability of the community. The stability of fish communities depends on four principal components, which are the magnitude, frequency, elasticity (resilience), and the persistence of the species (Badii and Landeros, 2007).

In the dive sites of Holguín, Cuba, the greatest richness of ichthyologic species was obtained in Canto Izzi. The fish community with the highest equitableness and alpha Fisher diversity was recorded in Cueva 1, presenting a greater Bigornia ecological dominance. The sites with the highest species replacement were Canto Azul with Canto Pionero and La Llanita. The set of communities in these sites is structured mainly by the replacement of species. No statistical differences were found with respect to the density of the species between the different sampling stations.

CONCLUSIONS

In the Holguín reef, the ichthyologic communities have low species richness, equitableness and alpha Fisher diversity. We speculate that this difference could be related to commercial and illegal overexploitation of fishing in the coral reef, however, there is no direct, empirical evidence to support this assertion.

The greatest richness of ichthyologic species was obtained in Canto Izzi (47) area. The fish community with the highest equitableness and alpha Fisher diversity was recorded in Cueva 1 (11) area, presenting a greater Bigornia ecological dominance (0.48).

The results suggest the poor state of conservation of the fish communities present in the Guardalavaca reef, Holguín, Cuba.

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