Zoological Studies **34**(2): 131-135 (1995)

Short Note

What Do the Sergeant Major *Abudefduf vaigiensis* Lose from Nesting in the Territories of Pacific Gregory *Stegastes fasciolatus*?

Rong-Quen Jan

Institute of Zoology, Academia Sinica, Nankang, Taipei, Taiwan 115, R.O.C.

(Accepted July 7, 1994)

Rong-Quen Jan (1995) What do the sergeant major *Abudefduf vaigiensis* lose from nesting in the territories of Pacific gregory *Stegastes fasciolatus*? *Zoological Studies* **34**(2): 131-135. The behavioral response of the territorial damselfish Pacific gregory *Stegastes fasciolatus* to nests built within their territories by the sergeant major damselfish *Abudefduf vaigiensis* was studied on the northern coast of Taiwan in the summer of 1986. In one instance where 24 *A. vaigiensis* nests were built on a reef area already occupied by 27 territorial *S. fasciolatus*, 75% of *S. fasciolatus* individuals were observed to take eggs from these new nests when the opportunity was available. The number of eggs consumed did not correlate significantly with the standard length of the predator. On the average, a *S. fasciolatus* individual consumed 1,100 eggs (SD = 370, n = 11) daily. The high incidence of egg predation suggests that eggs can be an important food item for these original territory-holders; when *A. vaigiensis* outcompete *S. fasciolatus* for a substrate for nesting, they have also made this otherwise unavailable food resource available to the latter fish.

Key words: Competition, Damselfish, Egg, Nest, Predation.

Pacific gregory, *Stegastes fasciolatus*, which predominates over most of the reef-flat region of northern Taiwan, is a damselfish highly aggressive toward both conspecifics and heterospecifics (Rasa 1969, Losey 1982). It defends both food and space resources within its territory (Losey 1982, Chiou 1984). Because of this strong territoriality, its presence is an important factor in determining the distribution and abundance of potential competitors, including not only fishes but other animals (Hourigan 1986). Nevertheless, Jan and Ormond (1992a) reported that, during the spawning season in 1986, most of the nests of another damselfish — the sergeant major *Abudefduf vaigiensis* — occurred within territories of *S. fasciolatus*. The association between these two fish species persisted for the entire spawning season (of *A. vaigiensis*). Thus it is of interest to closely examine reactions of the original territory holders to the intrusion, and to see what the intruder, the sergeant major, might lose from nesting on substrates within these territories. Herein the behavioral response of the original territory-holder, *S. fasciolatus*, to the territory-intruder's nests is examined, and an alternative tactic to the territory defence primarily adopted by *S. fasciolatus* is described.

Materials and Methods—This study was carried out in the subtidal waters at Kuei-hoe Village on the northern coast of Taiwan (121°41′E, 25°12′N) in the summer of 1986. The study site was located approximately 50 meters from the breakwater of the fishing port in the village; it was described in greater detail in Jan and Ormond (1992a,b). Relationships between two damselfishes, namely, *Stegastes fasciolatus* and *Abudefduf vaigiensis* were studied at this site. *S. fasciolatus* inhabits shallow reefs. Adults generally hold territories on the reef surface suitable for algal growth. *A. vaigiensis* is a free-ranging damselfish and a demersal spawner (Jan and Ormond 1992b). Spawning commences with the search, in groups, for spawning sites. When a suitable site is located, males settle and establish temporary territories covering available nesting substrates. Members in each group spawn synchronously. After spawning, the male remains at his nest and is responsible for egg-caring. In this study observations were made at three of these colonial spawning sites (designated Sites A, B, and C), where substrates were previously dominated by *S. fasciolatus*.

