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Colonization of Juveniles of the Damselfish *Dascyllus reticulatus* (Richardson) on the Southern Coast of Taiwan

Ching-Yi Hsiao[1,2], Tsen-Chien Chen[2,3], Chang-Feng Dai[1] and Rong-Quen Jan[2,*]

[1]*Institute of Oceanography, National Taiwan University, Taipei, Taiwan 106, R.O.C.*
[2]*Institute of Zoology, Academia Sinica, Taipei, Taiwan 115, R.O.C.*
[3]*Department of Leisure Management, Ming Hsin University of Science & Technology, Hsin Chu, Taiwan 304, R.O.C.*

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Ching-Yi Hsiao, Tsen-Chien Chen, Chang-Feng Dai and Rong-Quen Jan (2003) Colonization of juveniles of the damselfish *Dascyllus reticulatus* (Richardson) on the southern coast of Taiwan. *Zoological Studies* **42**(4): 551-555. On the southern coast of Taiwan, the majority of juveniles of the damselfish *Dascyllus reticulatus* (Richardson) live exclusively on table corals on reefs. Patterns of juvenile settlement were evaluated monthly on 5 coral heads from February 1997 to September 1998, to study the influence of recruitment on colonization. The population size, which was negatively linked to rainfall, ranged from 13 (minimal, in August 1997) to 187 individuals (maximal, in September 1998). New recruits occurred throughout the year. There was concordance among the monthly numbers of new recruits in different colonies. The main recruitment season occurred from late summer to early autumn and peaked in October 1997 and August 1998. The old residents had no effects on recruitment. Immigration to colonies was evident in certain colonies. Overall, results suggest that colonization was mainly governed by the influx of juveniles during peak recruitment. Apart from other post-settlement processes yet to be elucidated, migration and environmental factors such as typhoons and rainfall might also have contributed to temporal variations. http://www.sinica.edu.tw/zool/zoolstud/42.4/551.pdf

Key words: *Acropora*, Colony, Coral reef, Habitat, Recruitment.

On coral reefs, populations of many fishes are governed by life history factors. Most fish species have a pelagic stage in their early life history. This is generally followed by a stage of settlement, after which the individual's life becomes widely associated with the reef (Booth and Brosnan 1995, Caley et al. 1996).

Population studies focusing on the ecology of post-settlement stage of fish on coral reefs have found that abundances are mainly regulated through density-dependent processes such as competition and predation (Menge and Sutherland 1987, Robertson 1995, Caselle 1999, Sale and Tolimieri 2000, Wilson and Osenberg 2002). However, with recent knowledge of the pre-settlement stages of fish, attention has increasingly been focused on the importance of larval supply (Victor 1986, Caley et al. 1996); so much so that the idea of recruitment limitation, which addresses how local density is mainly constrained by an undersupply of larvae (Doherty 1981, Victor 1986, Doherty and Fowler 1994, Caselle and Warner 1996), has arisen as an important synthesis for explaining the dynamics of fish populations (Doherty 2002).

Reef fish populations are characterized by variable replenishment processes which demand scrutiny (Doherty and Fowler 1994, Doherty 2002). As a step in understanding the influence of recruitment on population dynamics, herein we evaluated temporal patterns in settlement of a damselfish *Dascyllus reticulatus* (Richardson), of which the majority of juveniles live on colonies of branching corals. In this work, we asked whether or not the number of new recruits (i.e., newly settled juveniles) in a colony was variable; and if so, what the possible causes for such variations were. We

*To whom correspondence and reprint requests should be addressed. Tel: 886-2-27899519. Fax: 886-2-27858059. E-mail: rqjan@ccvax.sinica.edu.tw

hope the answers will help assess factors affecting the recruitment of *D. reticulatus* and elucidate the relationship between recruitment and reef-based populations through juvenile colonization.

MATERIALS AND METHODS

Dascyllus reticulatus is a damselfish widely distributed in the West Pacific and Indian Oceans.

