

# Ontogeny of Labridae Family in Shore Ecosystems in Seaflower Biosphere Reserve, Colombian Caribbean

## Ontogenia de la Familia Labridae en Ecosistemas Costeros en la Reserva de Biosfera Seaflower, Caribe Colombiano

### Ontogénie de la Famille Labridae dans les Écosystèmes Côtiers dans la Réserve de Biosphère Seaflower, Caraïbes Colombiennes

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#### ABSTRACT

The current study researches the ontogenetic distribution of Labridae family in the three shore ecosystems of mangroves, seagrasses and reefs in San Andrés Island. For this we made visual census of juveniles and adults from 2009 to 2012 during rainy and dry seasons and recorded the levels of some abiotic factors. Here we found 24828 individuals belonging to 96 species and 30 families. From those, the Labridae family was the second most abundant with 4884 individuals (19.7%) and the fourth most diverse with eight species. The species *Halichoeres garnoti* used all the three biotypes to develop their juveniles, *Thalassoma bifasciatum* and *H. bivittatus* used seagrasses and reefs, preferring the last one and *H. radiatus*, *H. maculipinna*, *Clepticus parrae*, and *Bodianus rufus* used only the reefs. The juveniles of *H. poeyi* were reported only in sea-grasses from which we concluded this biotype is essential for its ontogenetic development. *T. bifasciatum* shows a relative abundance of 81%, however its populations can be threatened because comprises more than 83% of the diet of the invasive lionfish *Pterois volitans*. Comparisons between biotypes manifest that the highest similarity is in reefs, followed by sea-grasses and mangroves, additionally the seascape connected biotypes showed more richness (eight species). We do not find any relationships between climatic seasons or abiotic factors and species abundances (except for *H. poeyi*) according with the applied statistics. This research contributes to ecosystems connectivity, which is fundamental to guarantee the structure and functionality of marine protected areas, in Seaflower Biosphere Reserve, Colombian Caribbean.

KEY WORDS: Labridae, ecosystem connectivity, ontogenetic distribution

#### INTRODUCTION

The biotypes of mangrove, seagrasses and reefs are common components of the Caribbean shore ecosystems (Coralina-Invemar 2012), due to that, multiple studies have focused on the effect that the landscape configuration of those biotypes has in the reef fish community, finding that reef fishes use seagrasses and mangroves as nurseries (Dorenbosch et al. 2007). This conclusion is based on the high abundance of juveniles in mangroves (Unsworth et al. 2008) and seagrasses (Jaxion-Harms et al. 2012), which is attributed to the high availability of food (Laegdsgaard y Johnson 2001), shelters (Cocheret de la Morinière et al. 2003) and low predation pressure (Mumby et al. 2004).

Additional to this, multiple studies affirm that the biotypes of mangroves and seagrasses are very important for maintaining reef fish populations through the addition of adults, while others affirm that this importance varies depending on the study site (Chittaro et al. 2005). Those different positions added to the use of different sampling methods on adults and juveniles and studies length duration of less than two years (Nagelkerken et al. 2000, Nagelkerken 2007) have remained unclear the role of mangroves and seagrasses and their effect in reef fish populations (Jones et al. 2010).

In an attempt to enrich the knowledge of connectivity in shore ecosystems, different authors have investigated the ontogeny of the fish communities in mangroves, seagrasses and reefs in the Caribbean (Appeldoorn et al. 1997, Ley et al. 1999, Mumby 2006). Santos-Martinez and Sierra (2011) researched in San Andres Island-Colombia the ontogenetic and temporal patterns of the reef fish community in different biotypes and found that the families Scaridae, Haemulidae, and Labridae were the most diverse of the island and the families Pomacentridae, Labridae, and Clupeidae the most abundant.

Due to the importance that Santos-Martinez and Sierra reported for Labridae family, besides being considered one of the most important families worldwide due to:

- i) Its high diversity and broad diet (Randall et al. 1997),
- ii) The role of many of its species as ectoparasites cleaners,
- iii) Its high ecological and morphological importance (Westneat and Alfaro 2005), and
- iv) Its diurnal and conspicuous behavior, give rise to the need of investigated the ontogenetic distribution of the Labridae family and its species in shore ecosystems in San Andres island.

