Epibenthic Schooling by Larvae of the Clupeid Fish *Spratelloides gracilis*

Jeffrey M. Leis

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Recently, the larval fishes of shallow coastal waters have received increasing attention and it has become obvious that the epibenthos, or the interface between the sea bottom and the water column, is occupied by a number of fishes for at least a portion of their larval stage (e.g. Powles, 1977; Barnett *et al.*, 1984). In spite of this, the epibenthos has been little studied. There are few published observations of the behaviour of identified fish larvae within the epibenthic layer, because most previous studies have relied on remote samplers such as nets or pumps (but see Powles and Burgess, 1978). This note reports the epibenthic schooling of the larvae of *Spratelloides gracilis*, a wide-spread subtropical to tropical Indo-Pacific species of small (to 90 mm), inshore, spratelloidine clupeid.

Materials and methods

All observations were made by SCUBA divers in Igaya Bay on the west coast of Miyake-jima, Japan (34°05′N, 139°30′E). The study area was bounded by a submerged cliff which terminated in an area of large boulders and rubble. Beyond this was a gently sloping sand bottom with scattered rock and considerable algal cover (see Zaiser and Fricke, 1985 for a map). Water depth ranged from 10–15 m and temperature from 21–23.5°C. Observations were made during July 1985, initially during dives for set up and retrieval of underwater light traps. Captured larvae were fixed in 70% ethanol and registered into the collection of the Australian Museum, Sydney (AMS).

Results

No larval fishes were seen on five SCUBA dives in the area from 11–15 July. However, several large, coherent schools each visually estimated to contain 10^4–10^5 fish larvae were seen on 16 July between 1025 h and 1130 h. The schools were found over the gently sloping, sandy bottom well away from the cliff. The larvae actively schooled (see Blaxter and Hunter, 1982) within 0.5 m of the bottom. Vision, coordination within the school, and swimming ability of the larvae appeared well-developed. Two size classes of larvae but no mixed-size schools were seen. The eyes of the larvae were distinctly yellowish and the bodies transparent.

On 17 July between 1120 h and 1210 h, the same area was extensively searched specifically for the schools of larvae, and none were seen. Only a small school of about 15 larvae was seen about 2 m off the bottom during a dive along the cliff line between 1805 h and 1845 h on 17 July, but none were captured. On 18 July between 0810 h and 0840 h, another dive along the cliff line revealed no larvae.

A final dive was made on 19 July from 1035 h to 1145 h. Along the cliff line and out over the scattered boulders extending onto the sand flats, several large schools (10^4–10^5 individuals) of larvae were seen. Behaviour was similar to that observed on 16 July. When chased, schools would move toward the vertical cliff or around the boulders, obviously orienting to the bottom and generally remaining within 1 m of the bottom. Larvae avoided puffs of quinaldine placed in the path of a school.

The larvae were difficult to catch with the small aquarium-type net available, primarily due to their ability to easily dodge the net. Attempts by a second diver to herd a school resulted in the school splitting and swimming around the diver. Even when chased the larvae remained within 1 m of the bottom. I eventually found I could readily force the school to swim very close to the bottom by approaching it from above. I then trapped some of the larvae against the bottom with the net. One individual measuring 11.4 mm SL (following fixation in 70% ethanol) was captured in this manner on 16 July and was a member of the larger size class seen on that day (see above). On 19 July, a small individual (9.1 mm SL) swimming on its own (not in a school) was captured in this way as was a 13.1 mm SL larva from one of the schools.

The three captured larvae were identified as *Spratelloides gracilis*, a clupeid of the subfamily Spratelloidinae, tribe Spratelloidini (Whitehead, 1963). To make the identification, I used the descriptions of Hukuda (1934) and Mito (1966), who both called the species *S. japonicus* (see Whitehead, 1963 for nomenclature). I also compared the Miyake-jima larvae with specimens of *S. gracilis* from the Great Barrier Reef held at AMS. The 9.1 mm larva (AMS I. 25576-001) was very late flexion stage with dorsal and anal anlagen present (see Hukuda's, 1934, fig. 10 of a 9.7 mm larva). The 11.4 mm larva (AMS I. 25572-001) was a postflexion specimen, but both dorsal and anal fins were too damaged to permit examination. This specimen was very similar to Hukuda's (1934) fig. 11 of an 11.3 mm larva which still lacked rays in dorsal and anal fins. The 13.1 mm specimen (AMS I. 25576-001) had all dorsal (13) and anal (12) fin rays, but no rays in either pectoral or pelvic buds. Thus, *S. gracilis* is capable of schooling before all fins are formed; at least from 11 mm, and perhaps smaller. Other clupeoid larvae begin to school at 10–15 mm to 30–35 mm, depending on species (Blaxter and Hunter, 1982).

