Japanese Journal of Ichthyology
Vol. 33, No. 3 1986

魚類学雑誌
33巻3号 1986年

Courtship and Spawning of the Hawkfish *Cirrhitichthys falco* at Miyake-jima, Japan

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(Received December 28, 1985)

The hawkfish *Cirrhitichthys falco* Randall (Cirrhitidae) occurs from Japan (Masuda *et al.*, 1975) south to the Philippines (Randall, 1963), the Marianas (Myers and Shepard, 1980), Pohnpei (Gawel, unpubl. ms.), Fiji (Springer, 1982) to northeastern Australia (Russell, 1983) as far as Sydney (R. E. Thresher, pers. comm.). Although this species occurs at Miyake-jima, Izu Islands, Japan (34°05′N, 139°30′E) it is rare and may often be mistaken for *C. aprinus* (Bleeker).

Courtship and spawning behavior of cirrhitid fishes has been largely limited to aquarium observations. Lobel (1974), Takeshita (1975) and Tanaka *et al.* (1985a) reported on courtship and spawning of *Oxycirrhites typus* (Bleeker); Suzuki *et al.* (1980) reported spawning behavior of *Cirrhitichthys aureus* (Temminck et Schlegel); Tanaka *et al.* (1985b) reported spawning behavior of *Cirrhitops hubbardi* (Schultz).

Field studies of cirrhitid courtship and spawning behavior have begun to appear. Thresher (1984) briefly mentioned courtship of *Paracirrhites arcatus* (Cuvier) from One Tree Island, Great Barrier Reef and has also provided a detailed description of courtship and spawning of *Cirrhitichthys oxycephalus* (Bleeker) occurring in the Gulf of California. Here I report courtship and spawning behavior of a congener, *Cirrhitichthys falco*, at Miyake-jima.

Study area and methods

Courtship and spawning behavior of *C. falco* were studied on seven consecutive days between 6–12 August 1985 in Igaya Bay. All observations were made at a single site located ca. 100 m NE of the pier at Igaya Port at a depth of 10 m. The courtship and spawning site, henceforth referred to as the rendezvous site (Moyer, 1980, 1984), consisted of a rocky outcropping located atop a large boulder (ca. 2.5 m high) immediately adjacent to an abandoned pipeline. A number of sea anenomes (*Parasicyonis* spp.) were clustered on the seaward margin of the boulder, directly beneath the outcropping. The adjacent substratum consisted of five smaller boulders (ca. 0.5–2.0 m high), mixed volcanic rubble, sand, and various algae. A slight to moderate current, made stronger occasionally by the effects of passing swells generated by storms well offshore, flowed seaward past the site. Water temperatures ranged from 23 to 26°C.

Observations were made using SCUBA, and data were recorded on plastic slates and by underwater photography. Two dives were made daily, usually between 10: 30–14: 00h and 17: 45–19: 00h. The first dive consisted of a population census and observations of habitat utilization, territorial boundaries, and aggressive behavior, while the second dive was devoted to observations of courtship and spawning.

Results

Social organization and aggressive behavior. Two fish, a male (designated as M1, ca. 80 mm SL) and a female (F1, ca. 70 mm SL) were observed near and at the rendezvous site. No other conspecifics were present in the area. The female occupied a small territory (ca. 3 m^2) immediately beneath the outcropping on the shoreward side of the boulder. She was quite secretive and rarely left the shelter of a small hole located in this area. The male foraged over a territory, ca. 25 m^2, adjacent to and including the rendezvous site. No active territorial defense against conspecifics was observed. The male did defend parts his territory against some interspecific intruders. Many territorial interactions were with a neighboring congener, a large male (ca. 90 mm SL) *C. aprinus*, which occurred at the rendezvous site and at a common territorial boundary shared with this species. Defense was particularly pronounced just prior to and after sunset when courtship between M1 and F1 was about to commence. Males of both species interacted aggressively with one another but not with the female *C. falco*.