This study aims to analyze the abundance and ontogenetic distribution of the species in the Labridae family present in mangroves, seagrasses, and coral reefs, and the effect that abiotic factors such as pH, salinity, temperature, dissolved oxygen, and profundity had over this abundance in San Andres island during the period 2009 - 2011, contributing to the knowledge, sustainable and responsible management of the shore and marine ecosystems since the addition of this island complex to the world network of biosphere reserves in 2000 and its declaration as a protected marine area in 2005 (UNESCO 2014).

## METHODOLOGY

### Study Site

San Andres Island and Bolivar Key are located in the southwest Caribbean within the archipelago of San Andres, Providencia and Santa Catalina ( $12^{\circ}28'' - 12^{\circ}36''$  N and  $81^{\circ}40'' - 81^{\circ}44''$ ), 800 km northwest from Colombian Coast (UNESCO 2014) and 240 km east from Nicaraguan Coast (Mancera et al. 2014). This archipelago has an annual media temperature of  $27.4^{\circ}\text{C}$  and a bimodal climatic pattern; rainy season is between June and December and the dry season between January and April (COIH 2013).

### Fish Censuses

Visual censuses were made during the rainy and dry seasons in four stations (locations) where the reefs were associated either with mangroves or seagrasses (Phanerogams) (Figure 1). The four sampling stations were: 1. BB; Bajo Bonito, 2. Little Reef (reefs associated with seagrasses), 3. BH; Bahia Honda (reefs associated with seagrasses and mangroves) and 4. Bolivar key (BB and CB have reefs without associations).

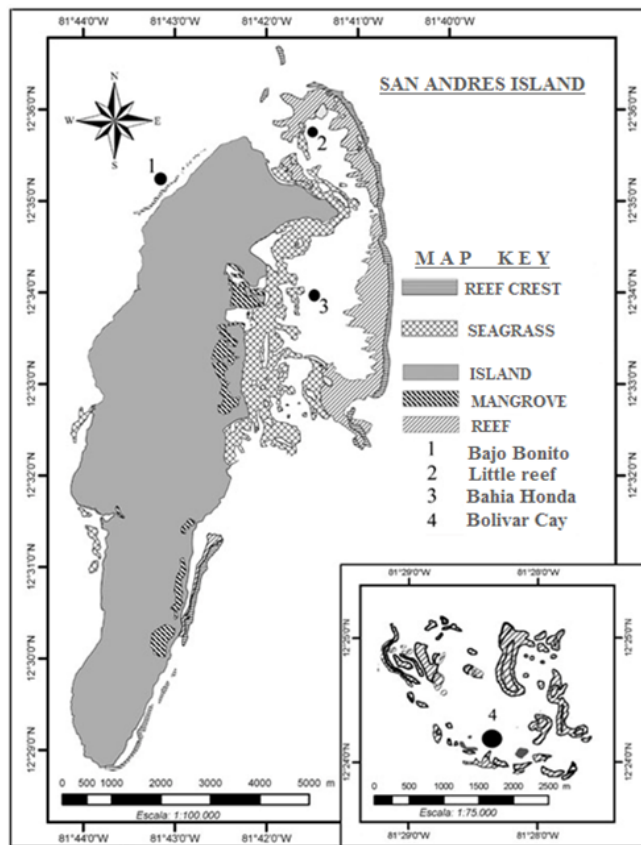
For identification and quantification of individuals, six transects of  $50\text{ m} \times 2\text{ m}$  separated between them by at least 10 m were made on each biotype from each station (Dorenbosch et al. 2007). In reefs, the transects were located parallel to the reef crest, in mangroves transects were placed adjacent to the mangrove roots, with 1 m within those and 1 m outside, in seagrasses the transects were placed randomly. For species identification, field guides were used (Human 2005), and the determination of the development state of each individual was done using the criteria established in FishBase World Wide Web (Froese and Pauly 2013); for those species that were not on the database were established as juveniles those individuals with  $1/3$  of the maximum length recorded for the species (Nagelkerken and Van der Velde 2002).

### Data Analysis

Diversity of Labridae family was determined using descriptive statistic and Shannon-Wiener (H) index (Diaz et al. 2012). The comparison between biotypes and stations was made using the equitability index (J), species richness (S), Sorensen similarity and Cluster analysis (Sierra et al. 2011). The seasonal comparison was carried out using the nonparametric test Mann-Whitney; normality was calculated with Shapiro-Wilk test. Finally, principal component analysis (PCA) was used to determinate the relations between species abundance and abiotic variables. All of the statistics were calculated using PAST version 2.17c (Hammer et al. 2001), except the H, D, J, and S indices that were analyzed with EstimateS version 9.1.0 (Colwell 2014).