This study includes two parts. In part one the behavior of *S. fasciolatus* towards adjacent *A. vaigiensis* and their nests was observed at Site A on May 2, at Site C on May 8, and at Site B on May 16. A total of twelve 20 minute observations were made. All were conducted in the afternoon of either the second or the third day after spawning. During the observation period a distance of three meters from the nests was maintained by the observer. In part two the number of egg predators appearing in each *A. vaigiensis* nest was counted on the afternoon of May 11 at site A, where 24 *A. vaigiensis* nests were built on a reef area already occupied by 27 territorial *S. fasciolatus*. Removal of some of the original territory holders was done on the same day after completion of counting. Countings were conducted again at the same site on May 12-14. Hatching occurred on May 15. Nest-guarding *A. vaigiensis* frequently formed small groups which at intervals left the nesting site for the reef channel approximately 20 meters away. Therefore, countings of egg predation by *S. fasciolatus* were made during the periods when *A. vaigiensis* nests were left unguarded. Each counting covered four nests and lasted for five minutes. It was not possible to determine the territories from which the *S. fasciolatus* originated, so the number of individuals preying on each *A. vaigiensis* nest, rather than the number of nests visited by each territory holder, was recorded. Counting was aborted when the nest guarder returned before the observation period was completed. In total, five repetitive counts were made on May 11 — each successfully covered all 24 nests. Though the original intention was to remove half of the territorial *S. fasciolatus*, only eleven, with standard lengths ranging between 70.6 mm and 104.4 mm, were successfully removed on the same day after completion of counting. Countings of egg predation were repeated on May 12-14; and data collected before and after partial removal of *S. fasciolatus* were compared.

Specimens of the removed *S. fasciolatus* were brought to the laboratory and kept at −3°C for gut content study. They were examined using dissecting microscopes four days later. When an egg mass in the digestive tract was observed, the number of eggs was counted. The distribution pattern of the egg masses in each digestive tract was categorized. For gut content comparisons, another eleven *S. fasciolatus* specimens were caught by spearing from an area of the reef framework where no *A. vaigiensis* nests were seen.

Results—When the nesting *A. vaigiensis* was at the nest, no confrontation was observed between the nester and the original territory holder. When the nester was absent from the nest, however, the territory-holding *S. fasciolatus* tended to prey on the eggs in the nest. During the three-day behavioral observation period, eighteen instances of egg predation were observed. Each started with the approach of *S. fasciolatus* through sheltered passages such as reef furrows or holes. The *S. fasciolatus* individual remained, nuzzled the egg-layer intermittently and nibbled at eggs from the egg patch. Egg predation, once commenced, occurred consistently at short intervals.

Most (12 out of 18) egg predators were chased away instantly by the returning nest-owner, thus excluding egg predators from their nests by these attacks. There were five instances in which egg predators were pursued for a distance of more than five meters. On two other occasions the nest-owner did not take immediate action against the egg predators. However, the egg predators abandoned their egg predation at the appearance of the nest owners. There were four instances in which the nesting *A. vaigiensis* was absent from its nest and the egg predator still remained at the nest when the observation period ended.

S. fasciolatus was the only egg predator observed on *A. vaigiensis* nests at Site A on 11 May. A total of 101 instances of egg predation, affecting 23 nests, were observed during five repetitive counts. The number of predators for each nest from the five countings are summarized in Box and Whisker plots (Tukey 1977, Hartwig and Dearing 1979) in Figure 1. Among the 24 nests, coded a to x, only nest q was free from egg predation. Nine nests experienced predation from two predators during some counting periods. The median number of predators in the five countings ranged from 0 to 2, and the most common was one, which occurred for 19 nests. These data also show that, on the average, there were 0.84 (SD = 0.43, n = 24) *S. fasciolatus* individuals taking eggs from any *A. vaigiensis* nest; that is, 75% of *S. fasciolatus* (n = 27) were involved in egg predation. On the day following the removal of eleven *S. fasciolatus*, egg predation pressure to each nest decreased (Fig. 2); on the average, there were 0.48 (SD = 0.41, n = 24) individuals of *S. fasciolatus* at any *A. vaigiensis* nest. That is, 72% of the remaining *S. fasciolatus* individuals (n = 16) took eggs. This figure is close to that obtained before the removal (i.e., 75%). On the third and the fourth days no more than one egg predator appeared at each

