

# Pair Spawning of *Cephalopholis boenack* (Serranidae)

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Reproductive behavior of epinepheline serranids is known from only a few studies describing group or pair-spawning in members of the genera *Epinephelus*, *Plectropomus* and *Variola* (see reviews in Thresher, 1984; Shapiro, 1987). Reproductive behavior of members of the genus *Cephalopholis* has yet to be described. Groupers of this genus range in size from 10–40 cm SL and inhabit tropical reefs at depths of 1–200 m. There are 19 recognized and three undescribed species distributed in the Indo-Pacific (Randall, 1987). Nzioka (1979) reported seasonality of spawning of *Cephalopholis* off East Africa; Smith (1966) described hybridization between *Cephalopholis fulva* and *Paranthias furcifer* in the Caribbean.

*Cephalopholis boenack* (Bloch) is a relatively small (to 250 mm SL) grouper distributed in the western Pacific and Indian Oceans where it usually occurs on dead reefs in protected waters (Randall, 1987). Pair spawning of this species was observed on the evening of 15 November, 1986 at Horseshoe Reef, part of the Papuan Barrier Reef system, off Bootless Inlet, Papua New Guinea. This is the first known report of reproductive behavior in this genus. The details are given herein.

## Methods and description of study site

Observations were made using scuba, and data recorded on plastic slates. Water depths and temperatures were measured with standard gauges.

The courtship site was located on a portion of the barrier reef, known locally as Horseshoe Reef, ca. 200 m east of the mouth of Bootless Inlet. The site consisted of a large coral boulder which rested on a submerged reef flat of pavement, coral and coral rubble 2 m from the seaward edge of the reef at a depth of 8 m. The edge of the reef was marked by a drop-off which sloped steeply to a depth of 30 m. A moderate current flowed along the face of the reef. The water temperature was 28°C, and the moon was in full phase.

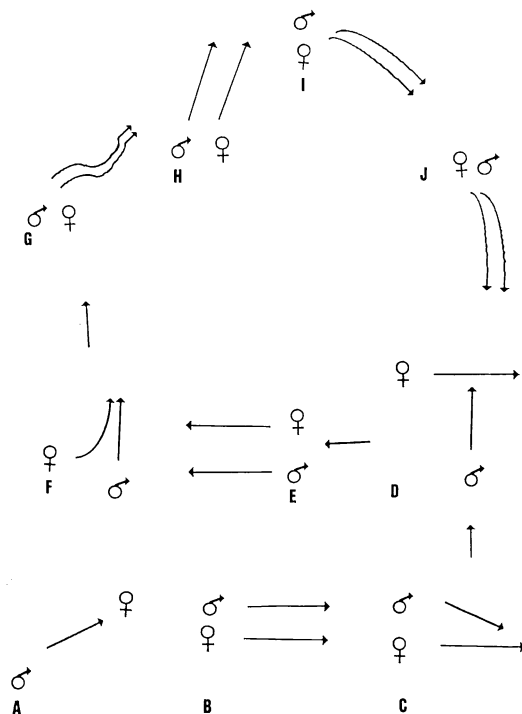


Fig. 1. Diagram of courtship and spawning behaviors of *Cephalopholis boenack*. A: Male approaches female on boulder. B: Male and female rest parallel to one another on boulder. C: Male presses against female on boulder. D: Male rests perpendicular to female above boulder. E: Male and female rest parallel to one another. F: Male and female begin to rise in the water column. G: Male and female slowly spiral into the water column. H: Male and female quickly rise into the water column. I: Male and female spawn at apex of rise, and turn towards substratum. J: Male and female quickly descend to the substratum.

## Results

The mating pair consisted of a male, ca. 250 mm TL, and female, ca. 200 mm TL. Both were presumed to be resident in the area, and had been observed at or near the site on previous days, so that migration to that site from somewhere else on the reef prior to the courtship period was unlikely.

Courtship (Fig. 1) began 21 minutes prior to sunset when the male approached the female, the latter already waiting at the coral boulder. There, the male aligned his body parallel to the female's,

tilted 90 degrees while swimming in place, and pressed against her flank with his operculum and snout. The male then rotated his body from the horizontal to the vertical, his head pointed towards the surface, and maintained this position against the now slightly horizontal female, who was swimming in place above the boulder, by strongly beating his caudal fin against the water. The pair then slowly settled to the boulder, shifted position slightly on the boulder's surface, and repeated the same behavior twice again. During the last episode of this behavior, the female slowly ascended into the water column with the male following closely behind, his snout pressed against her flank. At 2 m above the boulder the pair straightened to a vertical position, heads up, and slowly rose upwards for 5–6 seconds. When the pair was 4 m above the boulder they quickly dashed another 2 m upwards. There, the male turned his body over the now inverted female and together they released a small cloud of gametes. Courtship duration was five minutes since onset and spawning was completed 16 minutes prior to sunset.

Immediately after the spawning ascent was completed, the pair quickly descended to the same coral boulder and rested, their bodies parallel to one another, for another 50 seconds. Then, the female swam down to the reef flat and made her way to a second coral boulder located at the edge of the reef. The male followed close behind, approached the waiting female at the second boulder, tilted his body 70 degrees and pressed against her flank while strongly beating his caudal fin in an apparent repetition of courtship behavior. The female remained motionless for a few seconds and then swam down to a hole some 3 m over the edge of the reef. The male immediately followed and joined her in the same hole. No further courtship was observed.