## RESULTS

Labridae was the second most abundant fish family in the archipelago (19.7 % from all the identified ichthyofauna), represented by 4,884 individuals, distributed in three genders and eight species (Figure 2). From those, 80.2 % were juveniles and 19.8% adults, *T. bifasciatum* was the



**Figure 1.** Localization of the four stations in San Andres Island and Bolivar Cay. Images taken and modified from CORALINA.

most abundant species, while *C. parrae* had the lowest abundance from within the family.

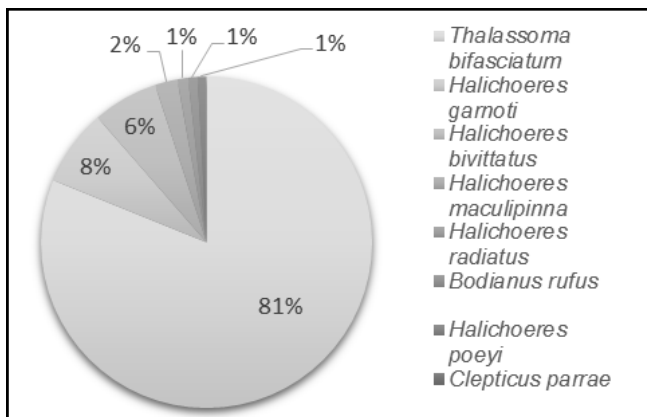
Adults from all the species were found exclusively in reefs, except for *H. bivittatus* and *T. bifasciatum*, in these species some adults (Table 1) were recorded in the seagrasses of LR and BB. Adults of *H. poeyi* were only found in the reef of LR.

Juveniles of the species *B. rufus* were only found only on reefs, 96.2% of *H. radiatus* and 89.2% of *H. maculipinna* were also recorded in this biotype. 6.3% of the juveniles of *T. bifasciatum* were observed in seagrasses while the remaining 93.7% were found in reefs. *H. garnoti* was the species with most incidence of those in seagrasses with 39.5% of them in this biotype. *H. poeyi* showed a different behavior compared with the other species of the family, 93.7% of the juveniles were found in all the three biotypes, preferring the reefs.

The species *T. bifasciatum*, *H. garnoti*, *H. bivittatus*, *H. maculipinna*, and *B. rufus* exhibited more abundance during dry season, while *H. radiatus* was the most abundant during rainy season. The species *H. poeyi* and *C. parrae* did not show changes in their abundances. *B. rufus* had the highest relative abundance of the family during dry season (Figure 3). The comparison between species abundances during climatic seasons did not exhibit statistically significant differences ( $p > 0,05$ ).

**Table 1.** Abundance of juveniles and adults from all the species of the Labridae family in three biotypes in San Andres Island from 2009 to 2011. (Biotypes A: reef, M: Mangrove, P: Seagrass).

Station	BH			CB	LR			Total	BH			CB	LR			Total	
	BB	A	M		A	A	P		A	A	M		A	A	P		
Biotype	A	A	M	P	A	A	P	Total	Juveniles								
Species / Development state	Adults								Juveniles								
<i>Thalassoma bifasciatum</i>	35	247	0	20	158	214	8	682	440	1538	0	131	273	824	74	3280	
<i>Halichoeres garnoti</i>	21	18	0	0	9	64	0	112	23	15	16	2	11	167	18	252	
<i>Halichoeres bivittatus</i>	0	56	0	1	7	17	2	83	0	80	0	29	16	54	50	229	
<i>Halichoeres maculipinna</i>	0	23	0	0	9	11	0	43	0	33	0	0	6	25	1	65	
<i>Halichoeres radiatus</i>	1	4	0	0	0	19	0	24	0	20	0	1	0	6	0	27	
<i>Bodianus rufus</i>	5	4	0	0	5	11	0	25	1	1	0	0	4	14	0	20	
<i>Halichoeres poeyi</i>	0	0	0	0	0	3	0	3	0	1	0	17	0	0	19	37	
<i>Clepticus parrae</i>	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	
<b>Total</b>	63	353	0	21	188	339	10	974	464	1688	16	180	310	1090	162	3910	