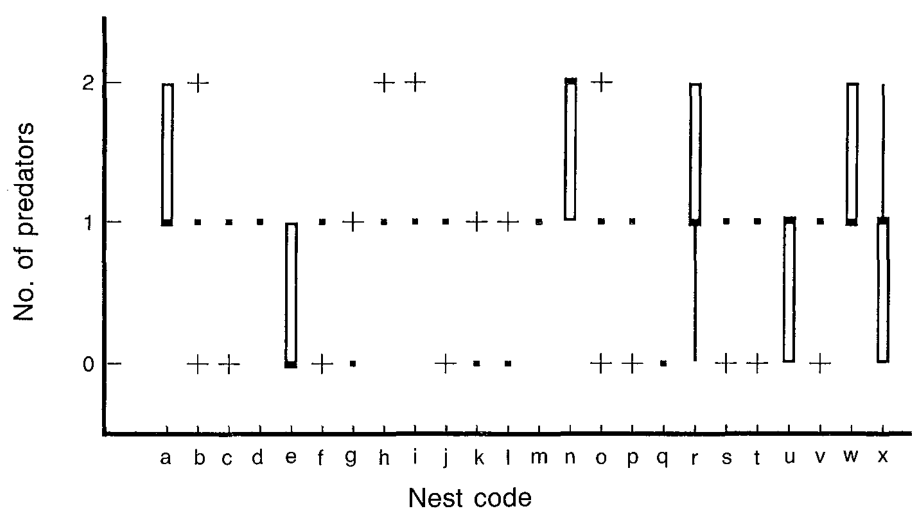

Fig. 1. A multiple Box and Whisker plot showing egg predation pressure (indicated as number of egg predators) for each *A. vaigiensis* nest by the territorial *S. fasciolatus*. A total of 24 *A. vaigiensis* nests (with codes from a to x) were surveyed five times. For each plot the central box covers the middle 50% of the data values, i.e., between the lower and the upper quartiles. The filled square indicates the median. The "Whiskers" extend out to the extremes (minimum and maximum values) but only to those points that are within 1.5 times the interquartile range. When the value is beyond 1.5 times of the interquartile range, it is plotted as a + sign.