### Discussion

Reproductive behavior of epinepheline serranids, summarized from Johannes (1978), Thresher (1984) and Shapiro (1987), is characterized by courtship and spawning at or near dusk, latitudinal variation in seasonality, strong lunar influence, particularly at new or full moon, migration to or use of a localized spawning ground delineated by special topographic features, group or pair spawning involving ritualized courtship, and the production

of pelagic eggs and larvae. The observed courtship and spawning of *Cephalopholis boenack* at Horseshoe Reef, Papua New Guinea, offered a limited basis of comparison between members of this genus and the rest of the subfamily Epinephelinae.

Courtship and spawning of *C. boenack* occurred prior to sunset and in advance of dusk compared with other epinephelines, who usually courted and spawned after sunset (Ukawa et al., 1966; Burnett-Herkes in Thresher, 1984; Thresher, 1984), with the exception of some courtship in the genus *Plectropomus* that occurred prior to sunset (Goeden, 1978). Since spawning occurred during a full moon the influence of a lunar cycle, cued to either that portion of the lunar cycle or possibly to both the full and new moons, is expected. Spawning peaks at or near the full moon occur for *Epinephelus merra* (Randall and Brock, 1960; Johannes, 1978, 1981), *E. guttatus* and *E. striatus* (Colin et al., 1987), although the latter, a possible aggregate-spawning species in the western Atlantic, also apparently spawns during a new moon (see Thresher, 1984; Shapiro, 1978 for reviews). Variation in spawning might result from latitudinal effects (Thresher, 1984) although such effects at tropical localities close to the equator, such as Papua New Guinea (9°S, 147°E), might be minimal or even non-existent (see Randall and Brock, 1960).

Spawning frequency probably depends upon individual fecundity as well as lunar or seasonal influences. Fecundity varies with female body size; large-bodied individuals, having fecundities of several thousand to over one million ripe eggs per female, probably spawn once or a few times a year (Thresher, 1984) while small-bodied tropical epinephelines, such as *C. boenack*, with probably much lower individual fecundities, may spawn with greater frequency, and realize greater reproductive success by releasing several small clutches of eggs throughout the year.

*Cephalopholis boenack* courted and spawned on a site adjacent to a steep seaward drop-off. This location of spawning site is common among other epinephelines and may serve to facilitate the transport of pelagic eggs offshore (Johannes, 1978, 1981; but see Colin et al., 1987). Further, the use of "localized" (Thresher, 1984) spawning grounds is common among other members of the subfamily; *Epinephelus*, *Plectropomus* and *Par-*

*anthias* all migrate to such areas (Thresher, 1984), and although *C. boenack* may not have migrated to the particular spawning site used, it still could have derived the benefits of such a site as a resident.

Pair formation has been seen in other *Cephalopholis*, including *C. miniata* at Bootless Inlet and *C. urodeta* at Guam, Mariana Islands (pers. observ.). Pair formation also occurs in some *Epinephelus* and *Plectropomus leopardus*; the former genus also has apparent aggregate-spawning species, such as *E. striatus* (Smith, 1972) and the latter may possess a lek-like mating system (Thresher, 1984). Body size, fecundity and spawning frequency may be determinants of spawning type. Relatively large, enormously fecund serranids, such as *E. striatus*, appear to spawn in large aggregations, in which millions of eggs may be fertilized at a single time. For smaller, less fecund serranids, ritualized courtship and synchronized pair spawning insures fertilization and maximizes reproductive investment. Epinepheline serranids are protogynous hermaphrodites as well (review in Shapiro, 1987), a condition that favors male-dominated social and mating systems that emphasize sequential paired spawnings (Thresher, 1984), as seen in harem anthiine serranids (Shapiro, 1977) but not in the epinephelines.

Courtship behavior of *C. boenack* resembled that reported for *Epinephelus akaara* (Ukawa et al., 1966), an unidentified *Epinephelus* at Heron Island, Great Barrier Reef (Thresher, 1984) and *E. fasciatus* (Gronell in Thresher, 1984). Common features of courtship by the male included: swimming in place while in a parallel or anti-parallel position (Thresher, 1984), tilting the body at or about 70 degrees while maintaining position next to the female (Gronell in Thresher, 1984), pushing or nudging the female with the male's operculum (Ukawa et al., 1966), pair-spiralling into the water column (Ukawa et al., 1966) and a rapid ascent into the water column to release pelagic gametes at the apex of ascent (Thresher, 1984). Differences unique to *C. boenack* included: nudging the female with the male's snout, rotation of the male's body to the vertical while nudging the female, and a lack of temporary sexual dichromatism, has been reported for pair-spawning *Epinephelus* (Thresher, 1984) and *Plectropomus* (Goeden, 1978; Thresher, 1984). In addition, extensive post-spawning courtship of the same female occurred. This activity might serve

to reinforce the pair bond or it may simply be a manifestation of harem behavior applied to mating in social groups where the "harem" consists of only one female. Post-spawning courtship has also been observed in a pair of *Cirrhitichthys falco* (Cirrhitidae), normally a harem-forming species (Donaldson, 1986, 1987).

Clearly, intensive studies of epinepheline social organization, in relation to reproductive behavior and mating systems, are needed to determine the extent of variability in the reproductive ecology and systematics of this important family of fishes.

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#### アオスジハタのペア産卵

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パプア 堡礁の礁縁でアオスジハタ *Cephalopholis boenack* (ハタ科) の産卵行動が観察された。満月の日の日没前に、全長約 25 cm の雄と 20 cm の雌が求愛を開始し、5 分後に底から約 6 m 上昇したところで放卵放精し、下降した。これはユカタハタ属で最初の産卵行動の報告であり、他のハタ科魚類の産卵生態と比較検討した。