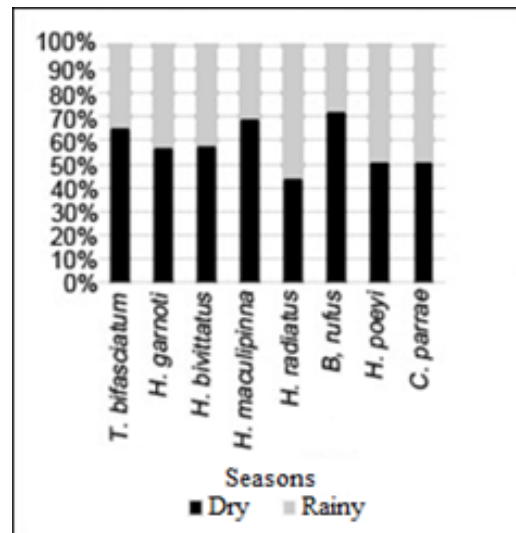
**Figure 2.** Relative abundance of the Labridae family species in San Andres Island.

The stations with multiple biotypes (BH and LR) had more individuals (Table 1). We found that diversity ( $H'$  index) and equitability ( $J'$  index) from each biotype is not determined by its connections to other biotypes (Table 2), this is demonstrated by the differences between the value of those indices in LRA and BHA, where both were connected to other biotypes and the similarities on the same index between CBA and BHA, where just one of them was connected to another biotype. (Figure 1.)

Additionally we resolved that the dominance values ( $D'$  index) had a positive correlation with the abundance of *T. bifasciatum* except in BHM, where this index has the maximum value (1) because only the species *H. garnoti* was found here, the exclusivity of this species in BHM also explains the value of the other indices in this biotype. The highest species richness ( $D$  index) and total density ( $Dt$ ) were found in the reefs connected to another biotypes.

The Sorensen similarity index (Table 3) showed the biggest similarities between the same kind of biotypes e.g., CBA-BBA and the lowest between mangrove and another biotypes e.g., BHM-LRP. This behavior was also evidenced by Cluster trees. (Figure 4).

The pH, dissolved oxygen, temperature, and salinity were the abiotic variables with low standard deviation



**Figure 3.** Abundance of species in the Labridae family during rainy and dry seasons.

(0.18; 0.60; 0.63, respectively) while profundity was the variable with more variation (4.22). Principal component analysis (PCA) did not determine any relationships between those variables and family abundance (Figure 5). However, it showed that the abundance of *H. poeyi* may increase with dissolved oxygen increases and temperature decreases (Figure 6).

**DISCUSSION**

**The Species and Their Ontogeny**

The results demonstrate that *B. rufus*, *C. parrae*, *H. radiates*, and *H. maculipinna* can be considered exclusively from reefs, and *T. bifasciatum* with *H. bivittatus*, although they prefer reefs, can inhabit seagrasses to develop their ontogeny. On the other hand, the exclusive presence of *H. poeyi* in BH and LR with 97.3% of its juveniles in seagrasses and all adults inhabiting reefs, make it the only species of Labridae family in San Andres Island which ontogeny relies on the ecosystem connecti-

**Table 2.** Index from the biotypes in San Andres island (H': Shannon-Wiener, D': Dominance, J': Equitability, S: Richness, Sm: average richness, Dt: Total density ind./m<sup>2</sup>).

Biotype	H'	D'	J'	S	Sm	Dt
BBA	0,4	0,82	0,23	5	0,05	5,27
BHA	0,5	0,77	0,26	8	0,08	20,41
BHM	0,0	1,0	0,0	1	0,01	0,16
BHP	0,8	0,59	0,48	5	0,05	2,01
CBA	0,6	0,75	0,36	5	0,05	4,98
LRA	0,9	0,56	0,47	7	0,07	14,29
LRP	1,2	0,76	0,76	5	0,05	1,72

ty between seagrasses and reefs. This phenomena had been observed in BH and BB, the only stations where those two biotypes were connected (Figure 1).

