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## DISTRIBUTION AND RELATIVE ABUNDANCE OF BUTTERFLYFISHES AND ANGELFISHES ACROSS A LAGOON AND BARRIER REEF, ANDROS ISLAND, BAHAMAS

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**Abstract:** Juveniles of *Chaetodon capistratus*, *C. striatus*, *C. ocellatus*, *C. sedentarius*, *Pomacanthus arcuatus*, *P. paru*, *Holacanthus ciliaris*, and *H. tricolor* occurred in the shallow lagoon habitats. Adults and subadults of these species were associated with the deeper barrier reef and seaward platform habitats. *C. aculeatus* occurred only on the outer seaward platform. In strip transects at a seaward platform site, *C. capistratus* and *H. tricolor* were found with significantly greater abundance than *P. paru* and *C. striatus*.

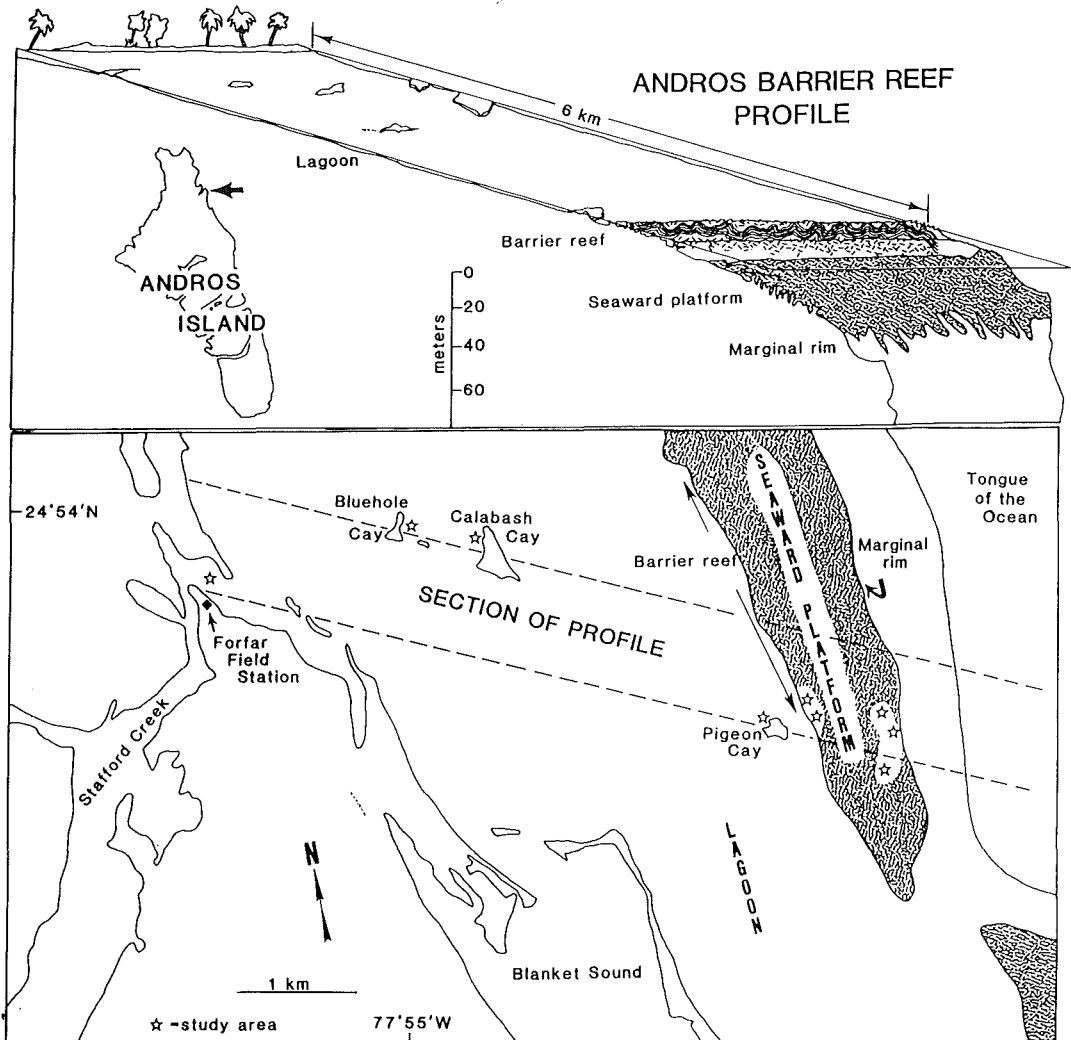
The butterflyfishes (Chaetodontidae) and angelfishes (Pomacanthidae) are conspicuous elements of tropical coral and rocky reefs. Each family is comprised of five and six shallow water species, respectively, in the Caribbean. Despite these facilitations, little ecological research has been published on the Caribbean species. The few ecological studies of the Caribbean species have examined aspects of the food, foraging behavior, and habitat use (Randall, 1967; Feddern, 1968; Randall and Hartman, 1968; Clarke, 1977; Birkeland and Neudecker, 1981), while behavioral studies have included brief examinations of cleaning symbiosis and mating systems (Brockman and Hailman, 1976; Neudecker and Lobel, 1982; Moyer et al., 1983). In contrast, many studies on the ecology of Indo-Pacific chaetodontids and pomacanthids have been published (e.g., Reese, 1973; 1977; 1981; Hobson, 1974; Bouchon-Navaro, 1981; Anderson et al., 1981). Many behavioral studies of these Indo-Pacific forms have also appeared (e.g., Reese, 1975; Ehrlich