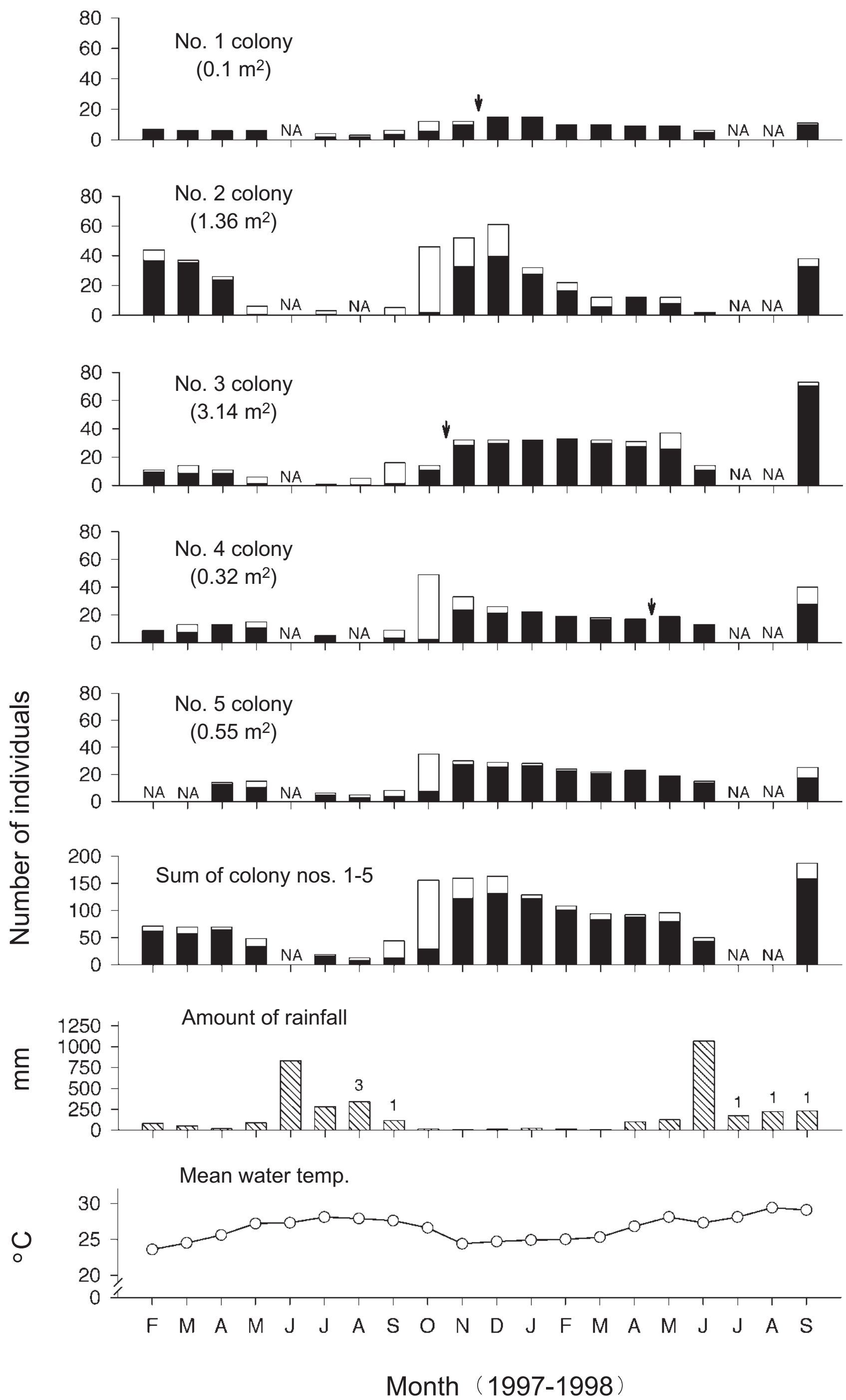

Fig. 1. Temporal changes in the amount of rainfall (appended with numbers of typhoon occurrences), mean water temperature, and numbers of individuals in 5 colonies of juvenile *Dascyllus reticulatus*. For each fish colony, the habitat size is indicated in parenthesis. The empty bar denotes new recruits, while the filled bar denotes old conspecific residents. The arrow indicates the occurrence of immigration to the colony. NA: data not available.

It usually lives in groups in live colonies of branching corals of such genera as *Acropora*, *Pocillopora*, and *Stylophora* (Hsiao 2000). In some instances, its habitats are also shared by *D. trimaculatus* and *D. aruanus*. *Dascyllus reticulatus* is sequentially hermaphroditic and lays demersal eggs (Schwarz and Smith 1990). Since the hatched larvae are pelagic, it is unlikely that social groups of *D. reticulatus* are self-recruited.