The diet is one of the factors that determines the preference for reefs of some of the studied species. *H. bivittatus*, *H. radiatus* and *B. rufus* have diets based on crabs (Randall 1967, Wainwright 1988, Clifton and Mora 1998), which are highly adapted to live on rocks and irregular surfaces. Adults of *B. rufus* also feed of *Diadema antillarum* (Randall 1967), a common echinoderm in the reefs of the island, and juveniles are primary cleaners of individual from the families Pomacentridae, Scaridae, and Acanthuridae (Johnson and Ruben, 1988), all of them visitors of the reefs in San Andres. *T. bifasciatum* and *H. bivittatus* have a limited diet of just ten taxa (Clifton and

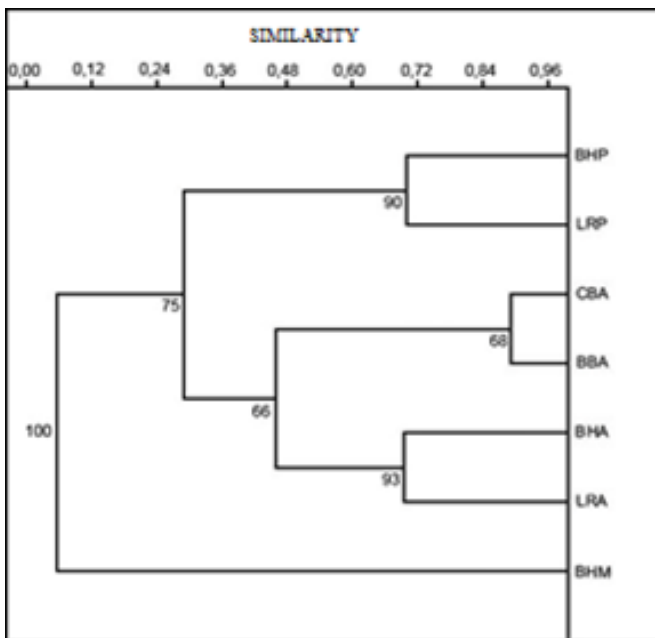
Motta 1998), which could limit their movements between biotypes.

The availability of shelter in reefs is another factor that promotes the use of this biotype. *H. bivittatus* prefers to inhabit places with high topographic complexity (Dominici -Arosemana and Wolff 2005) since its easier for it because it is a proficient swimmer (same than *H. poeyi* and *H. radiatus*). *H. poeyi* spend most of the time hiding in shelters to avoid predators (Jones 2002). This behavior is also common for *H. garnoti* during the day, which also uses cracks to feed (*in situ* observations, Thresher 1979). Juveniles of *H. radiatus* prefer to stay in the coral heads placed in the reef-sand interface (Sponaugle and Cowen 1997).

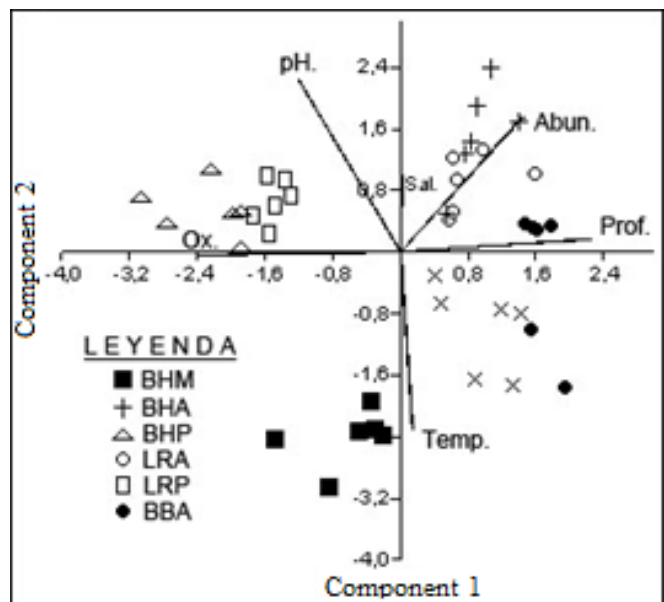
The reef preference had been reported for *B. rufus* in Venezuela (Lieske and Myers 1994) and Florida (Eggleston et al. 2004), for *C. parrae* in the Indo-Pacific

**Table 3.** Sorensen similarity index between biotypes in San Andres Island.

Bio-type	BBA	BHA	BHM	BHP	CBA	LRA	LRP
BBA	1						
BHA	<u>0.40</u>	1					
BHM	<u>0.06</u>	0,02	1				
BHP	<u>0.42</u>	<u>0.17</u>	0,02	1			
CBA	<u>0.89</u>	<u>0.39</u>	<u>0.06</u>	<u>0.50</u>	1		
LRA	<u>0.54</u>	<u>0.70</u>	0,02	<u>0.23</u>	<u>0.52</u>	1	
LRP	0,29	0,14	0,17	<u>0.70</u>	<u>0.37</u>	<u>0.19</u>	1