et al., 1977; Lobel, 1978, Moyer and Nakazono, 1978; Fricke, 1980; Bauer and Bauer, 1981; Ralston, 1981; Thresher, 1982; 1984; Ehrlich and Ehrlich, 1982).

Our objectives were to examine the distribution and the relative abundance of five chaetodontids: (*Chaetodon aculeatus*, longsnout butterflyfish; *C. capistratus*, foureye butterflyfish; *C. ocellatus*, spotfin butterflyfish; *C. sedentarius*, reef butterflyfish; *C. striatus*, banded butterflyfish), and four pomacanthids: (*Pomacanthus arcuatus*, gray angelfish; *P. paru*, French angelfish; *Holacanthus ciliaris*, gray angelfish; *H. tricolor*, rock beauty) across the lagoon and barrier reef habitats of the northeast coast of Andros Island, Bahamas (Fig. 1).

### METHODS AND MATERIALS

The study sites were located in the vicinity of the barrier reef of the northeast coast of Andros Island, Bahamas (Fig. 1). An atlas of the bottom topography and shelf features of the Andros barrier reef can be found in a



**Figure 1.** Diagrammatic representation of Andros barrier reef and map of study sites. Study sites were chosen to best represent a cross-section of available habitats at three main site groups (lagoon, barrier reef and seaward platform).

United States Naval Publication (Anonymous, 1967). Four study sites were chosen in the protected lagoon (Fig. 1). One lagoon site was located in the mouth of a tidal estuary (Stafford Creek) at a depth of 1-4 m. The three other lagoon sites were situated in the lee (protection) of small cays (lagoon islets). The creek mouth is characterized by irregular and overhanging limestone walls at the center cut, flanked by turtle grass (*Thalassia*) beds and mangrove forests on the sides. The bottom of the center cut is littered with densely packed thin-

shelled bivalves (*Pecten* sp.). The cay sites (depths of 1-2 m) have little coral development and are mainly composed of patch reefs with turtle grass and sand bottom in the calmer waters. A blue hole (entrance to an undersea cave) is located at the Bluehole Cay site. Blue holes have unusually large aggregations of fishes (Benjamin, 1970; Cousteau and Dirole, 1973). Two sites (depths of 3-6 m) were located on the barrier reef (reef crest) which parallels and is 2 to 6 km off the eastern shore of the island (Anonymous, 1967). The barrier reef crest is exposed

at low tide and is composed of large amounts of dead corals (with abundant crevices) capped with typical Caribbean corals (*Zooantharia* and *Alcyonaria*). Fire coral (*Milleporina*) was also common at the barrier reef sites. The three sites on the seaward platform (depths of 12-20 m) were characterized by luxuriant coral development (primarily *Montastrea annularis*) with spurs and grooves generally present and trending perpendicular to the barrier reef line. The seaward edge of the platform breaks sharply at the marginal rim escarpment at depths between 30 and 35 m.

We surveyed each of the study sites at least once (e.g., Calabash and Bluehole Cays) during each of five annual one-week study periods (July or early August, 1979 to 1983). Stafford Creek, Pigeon Cay, the barrier reef group, and the seaward platform were surveyed six to eight times during most years. Each site survey consisted of SCUBA or snorkel dives lasting, on average, from one to two hours, respectively. A minimum of 30 hours of underwater observations were totaled for each habitat lagoon, barrier reef, and seaward platform). Observations were made between 9:00 a.m. and 6:00 p.m. and were recorded on polypaper with a pencil and with still and movie cameras. Each survey covered an area of approximately 500 m<sup>2</sup>. Adult and juvenile chaetodontids and pomacanthids were searched out and recorded as they were encountered underwater. Juvenile, subadult, and adult stages were determined by color pattern (Böhlke and Chaplin, 1968; Feddern, 1972; Burgess, 1978; Allen, 1979). Fish abundance data was not used to attempt to derive density estimates of species, but the data were used to compare the relative abundance among species at the three site groups (lagoon, barrier reef, and seaward platform) and the relative

abundance of a species at the same site groups.