This study was undertaken at Tiaoshi, near Kenting on the southern tip of Taiwan (120°45'E, 21°57'N) from Feb. 1997 to Sept. 1998. The study site was located on a reef edge adjacent to a sandy bottom. The water depth was 10 m. Surveys were begun on 5 table-like corals (all *Acropora*) on which individuals of *D. reticulatus* had already settled. Distances to the nearest neighboring colonies were in the range of 12-16 m. The sizes of the coral colonies measured 0.10 (*A. cytherea*), 1.36 (*A. dendrum*), 3.14 (*A. cytherea*), 0.32 (*A. tenuis*), and 0.55 m^2 (*A. digitifera*), respectively for coral colony nos. 1-5. The occurrence of *D. reticulatus* on these 5 coral units was observed monthly by 2 scuba divers throughout the study period. Individuals inhabiting each coral colony were visually identified, and body sizes were recorded (in total length, to the nearest centimeter). In the data analysis, individuals of less than 1 cm (TL) in body size were recognized as new recruits, while larger individuals were categorized as old residents. Data on precipitation and water temperature were obtained from the web site of the Central Weather Bureau and from unpublished data of the nearby (a distance of 1.5 km away) Third Nuclear Power Plant, respectively. Correlations between parameters were analyzed using Spearman's correlation coefficient for ranked data (r_s). ANCOVA, including habitat size and old residents as covariates, was used to test for differences in monthly recruitments. Data of both new recruits and old residents were log(X+1)-transformed to satisfy the assumptions of the analysis. Concordance among colonies was analyzed using *W*, Kendall's coefficient of concordance.

RESULTS

The survey lasted for a period of 20 months (i.e., from Feb. 1997 to Sept. 1998). Except for June 1997 and July and Aug. 1998 when severe weather conditions occurred, monthly field data were available for all or most of the fish colonies (Fig. 1).

Numbers of established *D. reticulatus* on the various coral colonies differed throughout the survey. At the beginning of the survey, the no. 2 fish colony, which consisted of 44 *D. reticulatus* individuals, was the largest colony by far. In contrast, no more than 10 inhabitants were observed in any of the other colonies. Data collected in subsequent months showed that the total numbers of individual fish in colonies varied temporally, ranging from of 13 (minimal, in Aug. 1997) to 187 (maximal, in Sept. 1998). New recruits occurred throughout the year (Fig. 1). Recruitment was affected by month (ANCOVA, $F = 3.76$, $df = 16, 64$, $p < 0.001$). It increased with habitat size ($F = 5.70$, $df = 1, 64$, $p = 0.02$), but was not linked to the covariate of old residents observed in the same month ($F = 0.55$, $df = 1, 64$, $p = 0.45$). There was concordance among the monthly numbers of new recruits among sites ($W = 0.52$, $X^2 = 36.26$, $n = 5$, $p < 0.001$). Peak recruitment clearly occurred in Oct. 1997, with another in Sept. 1998. Within the year, the main recruitment season occurred between late summer and early autumn. In addition, heavy recruitment might have occurred in Aug. 1998, leading to the drastic increase in elderly juveniles in Sept. of that year.

When all 5 fish colonies were taken as a whole, the number of new recruits was linked to neither rainfall ($r_s = -0.39$, $n = 17$, $p = 0.12$) nor water temperature ($r_s = -0.17$, $n = 17$, $p = 0.52$). However, the population, including new recruits and old residents, was negatively linked to rainfall ($r_s = -0.56$, $n = 17$, $p = 0.02$).

Temporal changes in the new recruit/old resident composition showed that immigration to colonies no. 1, 3, and 4 was evident (in Nov. and Oct. 1997 and Apr. 1998, respectively) (Fig. 1). Yet, there were no erratic changes in the composition when all colonies were considered as a whole.

Throughout this survey, 69 individuals with a body size of 4-5 cm TL and 38 individuals with a body size of 5-6 cm TL were observed. By contrast, only19 individuals were observed in the size of 6-7 cm TL; these fish were also the largest in these colonies. The body-size structure of individuals in the colony varied among colonies. The summed-up data showed 2 repetitive cycles in body-size change (Fig. 2). These cycles were separated by the period of May-July 1997, when inhabitants were rare. Based on the monthly shift in the frequency-peak of body sizes in the 2nd cycle, new recruits in Oct. 1997 were estimated to have grown 4-5 cm in the subsequent year. Frequency distributions of body size also indicated that in Nov. 1997, the month following the peak recruitment, high mortality to new recruits (< 1 cm TL) occurred (Fig. 2).

DISCUSSION

Temporal variations in colony size and recruitment were found in colonies of juvenile *Dascyllus reticulatus* in local waters (Fig. 1). The synchrony of recruitments on table-coral colonies indicates that recruitment was governed by some common factors, among which environmental stresses and larval production were most likely (Robertson et al. 1988, Robertson 1990). Because the number of new recruits was linked to neither rainfall nor water temperature, these environmental factors most likely did not account for the changes. In the study area, spawning of *D. reticulatus* occurred throughout the year (pers. observ.). Although quantitative yearly data are not available, monthly variations in spawning are highly possible, as evidenced by the spawning of the whitetail damsel, *Pomacentrus chrysurus* (as *P. flavicauda*), from the same area (Shiah 1986). Therefore, variable fluxes in the larval supply may be responsible, for the most part, for temporal variabilities in recruitment.

