Chapter 7

Temporal and Spatial Recruitment Patterns in Chaetodontids and Pomacanthids in the Southern Red Sea

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Abstract

Temporal and spatial recruitment patterns were investigated by monitoring settlement of chaetodontids and pomacanthids on two reefs in the southern Red Sea. Recruitment data were collected by visual census on the reefs at monthly intervals. Seasonal patterns were studied by collecting recruitment data from two reefs for one year while long-term temporal patterns were investigated by monitoring settlement on one site for four years. Results show seasonal recruitment for *Chaetodon larvatus*, *C. semilarvatus* and *Pomacanthus* spp. Recruitment occurred mainly in June and July. The three species differed in their recruitment patterns. The chaetodontids were recorded mainly from sites rich in live coral where branching *Montipora* dominate the substrate while pomacanthids were abundant on sites where live coral cover was low.
Introduction

The life cycle of most marine organisms includes a pelagic larval stage preceding a demersal, less mobile adult stage (Sale 1980, Fowler et al 1992). For the species concerned, the input of young individuals to the local population comes from settlement of pelagic larvae. In coral reef population studies recruitment refers to the addition of individuals to the benthic environment via settlement from the pelagic phase (Sale 1980). Recruitment frequently shows pronounced spatial and temporal variation (Sale 1980, Doherty 1988, Fowler et al 1992), which can strongly affect the distribution and abundance of a species as well as its population dynamics.


Numerous factors, including microhabitat characteristics (Bell & Galzin 1984, Eckert 1984, Sale et al 1984), resident fishes (Jones 1987), and larval supply (Victor 1986, Milicich et al 1992), cause variations in recruitment. The reef substratum provides food and shelter from predation (Shulman & Ogden 1987), as well as shelter from aggression from adult fishes (Sale 1980). Substratum characteristics can also affect the outcome of interspecific interactions (Ebersole 1985). Variation in the distribution and abundance of recruits can be caused by habitat choice during settlement (Sale et al 1984, Wellington 1992) or survival after settlement (Wellington 1992). Furthermore, post-settlement processes such as predation or competition may alter the initial distributions of recruits.

Investigations on the relative importance of pelagic and demersal processes with an impact on recruitment have, for the most part, been limited to pomacentrid and labrid species (Doherty & Williams 1988), and mainly been conducted on the Great Barrier Reef or in the Caribbean (Mapstone & Fowler 1988). It is thus unclear how generally applicable the results from these studies are. Specifically, it is doubtful that the results from such studies can be applied to non-pomacentrid or non-labrid species of coral reef fish living in other parts of the world.
The objective of the present work is to investigate the recruitment patterns of chaetodontids and pomacanthids in the southern Red Sea. Attempts will be made to find answers to the following questions.

- Is recruitment in chaetodontids and pomacanthids seasonal?
- Is there inter-annual variation in recruitment?
- What are the differences in recruitment between chaetodontids and pomacanthids?
- Does the nature of the substrate play a role in the recruitment of these fish populations?

**Material and Methods**

*Study site*

Recruitment surveys were conducted on the Resimedri and Twalot reefs near Massawa (Fig 7.1). Resimedri is a fringing reef, which extends for about 2000 m along the southeastern coast of Massawa proper.

The depth of the reef drops gently from about 0.5 m on the reef flat to a maximum depth of 10 m. Mounds of *Porites* dominate the shallower part of the reef while encrusting and branching corals are abundant in the deeper part of the reef. Monogeneric stands of *Montipora, Echinopora,* and *Pavona* are common on the central part of the reef.

Twalot reef is situated on the southern end of Twalot Island. It is a narrow fringing reef, which runs parallel to the shore for about 1000 m and extends to maximum depth of 4 m. Dead coral dominates the reef and sub-massive *Montipora* and *Porites* are the most abundant corals in the area. Dead coral is full of crevices providing shelter for young fish. The bottom below the reef base is covered with fine sediment, which prevents extensive growth of corals.

*Survey methods*

Recruitment data were collected using visual census while diving or snorkelling close to the substrate. Butterflyfish and angelfish encountered within the quadrats were counted and their sizes estimated to the nearest cm. Length estimation was facilitated by a cm-scale glued to a PVC plate. Occasionally samples of young fish were collected from nearby sites (using the anaesthetic quinaldine) to validate the size estimates. Comparisons between estimated and actual lengths showed that the former are one third higher than the actual lengths. Hence, all estimated lengths were accordingly reduced by one third.
Growth of the species studied appears to be sufficiently rapid for an experienced observer to be able to distinguish one month's recruit from those that arrived during the previous month (see chapter 8). Hence, juvenile fish less than or equal to 4 cm in size are assumed to have recruited within a month. This method of estimating recruitment may underestimate recruitment in two ways (Williams 1983). First, transient individuals that both recruited and disappeared between successive censuses will be missed. Second, rapid replacement of individuals on the same site by conspecifics will be difficult to detect. However, in the study area juvenile fishes were not observed leaving the recruitment site. The only source of new recruits to the area was through settlement of larvae from the water column. Moreover, the mortality rate of newly recruited *C. larvatus* is relatively low during the first few weeks (see chapter 8). Restricted distribution of juveniles and the low mortality of recruits minimise the underestimation mentioned above.