We established a 50 x 6 m east-west strip transect at the southernmost seaward platform site (13-15 m depth) in 1982 by attaching flagging tape to coral heads. We visually censused chaetodontids and pomacanthids within the transect during the four daylight periods (three periods between 1000-1200 hours and one between 1400-1500 hours) over a three-day period in late July 1982 by noting the numbers of individuals of each species.

## RESULTS

Our surveys of the three Andros Island survey site groups (lagoon, barrier reef, and seaward platform) suggest that: chaetodontid and pomacanthid juveniles are confined to the lagoon habitats; adult *C. aculeatus* are restricted to the seaward platform; adult *C. capistratus* are the most abundant of the chaetodontids and pomacanthids observed; adult *C. ocellatus*, *P. arcuatus*, *P. paru*, and *H. ciliaris* are more commonly observed on the barrier reef; and adult *H. tricolor* are more commonly observed on the seaward platform (Table 1). Although our data on relative abundance suggest certain overall trends (Table 1), the analysis must be tempered by the shortcomings of our nonreplicative sampling procedure. For example, our surveys rarely covered the same paths over the site habitats, and we may, at times, have underestimated shy or secretive species (e.g., *H. ciliaris*) that tend to hide in specific coral caves or crevices. This is especially true for the small juveniles that could easily disappear from view by hiding between empty mollusk valves (Stafford Creek), in blades of turtle grass, and in crevices on patch reefs. Finally, although we attempted to avoid

**Table 1.** Relative abundance of juvenile and adult chaetodontids and pomacanthids at the survey locations, Andros Island, Bahamas (see Fig. 1). Depth ranges for each location are given in parentheses.

	Locations					
	Lagoon (1-4m)		Barrier reef (3-6m)		Seaward platform (12-20m)	
	adult	juven.	adult	juven.	adult	juven.
<i>C. capistratus</i>	0	20	66	0	58	0
<i>C. striatus</i>	0	16	16	0	19	0
<i>C. ocellatus</i>	0	3	17	0	5	0
<i>C. sedentarius</i>	0	2	3	0	1	0
<i>C. aculeatus</i>	0	0	0	0	9	0
<i>P. arcuatus</i>	0	6	19	0	4	0
<i>P. paru</i>	0	5	6	0	0	0
<i>H. tricolor</i>	0	3	5	0	17	0
<i>H. ciliaris</i>	1	1	12	0	2	0

recounting the same individuals at the same site, our success was probably diminished at site visits separated by a year. Chaetodontids, at least, are known to maintain a home range residence of a year (Reese, 1973).

Only two chaetodontids and two pomacanthids were observed during our transect counts on the seaward platform (Table 2). The means of the four sample periods for each species are generally comparable with the exception of the 7.27.1982 sample for *C. capistratus* which is significantly less ( $t=3.8$ ,  $p<0.05$ ). The combined means for each species indicate that *C. capistratus* and *H. tricolor* are significantly more numerous ( $t$ -tests),  $p<0.05$  than *C. striatus* and *P. arcuatus* (Table 2).

## DISCUSSION

Of the eleven species of chaetodontids and pomacanthids that occur in the Bahamas (Böhlike and Chaplin, 1968), we found nine to occur at our study sites. We did not record two pomacanthids: *Holacanthus bermudensis*, the blue angelfish, and *Centropyge argi*, the cherubfish. *H. bermudensis* is primarily a continental species (Feddern, 1972) and is considered by Böhlike and Chaplin to be either rare or restricted in its distribution among the Bahama islands. *C. argi* rarely occurs on the reef but is apparently common around the reef base in small rock rubble (Thresher, 1980). Clarke (1977) reports large numbers, 60 and 84, from rock terraces at 10 m and

**Table 2.** Means and standard deviations of chaetodontid and pomacanthid individuals counted along a 50 x 6 m transect on the seaward platform.

Species	7.26.1982		7.27.1982	7.28.1982	Combined (n = 40)
	am (n = 9)	pm (n = 13)	am (n = 12)	am (n = 16)	
<i>C. capistratus</i>	1.8 ± 1.9	2.5 ± 1.7	0.7 ± 0.9	1.8 ± 1.8	1.7 ± 1.7
<i>C. striatus</i>	0.4 ± 0.9	0.2 ± 0.6	0.2 ± 0.4	0	0.2 ± 0.6
<i>P. arcuatus</i>	0.1 ± 0.3	0.3 ± 0.5	0.2 ± 0.6	1.5 ± 1.4	0.4 ± 0.8
<i>H. tricolor</i>	1.1 ± 1.3	1.8 ± 1.2	2.8 ± 1.7	2.0 ± 1.4	2.0 ± 1.5

14-17 m, respectively, at Bimini, Bahamas. It is possible that we may have overlooked *C. argi* since it is small (6 cm) and behaves much like one of the ubiquitous damselfishes (Böhlike and Chaplin, 1968).