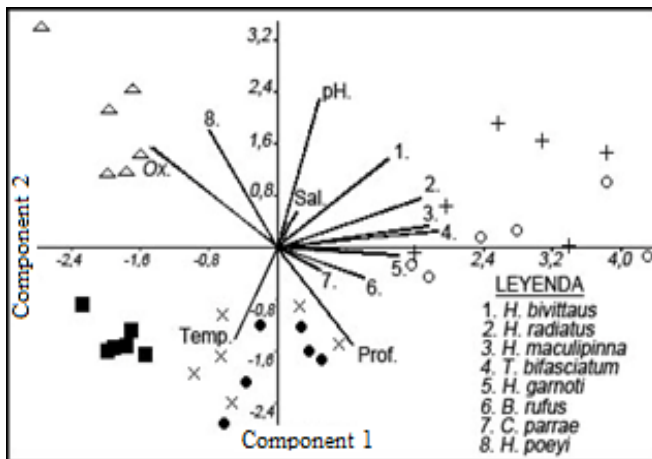


**Figure 4.** Abundance based dendrogram comparing biotypes. From Paired Group logarithm and Bray-Curtis similarity measurement (Bootstrap 1000, Coef. Corr. 0,9366).



**Figure 5.** Principal component analysis (PCA) showing the lack of correlations between temperature (Temp.) profundity (Prof), dissolved oxygen (Ox), and pH with family abundance. First component explains 33.8% of variation and second explains 30.4%.





**Figure 6.** Principal component analysis (PCA) showing correlations between abiotic factors and species abundance. First component explains 30% of variation and second explains 20,1%. The abiotic factors are named in Figure 5.

region (Lieske and Myers 1994), for *H. radiatus* in Florida (Eggleston et al. 2004) and Brazilian Atlantic coast (Rocha et al. 2005) for *H. maculipinna* in Florida (Eggleston et al. 2004), Puerto Rico (Aguilar-Perera and Appeldoorn 2008), Panama and Brazilian Atlantic coast (Dominici-Arosemana and Wolff 2005). The juveniles of *H. bivittatus* prefer reefs in Florida Keys (Rocha et al. 2005), US Virgin Islands, Brazil (Aguilar-Perera and Appeldoorn 2008) and British Virgin Islands (Gratwicke et al. 2006).

However it has been determined that *H. bivittatus* prefers a specific biotype according to location, for example it prefers coral rubble and sand substrate in Barbados (Sponaugle and Cowen 1997). This suggests that the abundance of *H. bivittatus* in the seagrasses from San Andres may respond to unique variables of the island such as predation pressure, food and space availability, competence with another species, and illness (Bay et al. 2001, Mora et al. 2003).

The use of seagrass by *H. poeyi* had been previously reported in Brazil (Rocha et al. 2005, Godoy and Coutinho 2002), Lesser Antilles (Bouchon-Navarro et al. 2006), Puerto Rico (Aguilar-Perera and Appeldoorn 2008) and British Virgin Islands (Gratwicke et al. 2006). However, its exclusive use by juveniles has not been reported. One factor that might suggest this preference is predation pressure. Jones (2002) reports that juveniles of this species use the eye flickering more than the other species of the family as a mechanism to avoid predators.

The preference of *T. bifasciatum* for the reefs can also be in response to its reproductive habits, which is linked to corals or rocks close to the reef (Feddern 1965) and its associations with *Millepora complanata* (fire coral), which is frequently found on the reef (Gratwicke et al. 2006). One of the factors that could promote the presence of juveniles of this species in seagrasses is the consumption of the eggs of *Abudedefduf saxatilis* (Feddern 1965), which nursery zone in San Andres island are the seagrasses. (A. S. M. and O.S. unpublished data). The adults of *H. garnoti* are occasionally associated with *Pseudupeneus maculatus* and *Mulloid*

*martinicus* (Aronson and Sanderson 1987), which feed in the bedrock and sandy substrates in the bottom of the reefs (Cervigón 1993, Lieske and Myers 1994).