Discussion

Although the epibenthic schooling of *S. gracilis* larvae begins well before transformation, the presence of the larvae in the epibenthos is at least spatially variable, as indicated by the present observations, and quite possibly temporally variable. It is obvious from other work that larvae of *S. gracilis* are not confined to the epibenthos. In shallow water (10–15 m) in the northern Great Barrier Reef, *S. gracilis* larvae were much less concentrated at the surface than at 3–4 m or 6–7 m during the day (Leis, 1986). At night, preflexion larvae were uniformly distributed vertically while postflexion larvae increased in concentration with depth. There is no information on epibenthic schooling of *S. gracilis* in the Great Barrier Reef.

The apparent facultative occurrence of *S. gracilis* larvae in the epibenthos creates great problems for quantitative sampling. Conventional plankton sampling cannot be assured of adequately sampling *S. gracilis* larvae. Epibenthic sampling is required, yet towed epibenthic nets cannot sample in the type of high-relief rocky bottom areas where the larvae were observed at Miyake-jima. To obtain quantitative estimates of abundances of larval *S. gracilis*, it may be necessary to combine sampling with conventional plankton nets and epibenthic nets with either pumps (e.g. Powles, 1977) or diver-operated propulsion vehicles fitted with nets (Ennis, 1972; Schroeder, 1974). However, the present observations of the strong swimming ability and coordinated schooling of *S. gracilis* larvae make it likely that avoidance of such gears by the larvae will be high, and that spatial and temporal patchiness will be extreme.

Within the small (2 genera) tribe Spratelloidini, are found widely different strategies of larval distribution ranging from epibenthic to neustonic: what the strategies share is an orientation toward surfaces. Powles (1977) concluded that larvae of the spratelloidine clupeid *Jenkinsia lamprotaenia* were epibenthic most, if not all, of the time. Larvae of *S. gracilis* are apparently facultatively epibenthic and avoid surface waters during the day. However, larvae of *Spratelloides delicatulus* are found primarily, if not exclusively, at the surface during the day, and are more-or-less uniformly distributed vertically at night (Leis, 1986; P. D. Schmitt, personal communication). In the Great Barrier Reef, larval *S. delicatulus* are commonly attracted to surface nightlights. Although I have never captured *S. gracilis* larvae at such lights in the Great Barrier Reef, they are commonly collected at surface nightlights in Japanese waters (M. Okiyama, presonal communication). Larvae of *S. gracilis* school in the epibenthos from as small as 11 mm, while larval *S. delicatulus* school in the neuston and around coral heads and reefs near the surface at similar sizes (personal observations and P.D. Schmitt, personal communication). Schooling of larval *J. lamprotaenia* has not been observed, but may occur judging from the very patchy pump collections reported by Powles (1977). *Spratelloides gracilis* has demersal eggs (Hukuda, 1934; Mito, 1958), while the eggs of the other species are unknown. It is not known if demersal eggs are connected with the epibenthic habits of *S. gracilis* larvae, nor is anything known of the significance, if any, of the differences in behaviour between the larvae of the three species.

Recent studies (e.g. Powles, 1977; Powles and Burgess, 1978; Barnett *et al.*, 1984) have shown that a number of nearshore fish larvae spend a significant portion of time in the epibenthic layer. *Spratelloides gracilis* is facultatively epibenthic during its larval stage and is the only clupeid larva presently known to school in the epibenthos.

Only *S. gracilis* larvae were captured from the Miyake-jima epibenthic schools. It is possible that the larvae of other species were also present in these schools, although there was nothing in the general appearance of the schooling larvae to suggest that this was the case. However, one should expect more types of fish larvae to be reported from the epibenthos as this habitat is more thoroughly studied.

Knowledge of the biology of epibenthic fish larvae is too rudimentary to enable a clear assessment of the advantages and disadvantages to the larvae of an epibenthic mode of life. Possible advantages include avoidance of dispersal, availability of certain food organisms such as epibenthic mysids, avoidance of pelagic predators and avoidance of unfavourable physical or biological conditions at the surface in stratified waters. Possible disadvantages include increased exposure to demersal predators and possible damage due to contact with the bottom. Studies of the biology of fish larvae within the epibenthic layer are difficult, but it is increasingly obvious they cannot be ignored if we are to fully understand the early life history of fishes in shallow coastal waters.

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(Division of Vertebrate Zoology, The Australian Museum, P.O. Box A285, Sydney South, NSW 2000, Australia)

キビナゴの稚魚の底層における群泳

Jeffrey M. Leis

伊豆諸島の三宅島でキビナゴの稚魚が海底から 1–2 m の海中を高密度で群泳しているのを観察した．観察日時は 1985 年 7 月 16 日と 19 日の午前中で，稚魚は 1 万–10 万尾のいくつかの群を形成していた．これらの稚魚を上方から海底に追いこむ方法で採集した．採集した稚魚は体長 9.1 mm–13.1 mm であった．

キビナゴの稚魚は日中水面近くを泳ぎ，夜間は鉛直的に散在する事が判明している．稚魚はプランクトンネットや集魚灯で採集されているが，底層で高密度の群を形成する事は知られていなかった．このような群の採集は通常の方法では困難であるが，他の沿岸性の稚魚も同様の群を形成する事が明らかにされつつあるため，今後このような群の研究を更に進める必要がある．