Our observations and those of others (Bohlke and Chaplin, 1968; Clarke, 1977; Colton and Alevizon, 1981; Neudecker and Lobel, 1982) indicate that *C. capistratus* is the most common and abundant Caribbean chaetodontid. The reason for this is unclear, but it may be related to its generalistic pattern of foraging (Birkeland and Neudecker, 1981) and to its successful use of both the shallow barrier reef and deeper seaward platform habitats. Neudecker and Lobel (1982) report *C. capistratus* to be nearly as abundant as *C. aculeatus* on deeper reefs (30 m) in the United States Virgin Islands and conclude that the abundance of *C. capistratus* is positively correlated with coral cover (both stony and horny corals). We might predict then, that the abundance of *C. capistratus* should be less on the Andros barrier reef (less total coral cover) and higher on the seaward platform (more total coral cover). Our general survey figures do not bear this out. However, we cannot accurately compare between the site groups. Obviously, quantitative transect samples are also desirable from the barrier reef sites.

We verify that *H. tricolor* is more abundant on the deeper reef (Clark, 1977), and that *C. aculeatus* is restricted to the deeper reef (Neudecker and Lobel, 1982). Neudecker and Lobel present mixed depth results for *H. tricolor* and conclude that the abundance of *H. tricolor* is positively correlated with the amount of sponge surface area (and not necessarily depth). Their shallower depth (15 m) is not comparable to ours at the barrier reef. Since sponges were much

less abundant on the Andros barrier reef, we tend to agree with Neudecker and Lobel that sponge prey availability is an important distribution factor for *H. tricolor*. The reason for the deeper distribution pattern of *C. aculeatus* is not clear but may also be related to prey availability (Neudecker and Lobel, 1982).

Neudecker and Lobel's overall abundances of *C. capistratus* and *H. tricolor* for their 15 m and 30 m study sites are surprisingly similar to our mean values in Table 2. If these data are standardized to 100 m<sup>2</sup>, our *C. capistratus* density is 0.6 compared to their 1.1, and for *H. tricolor* they have 0.6 compared to our 0.7. The abundance numbers reported by Clarke (1977) could not be standardized to area since it was not possible for him to obtain measurements of the area covered in his surveys.

There is little documented information on the distribution of juvenile chaetodontids. The Caribbean species, as exemplified by our studies at Andros, appear to prefer the inshore areas such as the protected lagoon (Thresher, 1980). Data from Indo-Pacific chaetodontids indicates that many of the *Chaetodon* species show patterns where juveniles are found in the shallower inshore reef zones (Fricke, 1973; Bouchon-Navaro, 1981). Gilligan (1980) has shown that chaetodontid and pomacanthid adults in the Gulf of California, Mexico, are usually found on the seaward points of rocky coasts near deeper water. Juveniles rapidly colonize small artificial reefs in shallow protected embayments (Molles, 1978; Gilligan, unpublished). It was suggested by Gilligan (1980) that there may be a correlation between the magnitude of life history niche-shift (e.g., juvenile/adult habitat transition) and reproduction-dispersal strategies in reef fishes. Two advantages seem inherent for juveniles occurring the shallow

inshore areas: first, there are fewer large predators (e.g., groupers, snappers, etc.) regularly patrolling these shallow areas; and second, the juveniles are separated from the adults and thus do not have to compete with them for food and space. An inherent disadvantage is that juveniles must somehow find their way to the main reef, a distance of 6 km in the case of the juvenile chaetodontids inhabiting the Stafford Creek site. How and when this migration from the shallow to the deeper areas takes place is of great interest and deserves a detailed investigation (Thresher, 1980; 1984).

Although our data suggest a similar depth pattern to chaetodontids for the juveniles and adults of the pomacanthids, there is little support for this in the literature. Reynolds (1979), Thresher (1980), and Fricke (1980) all report juvenile pomacanthids on deeper reefs and sometimes within the territories of the adults. Still another exception to our juvenile-adult distribution pattern is the presence of large subadults and adults in the lagoon blue holes (Lindquist, 1982). Blue holes offer reef-like conditions with ample cover and food resources not typical of the shallow lagoon (Cousteau and Dirole, 1973).

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