Recruitment data were collected from two sites on Resimedri reef and one site on Twalot reef. The first site on Resimedri reef (referred henceforth as the monitoring site) was monitored for over three years to investigate seasonal and inter-annual variations in recruitment. Spatial variation in recruitment was investigated by comparing the data recorded from this site with recruitment data collected from Twalot reef. The second site on Resimedri reef (referred to as ‘the comparison site’) contained two stations with different coral composition. Recruitment data from the two stations were compared and the effect of the nature of coral on recruitment investigated. Due to the difference in the

![Figure 7.1. Study site. CS = comparison site; MP = Massawa proper; MS = monitoring site; RR = Resimedri reef; TR = Twalot reef; TW = Twalot.](image-url)
maturity of the reefs, we used different sampling techniques to collect field data. The methods used at each site are presented separately.

**a) Surveys on the monitoring site**

Temporal recruitment patterns were investigated by monitoring settlement of recruits in five 50 m\(^2\) quadrats fixed at the monitoring site. Each quadrat was subdivided using ropes into five 10 m\(^2\) stripes to assist in the counting process and to avoid double counts. Recruitment surveys were carried out at monthly intervals from January 1998 to July 2000. Additional data were collected from the same site in June and July 2001.

**b) Surveys on the comparison site**

The effect of coral type on fish recruitment was assessed by monitoring recruitment in two stations. The stations were separated by a distance of about 100m and they were selected based on their differences in the morphology of the live coral. Three 25 m\(^2\) quadrats were fixed on each station and recruitment in the quadrats was monitored at monthly intervals from August 1999 to July 2000.

**c) Surveys on Twalot reef**

Monthly recruitment data were collected from Twalot reef from April 1999 to July 2000. The narrow character of the reef precludes the use of the quadrat method. Hence, four 50 m nylon ropes were laid parallel to the shoreline and fixed at 1m depth. Visual censuses were conducted by slowly snorkelling above the lines and counting all chaetodontids and pomacanthids observed within 1 m on either side of the lines.

**Estimation of bottom cover**

The bottom cover was estimated using the quadrat method (English et al 1994). Fifty random points were selected within each fixed quadrat or along each transect line. A sampling quadrat of 0.25 m\(^2\) was placed around each randomly selected point and the substrate cover was estimated. The types of substrates encountered were: live coral, macro-algae, other benthic animals, dead coral, and sand. The live corals and macro-algae were further identified to the genus level. Cover estimates from each sample were pooled to estimate the cover for the entire monitoring area. Bottom cover estimation was done on all sites in July 2000.
Results

Bottom cover

a) monitoring site

Montipora is the dominant coral on the monitoring site and covers 56% of the bottom (Fig 7.2). The coral forms a monogenic stand of dense branches which serves as a shelter and provides food for the juvenile butterflyfishes. The second and third most abundant substrates are Halimeda and dead coral which cover 21% and 17% of the bottom respectively. Halimeda is calcareous seaweed which grows seasonally on the site. The coral rubbles are the result of invasion of branching Montipora by Halimeda.

![Figure 7.2](image)

Figure 7.2. Substrate cover on the monitoring site on Resimedri reef (black bars) and of Twalot reef (grey bars). Error bars represent standard deviations. Substrate labels: Mont= Montipora, Pori=Porites, Hali=Halimeda, Padi=Padina, dead=dead coral, other=coral genera different from Montipora and Porites, and inver=benthic invertebrates.

b) comparison site

The nature of the substrate of the two stations at the comparison site is markedly different (Fig 7.3). Station I was covered by dead coral (48 %) and by Halimeda (29 %). The live coral cover on this site is only 23% including 20% branching Montipora. The remaining 3% were other coral genera.

On station II Echinopora covers 55% of the bottom while non-living substrates (dead coral and sand) cover 43%. Echinopora forms packed plates of coral, which provide little shelter for young fish.
c) Twalot reef

Twalot reef was mainly covered by sand and dead coral occupying 35 and 30% of the bottom respectively (Fig 7.2). Porites covered 28% and Montipora 7% of the bottom. Both coral genera form a sub-massive substrate that provides limited shelter for young fishes. The dead coral was covered with epiphytic algae. The reef had a complex structure and was full of crevices serving as refuges for juvenile fishes.