The high density of *T. bifasciatum* can be attributed to lower predation pressure (Randall and Randall 1960) because its role as a secondary cleaner of fishes like *C. parrae*, *Acanthurus coeruleus*, *A. bahianus* (Johnson and Ruben, 1988), and *Pomacanthus paru* (*in situ* observation). Despite that, the populations of *T. bifasciatum* in San Andres Island are being threatened because they correspond to more than 83% of the diet of invasive fish *Pterois volitans* (Abril et al. 2012). The importance of this species in the diet of lionfish has been reported in the Bahamas (Albins and Hixon 2008, Morris and Akins 2009) and the rest of the Colombian Caribbean (Acero et al. 2008, Pabon 2013).

The density of juveniles of *H. poeyi* (Table 1) showed in here is between the previously reported ranges for Honduras (Jaxion-Harm 2010) and Puerto Rico (Aguilar-Perera and Appeldoorn 2008). Nevertheless, the abundance of this species varies throughout the Atlantic, being high in Arraijal de Cabo (Ferreira et al. 2001) and Farol beach (Godoy and Coutinho 2002), both in Brazil, and low in Honduras (Jaxion-Harm 2012). The low density of adults of this species can be attributed to the high presence of tourists (Ilarri et al. 2008), which is the main economic activity on the island (Santos-Martinez and James 2007).

Territorial behavior limits the density of some species of the family and decreases the abundance per area unit. *H. garnoti*, which does not exhibit this behavior (Thresher 1979) showed high density compared with the other species of the family (except *T. bifasciatum*), while *H. maculipinna* and *B. rufus* have a strong territorial behavior (Rocha 2000, Adreani et al. 2004, Roberston 1981) and showed low densities. *H. maculipinna* limits this behavior only to conspecific adults of the same size (Thresher 1979); this allows adults and juveniles to inhabit the same space.

*B. rufus* and *H. radiatus* also showed low density on St. Croix Island and the Yucatan Peninsula (Johnson and Ruben 1988, Vega-Cendejas and Hernandez 2004).

*H. garnoti* can use all three studied biotypes, however it prefers reefs and/or mangroves over seagrasses, indicating that its ontogenetical development does not depend on the ecosystem connectivity, but other biotypes besides reefs can be used as long as they are available (Table 1, BH).

The presence of juveniles of *H. garnoti* in the three biotypes may be a response to its generalist diet (the same as adults) integrated in similar amounts by crabs, ophiuroids, and gastropods (Randall 1967), allowing them to adapt their diet depending on the prey availability within the biotype they are located (Wainwright 1988). The use of mangroves by juveniles maximizes the resources acquired (Bay et al. 2001, Mora et al. 2003) by decreasing the competence within the same family species (Table 2, D' Index).

Additionally, spawning has irregular patterns (Robertson 1981), occurring within the male's home range, which can have up to 2,500 m<sup>2</sup> (Thresher 1979) and can include areas and biotypes outside the reef, such as mangroves and seagrass. Moreover, this species is able to reproduce outside the feeding area, which is located within

the reef (Robertson 1981), and even if reproduction take place inside the reef, the juveniles are more mobile and have wider distribution ranges than adults (Thresher 1979).

The absence of significant differences between the abundances of eight species during climatic seasons can be due to the fact that seven have reproductive cycles influenced by the moon. *H. bivittatus*, *H. radiatus*, *H. poeyi* and *H. garnoti* have recruitment patterns affected by full moon and its high tide, while recruitment of *H. maculipinna*, *T. bifasciatum* and *B. rufus* are under the influence of low tides (Sponaugle and Cowen 1997). Additionally, *T. bifasciatum*, *H. maculipinna*, and *H. garnoti* were reported to have stochastic recruitment patterns throughout the year and *C. parrae* is reported to lack abundance variations (Tolimieri et al. 1998).

The similarity between biotypes, determined by the Sorensen index (Table 3) and Clusters dendrogram (Figure 5), demonstrate that each biotype, despite the station it belongs to, had the same influence over diversity and abundance of the Labridae family species. This dendrogram and the H', D' and S' indices showed that mangroves are the biotypes with the lowest affinity within the Labridae family.

The lack of relationships between abiotic variables and family abundance (Figure 5) indicates that abundance is influenced only by biotic variables as mentioned above or the biotypes connectivity (Table 1).

*H. poeyi* showed a positive relationship for temperature in Itaipu, Brazil (Mendonça-Neto et al. 2008) but different to the one we found in here. This variance and the positive relationship with dissolved oxygen and the use of seagrasses as nurseries stand out as the differences between the populations of this species that inhabit San Andres Island and the wider Caribbean.

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