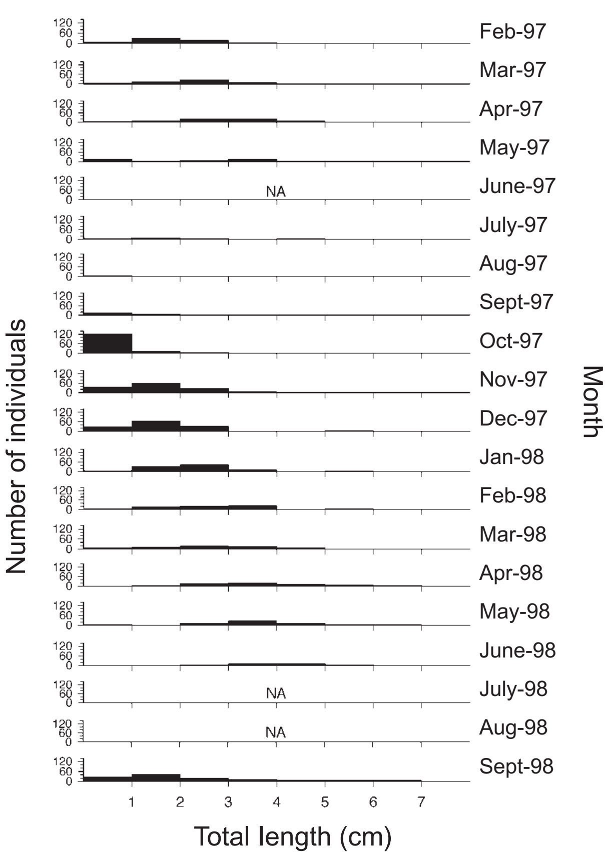

Fig. 2. Monthly frequency histograms of body length of juvenile *Dascyllus reticulatus*. NA: data not available for the month.

Successful recruitment further rests on chance elements and integrated effects of biological factors such as the existence of conspecifics and the availability of suitable habitats (Roughgarden et al. 1985, Jones 1987). In some coral reef fishes, rates of recruitment may respond to the density of individuals already present in a local population (Doherty 1982, Jones 1987). However, the positive link described between *D. reticulatus* juveniles and residents at Lizard I., Great Barrier Reef, Australia (Sweatman 1983 1985) was not found in the present study. Further comparisons revealed some environmental differences between the 2 study sites. In the present study, observations were made of fish colonies inhabiting *Acropora* coral colonies at a depth of 10 m on the reef edge where inshore currents prevailed, while at Lizard I. observations were made of individual fish inhabiting *Pocillopora damicornis* coral colonies at depths of 1.5-2 m on a reef flat where the environment was predominated by tidal flows. Hence, larval supply and substrate availability might vary, leading to different recruitment patterns between sites. Or, if *D. reticulatus* truly prefers to settle where there are higher densities of conspecifics, it is possible that in the present study, there are other factors diluting this effect.

Dascyllus reticulatus is strongly associated with substrates. Juveniles and sub-adults mainly inhabit table-coral colonies (Hsiao 2000). Adults eventually migrate to coral colonies of other forms (pers. observ.). Despite long distances between suitable habitats (i.e., 12-16 m in the present study) and the accompanying searching required with concomitant risks of predation, migration of juveniles between colonies was evident, as shown on 3 occasions where erratic increases in old residents occurred (Fig. 1). Also emigration of large juveniles was highly possible in view of the escalating decline in the number of large individuals (Fig. 2) and their needs for changing habitats.

The negative link between monthly population sizes of *D. reticulatus* and rainfall, and the possible impact of typhoon prevalence on the population are consistent with findings from related studies (Mah and Stern 1986, Ault and Johnson 1998, Shao and Jan 2002). For colonies of juvenile *D. reticulatus* that are relatively immotile, serious effects of physical disturbances caused by severe climate conditions become more easily interpretable (Kaufman 1983, Letourneur 1996). In parallel, it was also reported that typhoons might have produced irrecoverable faunal changes in the study area during 1984-1985 (Jan et al. 2001).

By choosing different substrates to inhabit, juveniles and adults of *Dascyllus reticulatus* have effectively alleviated the density-dependent nature of mutual competition. Ideally a study would be conducted at the scale of the entire life span of the target species (Caselle 1999). In reality we focused on temporal changes in juvenile colonies of the fish and found that colonization was mainly governed by the influx of juveniles during peak recruitment. Also, apart from other post-settlement processes (i.e., mortality) yet to be elucidated, migrations and environmental factors (i.e., typhoons, rainfall) might have contributed to the temporal variations in juvenile colonization. Whether the yearly strength of recruitment is sufficient to explain the variance in adult numbers on the reef, as found for some other damselfishes (Doherty and Fowler 1994, Doherty 2002), remains unclear. More studies are needed to answer this question.

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