Seasonal and annual recruitment patterns

Five species of adult butterflyfish species were recorded from the study area (see chapter 3 & 4) but only two species, *Chaetodon larvatus* and *C. semilarvatus*, were observed as recruits. The minimum size of newly settled *C. larvatus* and *C. semilarvatus* is 18 and 20 mm respectively. These recruits live very close to the substrate and feed on coral polyps. The density of adult fishes in the recruitment site is very low. In the nearby area, where massive corals dominate, a very high density of adult *C. larvatus* was recorded (see chapter 3 & 4). Adults live in heterosexual pairs and chase juvenile fishes out of their territories. In the recruitment site the density of juveniles was very high and there were ample hiding sites among coral branches. The density of *C. semilarvatus* in the study area was low. Adults of this species live solitary or in groups and defend no territories (see chapter 4).
Two Pomacanthid species, *Pomacanthus asfur* and *P. maculosus*, are common in the area. Juveniles of both species are light blue in colour and have characteristic white and/or yellow lines that can be used to identify the species. However, the lines of new recruits are less conspicuous and identification of the species is difficult. Due to these difficulties, no distinction is made between the two species during the survey. The recruits of both species are referred to as ‘*Pomacanthus* spp.’. The size of new *Pomacanthus* spp. recruits is 20 mm. These feed on turf algae and are observed to hide within coral crevices. Adult angelfishes feed on sponges and other invertebrates (Randall 1983). Due to the cryptic behaviour of the newly settling angelfishes, recruits may have been overlooked during visual censuses.

**Seasonal pattern**

Recruitment of *C. larvatus* and *Pomacanthus* spp. was highly seasonal during the study period (Fig 7.4-7.6). In all surveyed sites, recruitment took place mainly in June and July. During the other months, recruitment was either very low or totally absent. The density of *C. semilarvatus* recruits was too small to detect seasonality.

**Annual patterns**

There was significant between year variation in recruitment of *C. larvatus* (Fig 7.4). The highest density of recruits was observed in 1998 when about 1270 recruits were recorded. In 1999 and 2000 this density was reduced to about 400 individuals. Recruitment was very low in 2001 when only 172 recruits were found. Annual recruitment variation is also evident for *Pomacanthus* spp., although small numbers make it difficult to substantiate the conclusion.

**Spatial variations**

The density of fish recruits varied between Resimedri and Twalot reefs. More *C. larvatus* recruits were recorded at Resimedri reef (Fig 7.5). From April 1999 to May 2000 Resimedri had about 400 recruits while the number at Twalot was only 53. On the other hand, more *Pomacanthus* spp. recruits were present on Twalot reef. The densities were 20 recruits on Resimedri and 35 on Twalot. The result shows that *C. larvatus* recruits dominate in both sites. This species accounts for 84% of all recruits in Resimedri and 60% in Twalot. The proportion of *Pomacanthus* spp. was much higher at 40% on Twalot reef compared to only 4% on Resimedri reef. *C. semilarvatus* recruits were found on
Figure 7.4. Monthly recruitment of *C. larvatus* in the southern Red Sea from 1998 to 2001.
Figure 7.5. Recruitment of *C. larvatus* (open bars) and *Pomacanthus spp* (solid bars) on two reefs in the southern Red Sea. A) Resimedri reef and B) Twalot reef.
Chapter 8. Growth Patterns

Recruitment variation between sites with different coral cover.

Recruitment of *C. larvatus* varied significantly between the two stations of the comparison site on Resimedri reef (Fig 7.6). Recruitment was higher in site I where about 500 recruits were recorded. Branching *Montipora*, which covers 20% of the substrate, is the dominant coral in the area. Site II has the highest coral cover but received only 40 recruits. *Echinopora*, an encrusting coral, covers 55% of the bottom in site II. This coral provides little refuge for fish recruits.
Discussion

Seasonal Variation

Recruitment in C. larvatus, C. semilarvatus and Pomacanthus spp. was highly seasonal. It took place mainly in June and July and during the other months, recruitment was either very low or absent. Seasonal recruitment is widespread in reef fishes. For example, Williams & Sale (1981) and Williams (1983) found strong seasonal variation in the recruitment of guilds of pomacentrids on the Great Barrier Reef.

A number of biological and environmental factors cause seasonality in recruitment. These factors include: seasonality in spawning of adult fishes (Hunt von Herbing & Hunte 1991), seasonal changes in current patterns (Johannes 1978, Talbot et al 1978), and/or seasonal variation in the survival of planktonic larvae (Sale 1980, Victor 1986).