Courtship and spawning. Five distinct motor patterns were recognized during male-female interactions: 1) Parallel Rest, 2) Nudging, 3) Circling, 4) Hopping and 5) Spawning. Circling and Parallel Rest were also seen in interactions be-

tween male *C. falco* and *C. aprinus*. Motor patterns are described as follows:

1) Parallel Rest. The male and female aligned themselves on the substratum in a position parallel to one another (Fig. 1A). Occasionally, the male was positioned slightly behind the female. This motor pattern often preceeded the performance of other motor patterns and always preceeded spawning.

2) Nudging. During Nudging the male placed his snout against the flank of the female at a point directly beneath the soft dorsal fin (Fig. 1B) while both the male and female remained motionless. The behavior was seen soon after pair formation and was often repeated during a courtship encounter. This motor pattern is similar to that reported for *C. oxycephalus* by Thresher (1984).

3) Circling. The male positioned his snout near the caudal fin of the female and vice versa; together they swam in a circular fashion (Fig. 1C) around the rendezvous site and made frequent stops to Parallel Rest. This motor pattern frequently occurred while the male and female were engaged in Hopping.

4) Hopping. The male and female engaged in short swimming bouts, resembling hopping, around the rendezvous site. The male was positioned slightly behind the female as they swam (Fig. 1D). Hopping was often preceeded and followed by Parallel Rest displays. This motor pattern was also reported for *C. oxycephalus* by Thresher (1984).

5) Spawning. After the last Parallel Rest display the male and female ascended into the water column to a height of 20–50 cm, pointed their snouts downward (Fig. 1E) from the parallel rest position, and released a cloud of gametes before quickly returning to the substratum.

Courtship and spawning events involved only M1 and F1 although the male *C. aprinus* attempted courtship with F1 on a number of occasions but was always driven off by M1. Time of courtship commencement ranged from one minute before sunset to 20 minutes past sunset over a period of seven days and lasted between 2–16 minutes before spawning occurred (Table 1). Typically, either M1 or F1 arrived at the rendezvous site first and was joined immediately by the other. On one occasion M1 was observed to herd F1 towards the rendezvous site from a position directly below the site.

Once at the rendezvous site the pair first exhibited the Parallel Rest motor pattern for 5–20 s and then the male nudged the female. Hopping and Circling followed with intervals of Parallel Rest and Nudging and ended in the Parallel Rest for a period of 10–40 s. The spawning ascent immediately followed the last Parallel Rest display. Spawning times varied between 4–22 minutes past sunset (Table 1). After the release of gametes, the small white cloud was visible for 3–9 s. Egg predation was not observed.

After returning to the substratum the male attempted to court the female again on five of seven evenings when spawning was observed. The male assumed the Parallel Rest position and nudged the female. However, this second attempt at courtship was never successful; either the female returned to her shelter beneath the rendezvous site or the courtship behavior was interrupted by the approach of the male *C. aprinus* or other

Table 1. Temporal patterns of courtship and spawning of the hawkfish *Cirrhitichthys falco* at Miyake-jima, Japan.

Date	Water temperature	Sunset	Courtship onset (Min past sunset)	Duration (Min)	Spawning (Min past sunset)	No. interruptions	
						Pre-spawn	Post spawn
6-VIII-85	26°C	18: 41h	−1	5	+4	0	1[a]
7-VIII-85	26°C	18: 40h	0	15	+15	4[a]	0
8-VIII-85	26°C	18: 39h	+20	2	+22	3[b,c,e]	1[f]
9-VIII-85	23°C	18: 38h	+15	7	+22	0	1[a]
10-VIII-85	23°C	18: 37h	+13	3	+16	0	0
11-VIII-85	23°C	18: 36h	+9	3	+12	1[d]	0
12-VIII-85	23°C	18: 35h	+2	16	+18	2	0

a, *Cirrhitichthys aprinus* (male); b, *Epinephelus fasciatus*; c, *Anthias* (*Franzia*) *squamipinnis* (male); d, *A.* (*F.*) *squamipinnis* (female); e, *Stegastes altus*; f, *Pempheris oualensis*.