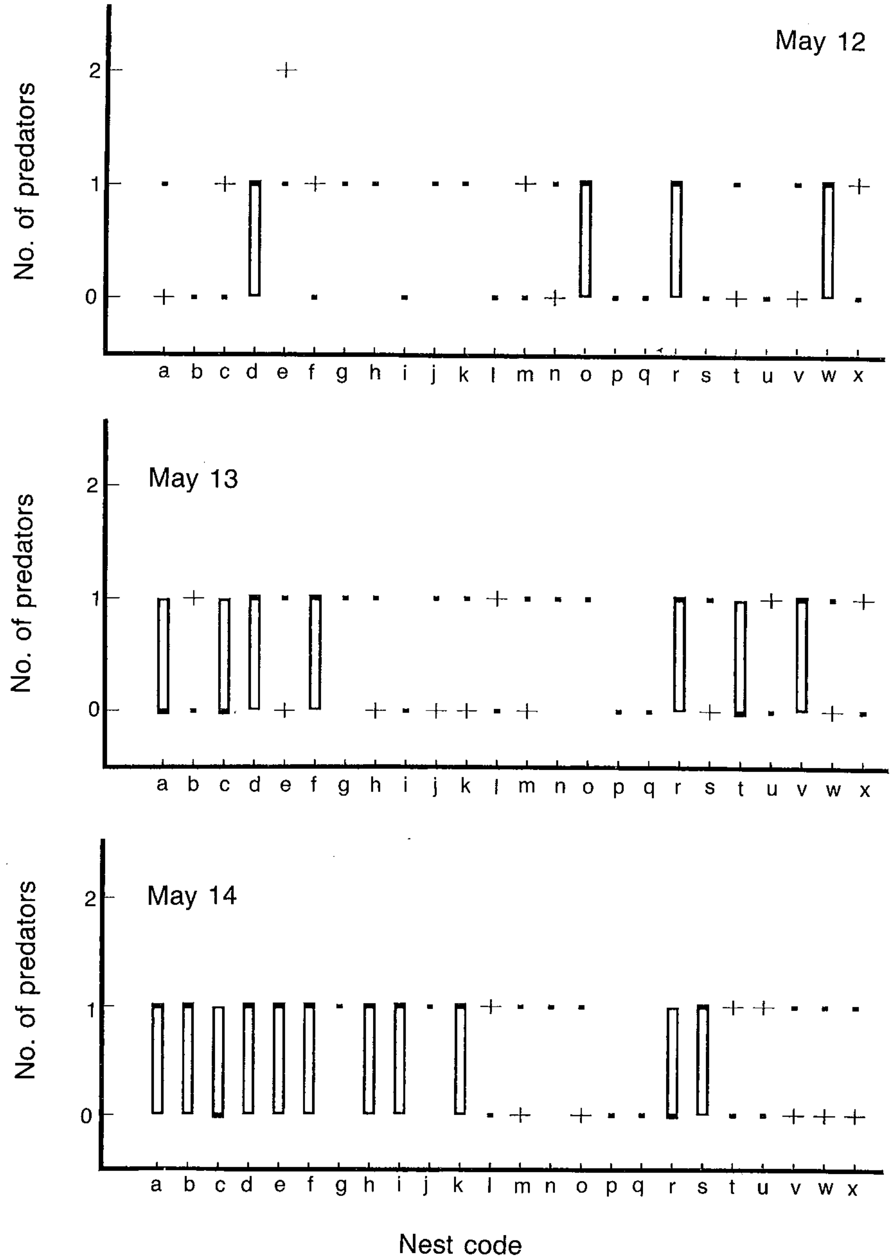

Fig. 2. Multiple Box and Whisker plots showing daily data on egg predation after the removal of eleven of the 27 territorial *S. fasciolatus*. A total of 24 *A. vaigiensis* nests (with codes from a to x) were surveyed five times.

nest (Fig. 2), and the average egg predation pressure at each nest was 0.54 (SD = 0.35, n = 24) and 0.57 (SD = 0.32, n = 24) predators, respectively. On the third day, however, one new *S. fasciolatus* arrived at the experimental site. When this individual is included in the calculations, 76% of the *S. fasciolatus* (n = 17) took eggs on the third day and 81% on the fourth day.

The digestive tracts of the removed *S. fasciolatus* specimens were full, and all of them contained eggs of *A. vaigiensis*. Eggs occurring in each gut were at a similar developmental stage. In addition to eggs of *A. vaigiensis*, one individual of *S. fasciolatus* had also consumed approximately 50 conspecific's eggs, which were identified from both their morphology and color (Jan 1989). Small quantities of filamentous algae and gravel were also found in the digestive tracts of all specimens. The algae was mainly distributed in the chyme-like matter in the tract; little was mixed with the egg mass. Numbers of eggs consumed by one predator varied from 650 to 1,700 (Table 1) and did not correlate significantly to the standard lengths of the specimens (r = 0.40, p = 0.22). On the average, 1,100 (SD = 370) eggs were taken by an individual. Additionally, these eggs appeared to be patchily distributed along the digestive tract, forming from four to six "bands" which were separated by chyme-like matter. The number of eggs in

Table 1. Numbers of *A. vaigiensis* eggs found in the guts of *S. fasciolatus*. A total of eleven specimens were examined. Figures are entered according to the band-like pattern in which eggs were distributed in each gut; where "-" denotes absence of a band

Specimen no.	Standard length (mm)	Band No.						Sum
		1	2	3	4	5	6	
1	70.6	50	150	150	50	50	—	450
2	73.3	150	350	100	150	150	—	900
3	87.1	800	300	150	400	50	—	1,700
4	88.5	350	400	150	100	250	—	1,250
5	89.2	250	350	100	150	—	—	850
6	89.4	450	350	100	250	—	—	1,150
7	92.7	450	250	200	150	100	—	1,150
8	93.5	150	200	50	200	50	—	650
9	95.7	350	150	200	550	250	100	1,600
10	98.3	450	300	100	250	—	—	1,100[a]
11	104.4	350	200	50	350	50	50	1,050
							Average	1,077[b]
							SD	369[c]

[a]Other than *A. vaigiensis* eggs, 50 *S. fasciolatus* eggs were found.
[b]Approximated as 1,100.
[c]Approximated as 370.

each band varied from band to band, and between different individuals. The largest band contained 800 eggs, while the smallest contained only 50. By comparison, the gut contents from the eleven *S. fasciolatus* (adult) specimens collected from the reef flat, where no *A. vaigiensis* nests occurred, were mainly composed of algae. Two specimens also had preyed on small crustaceans. No fish eggs were found in the guts of these fish.