Spawning and recruitment follow similar seasonal patterns and the time lapse between the two events is equal to the duration of the planktonic larval stage (Hunt von Herbing 1988). In the study site C. larvatus spawns from April to June (see Chapter 6) and the duration of the planktonic larval phase is approximately 20 days (Zekeria, unpublished data). The present work shows that C. larvatus are recruited in June and July about one month after spawning.

Annual variation

The recruitment of C. larvatus took place mainly during the summer months. The timing of recruitment was consistent in the 3 years of the investigation but the magnitude showed annual variations. The density of C. larvatus recruits varied by an order of magnitude between 1998 and 2001. Similar variability in year-to-year recruitment of other reef fishes has been recorded in the Indo-Pacific (Williams & Sale 1981) and in Curaçao (Luckhurst & Luckhurst 1977).

Larval survival is the major determinant of yearly variability in recruitment strength. In turn, it may be related to such factors as food availability, predation, or oceanographic conditions such as water temperature, salinity, and currents. Lies (1991) reported pronounced yearly variability in zooplankton abundance.

Annual recruitment variations have previously been observed in many other areas. Such variability may be an important factor influencing community structure. In coral reef fishes, which have high longevity, the potential impact of a particularly successful recruit cohort may affect population for many years.

Spatial variation and habitat selection

The distribution of recruits varied significantly between the sites and among species. Recruits of both species of butterflyfishes, C. larvatus and C. semilarvatus, were
more abundant on the site covered by branching *Montipora*, angelfish recruits, *Pomacanthus spp.*, dominated the site covered with dead coral. From our observations on these species, it was clear that the branching corals of Resimedri reef were used as food and shelter by the butterflyfishes. The angelfish feed on epiphytic algae which covered the dead corals.

The relatively low recruitment of *C. larvatus* in Twalot reef could be due to high mortality of the recruits settling on dead coral. These recruits may face high predation pressure when they leave the holes in search for food. However, *Pomacanthus* spp. may readily find epiphytic algae within the crevices of dead corals. On the other hand, *C. larvatus* may encounter less predation risk on sites covered by live coral, whereas *Pomacanthus* spp. has to leave the branching corals in search for food.

A variation in microhabitat use is common among coral reef fishes. Victor (1986), for example, found considerable variation in recruitment intensity of *Thalassoma bifasciatum* among 24 reefs. The distribution of the recruits also showed significant variation among different regions of the same reef. These recruits preferred flat dead coral surfaces. Similarly, Tolimieri (1995) found high variation in the recruitment of *Stegastes planifrons* among sites in the Caribbean. He noted a strong correlation between *S. planifrons* recruitment and the abundance of the coral *Montiporastrea annularis*. Nevertheless, the recruitment was uncorrelated with habitat characteristics. In the Great Barrier Reef small-scale variation in the distribution of recruits was attributed to the preference for specific microhabitats within a reef Doherty (1983) and Sale et al (1984).

A number of reasons were put forward to explain the distinct patterns of microhabitat use exhibited by the recruits of various species. First, the distribution of recruits may be established by substratum choice during settlement. Second, Settlement may be unaffected by habitat availability, but differences in mortality rates among substratum types for different species may result in the observed patterns of microhabitat use. Third, patterns of microhabitat use by recruits may reflect the movement of individuals shortly following settlement. Larvae may settle randomly over the reef but may relocate according to habitat preferences or in response to the density of predators or competitors. Ault and Johnson (1987) found a stronger relationship between total population density and habitat structure on contiguous reefs than on patchy reefs. They pointed out that this might reflect the enhanced opportunities for site-attached fish species on contiguous reef to relocate following settlement.

Habitat and microhabitat selections at smaller spatial scales are well documented for coral reef fishes (Sale et al 1984, Wellington 1992, Tolimieri 1995, 1998, Doherty et al 1996). Doherty and Fowler (1994) suggested that species with strong microhabitat selection may show more spatial variation in recruitment, but these spatial patterns may be more consistent through time. This was the case for two species of pomacentrids
studied on the Great Barrier Reef. *P. Maculosus* selected live branching coral during settlement. This species showed 10-fold variation in recruitment but the pattern was consistent through time. They suggested that larval supply might have been slightly over-ridden by microhabitat selection.

In conclusion, larval supply, microhabitat use (including food supply and shelter) and predation are the main factors determining the distribution patterns of fish recruits on coral reefs. In the present study only the nature of the substrates was investigated. Recruitment correlated with the nature of substrate. However, the effect of larval supply on recruitment patterns remains unknown.