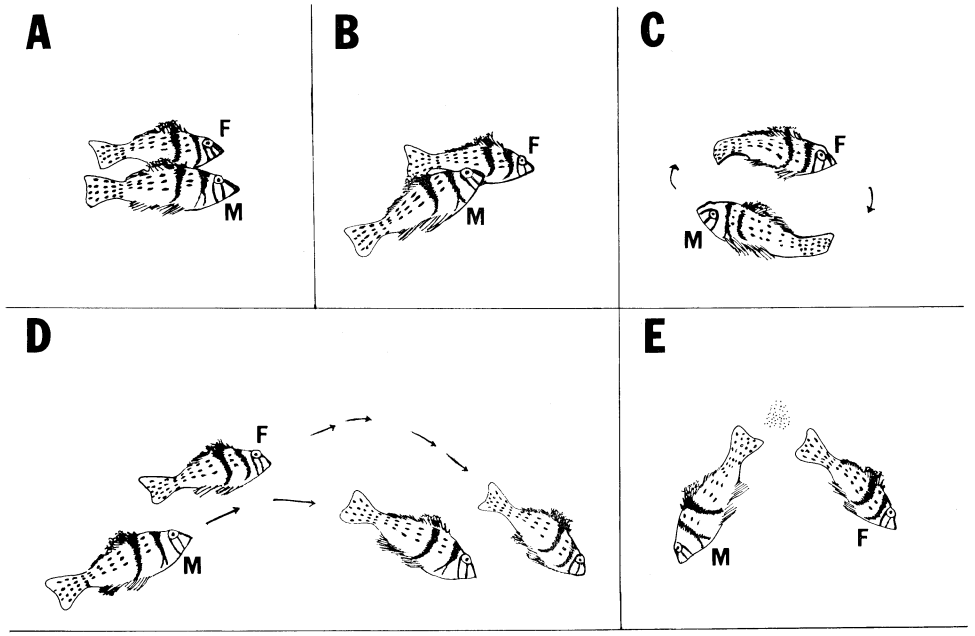

Fig. 1. Motor patterns observed during courtship and spawning of the hawkfish *Cirrhitichthys falco* at Miyake-jima, Japan. A) Parallel Rest, B) Nudging, C) Circling, D) Hopping and E) Spawning. (Male denoted by M; female denoted by F).

species of fishes resident in the area.

Interspecific interactions. Courtship behavior was often interrupted by the presence of the male *C. aprinus* or other species of fishes, resulting in variable durations in time before spawning occurred (Table 1). The male *C. aprinus* interrupted courtship both before and after the spawning; interruption took the form of swift charges at M1 and attempted courtship with F1 before M1 was able to drive the male *C. aprinus* away. Courtship motor patterns displayed by the male *C. aprinus* included the Parallel Rest and Hopping. Other species of fishes in the area interrupted courtship both before and after M1 and F1 spawned (Table 1). Courting male and female *Anthias* (*Franzia*) *squamipinnis* (Peters), foraging *Epinephelus fasciatus* (Forsskål) and territorial *Stegastes altus* (Okada et Ikeda) all interrupted *C. falco* during the first bout of courtship prior to spawning; an aggregation of *Pempheris oualensis* Cuvier interrupted post-courtship displays after spawning on one occasion.

Discussion

Social organization and mating system in Cirrhitidae. The occurence of a male-female pair of *C. falco* at the spawning site was consistent with observations of this species made at Guam, Mariana Islands although social groups of up to six individuals have also been seen (pers. obs.). Thresher (1984) reported social groups of one male and up to seven females for *C. oxycephalus* in the Gulf of California. I have seen male-female pairs only of the following other species of cirrhitids: *O. typus* at Pohnpei, Caroline Islands; *Paracirrhites hemistictus* (Günther) at Pohnpei and Guam; *P. forsteri* (Schneider) at Pohnpei and Guam; *Neocirrhites armatus* Castelnau at Guam. However, *N. armatus*, *P. arcatus*, *P. forsteri* and *P. hemistictus* have been observed also in groups of one male and up to four females at Guam. J. T. Moyer (pers. comm.) reported sightings of two *C. aprinus* social groups at Igaya Bay, Miyake-jima during 1984–85. Each social group consisted of one male and two females. Both social units disappeared during a typhoon in June, 1985. This same typhoon may account for the attempts made by the male *C. aprinus* at courting the female *C. falco*; the former may have lost his mate(s) by the typhoon. Moyer (1981) observed interspecific spawning between a male *Centropyge*

shepardi Randall et Yasuda and a female *C. bispinosus* (Günther) at Guam, where the latter species is rare and the former is common. Moyer hypothesized that such interspecific spawnings usually involve females of rare species and males of common species. Such spawnings may occur as a result of constraints imposed by energy expenditure in the production of eggs versus sperm; females should engage in interspecific spawnings only when male conspecifics are absent whereas males can afford to be less discriminating in choosing mates.