Discussion—*S. fasciolatus* is considered a herbivorous fish known to sometimes share its territory with other herbivorous fishes (Robertson and Polunin 1981). However, the territory-holding *S. fasciolatus* in this study did not share its substrate benignly with *A. vaigiensis*. Instead, it preyed on the eggs in nests of the latter fish. The high incidence (72-81%) of egg predation suggests that eggs can be an important, though not normally available, resource to these original territory-holders. The total egg loss from a nest of *A. vaigiensis* seems to be affected largely by the abundance of *S. fasciolatus* in the neighboring environment and the egg-caring behavior of the nester. The finding that less egg predation occurred when the population of *S. fasciolatus* was partially depleted has shed some light on the influence of predator abundance on egg loss. By contrast, the band-like patchy distribution of eggs along the digestive tract of *S. fasciolatus* primarily indicates opportunistic heavy egg consumption resulting from periodic absence of egg-guarding by nesters. It is possible that plankton may periodically be available in the nearby reef channel, hence serving as a discontinuous feeding ground for these nesters. This may also explain why nesters would simultaneously move to the reef channel, even at the cost of losing their eggs.

The overt dominance by *S. fasciolatus* of the local fish fauna may have been the major factor leading to the formation of this heterospecific association. With their established long-term territories covering most of the "suitable nesting substrate" of *A. vaigiensis*, the latter fish would inevitably have to enter these territories and compete for the substrate to successfully spawn. One factor which may have contributed to the success of *A. vaigiensis* in establishing itself in these substrates is body size: that of *A. vaigiensis* being, on average, bigger than their counterpart's (Jan and Ormond 1992a). Also, the invasion by *A. vaigiensis* may well have benefited from nesting in groups, as group formation is a tactic sometimes used by reef fish to gain access to a defended resource (Robertson et al. 1976, Foster 1987).

In a reef environment the substrate is an important resource from various aspects (Hourigan 1986, Jan and Chang 1993). Encounters between *A. vaigiensis* and *S. fasciolatus* in this study have demonstrated such a situation where there was a heavy demand on the substrate. For these two damselfish species, the need for this resource appears to overlap both spatially and temporally. However, the extent of overlap in either space or time is not exhaustive, because *A. vaigiensis* only tended to secure the substrate when they were ready to spawn. When this occurred, they only used portions of the substrate within the *S. fasciolatus* territory. Besides, egg predation in this case can hardly be considered as a trade-off of *A. vaigiensis* for the nesting substrate because egg predators might have also arrived sometimes from neighboring territories; neither should the original territory holder be considered as completely losing (for its giving away algal-farming substrates), as it has the advantage of a better knowledge of the topography in obtaining this otherwise rare resource (i.e., *A. vaigiensis* eggs). Overall, with the complexity of resources involved between the two fishes in their heterospecific interactions, the assumption that there is severe heterospecific competition might thus have to be relaxed. Also, this may help explain the coexistence of these two damselfish species in the local waters.

Acknowledgements—I am grateful to two anonymous reviewers for their valuable criticisms. This study was supported financially by the R.O.C. National Science Council (partially through Project NSC82-0211-B-001-016).

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條紋雀鯛*Abudefduf vaigiensis*在太平洋眞雀鯛*Stegastes fasciolatus*領域中築巢時所付代價爲何？

詹 榮 桂[1]

在1986年的夏季，台灣北部海域內大多數的條紋雀鯛*Abudefduf vaigiensis*將生殖巢興築在太平洋眞雀鯛*Stegastes fasciolatus*的領域內。其間，作者觀察原領域持有者對入侵者的生殖巢所產生的一些行爲反應。此項研究主要是在一個棲息有27尾太平洋眞雀鯛的礁區上進行，當時(在五月份)有24尾條紋雀鯛在此築巢。調査發現這裡75%的太平洋眞雀鯛會趁條紋雀鯛不在的時候掠食巢內的卵。太平洋眞雀鯛所吃入胃中的卵粒數與其標準體長之間並未構成顯著的相關關係，而平均一尾太平洋眞雀鯛一天之中所掠食的卵數約爲1,100粒(SD = 370, n = 11)。這種大量掠食的現象顯示這些魚卵可能是太平洋眞雀鯛的一項重要食物；是以當條紋雀鯛成功的在太平洋眞雀鯛的領域內佔據用以築巢的基質時，其實也正爲後者帶來了一項平日所無法獲得的食物資源。

關鍵字：競爭, 雀鯛, 魚卵, 巢, 掠食。

[1] 中央研究院動物研究所