Thresher (1984) considered *C. oxycephalus* to possess a mating system of male-dominated socially controlled hermaphroditism. Kobayashi *et al.* (1985) recently reported the existence of protogynous hermaphroditism in *C. falco* and in *C. aureus*, *C. aprinus* and *Cirrhitops hubbardi* as well. Donaldson (unpubl. ms.) has recently described the mating and social systems of *P. arcatus*, *P. forsteri*, *P. hemistictus*, and *N. armatus*.

Male defense of both the rendezvous site and the female was indicated in *C. falco*, but the relative importance of defending one over the other is uncertain. J. T. Moyer (pers. comm.) reported that males of *C. aprinus* at Miyake-jima travelled over "well-known" paths in given areas but did not engage in intraspecific territorial defense of these areas although they did defend females from male conspecifics.

Interspecific comparisons of courtship and spawning. Four of the *C. falco* courtship and spawning motor patterns observed at Miyake-jima are relatively consistent with those observed for *C. oxycephalus* in the Gulf of California (Thresher, 1984). These patterns are Parallel Resting, Nudging, Hopping and the spawning ascent. Male *C. oxycephalus* approached females at a single spawning site and, in succession, nudged, hopped, and rested before executing the spawning ascent. Two of the motor patterns, Nudging and the spawning ascent, seem common of pelagic-spawning reef fishes in general. Males of *C. aprinus* apparently nudge females by lying over their bodies (J. T. Moyer, pers. comm.); I have observed males of *N. armatus* performing a similar pattern during courtship. The significance of the Nudging motor pattern is uncertain, although Thresher (1984) speculated that it served to stimulate egg movement in the female prior to spawning. The spawning ascent allows free-floating eggs to escape predation from bottom-dwelling organisms by their release into the water column above the substratum. The height of the release may be constrained by the risk of predation on the spawning adults (Thresher, 1984). Emery (1973), Robertson and Hoffman (1977), Moyer and Yogo (1982) and Thresher (1984) reported that predators often attacked spawning individuals; the probability of such attacks may be minimized by rapid ascents to minimal heights that would allow spawning adults to avoid the risk of predation while conveying an anti-predation advantage to the free-floating eggs released during the ascent (Thresher, 1984). A test of this hypothesis on small site-attached species seems warranted.

Acknowledgments

I wish to thank J. T. Moyer, J. E. Randall, P. L. Colin, L. J. Bell-Colin, D. Y. Shapiro, J. M. Fitzsimons, M. C. Wilkins and S. de C. Wilkins for their advice, comments and assistance. G. B. Constantino kindly prepared Fig. 1. I also thank the Tatsuo Tanaka Memorial Biological Station for its hospitality. This work was made possible through the generous support of the Japan Airlines 50th 747 Asian Studies Scholarship and the LSU Museum of Natural Science. This is contribution no. 64 of the Tatsuo Tanaka Memorial Biological Station.

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三宅島におけるサラサゴンベの求愛・産卵行動

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1985 年 8 月，伊豆諸島の三宅島においてサラサゴンベ（ゴンベ科）の産卵行動がはじめて観察された．1 週間の調査期間中，雄（体長 8 cm）と雌（7 cm）のペアが産卵場所となる岩を中心として定住していた．毎日，日没直後になると，ペアは定った岩の上で一連の求愛行動を始め，3–16 分後に 20–50 cm 急上昇して放卵放精した．産卵前後には，同属のミナミゴンベの雄がこの雌に求愛することや，その他の魚種による干渉もしばしば観察された．本種の社会構造・婚姻組織および求愛・産卵行動を他のゴンベ科の魚類と比較して考察した．