Spines in Larval Red Grouper, *Epinephelus morio*: Development and Function

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ABSTRACT

The second dorsal and pelvic fin spines of larvae *E. morio* start to develop at the same time, about seven days post hatch and 3 mm notochord length (NL). They reach their maximum absolute and relative sizes within another seven to ten days at 6-7 mm NL. The dorsal spines can be moved forward of vertical and the pelvic spine moved to near vertical. The orientation of the spines and their length results in increasing the effective size of the larvae. No spine function in feeding, aggression, mimicry or flotation was observed and it is felt, based on observed spine growth rates and patterns that predator deterrence is the most likely function of the larval spines.

KEY WORDS: Larval development, grouper, ontogeny, predation deterrence

INTRODUCTION

Although the larvae of the groupers (Serranidae: Epinephelinae) have been known to possess spectacularly elongated second dorsal and pelvic fin spines for some time (Fage, 1918; Bertolini, 1933; Sparta, 1935), virtually nothing has been published regarding the development and function of these spines. Johnson and Keener (1984) reported differences in the size, shape and serrations of the spines among some American groupers and that these differences are useful characters for separating species. There has been, however, virtually nothing published regarding the mobility of the spines and how they might be put to advantage. During the spring of 1990 we reared red grouper, *Epinephelus morio*, from the egg and took a regular series of larval specimens through metamorphosis. We also observed in detail the behavior of larvae in rearing aquaria.

MATERIALS AND METHODS

E. morio were raised in the laboratory from artificially-spawned eggs obtained from wild-caught brood stock. Larvae were reared in aquaria and fed with wild-caught zooplankton. A series of specimens were preserved in 10%

buffered formalin and 70% ethanol at regular intervals. Specimens were measured with dial calipers or an ocular micrometer in a dissecting microscope. Video recordings of live larval specimens were made through a dissecting microscope after chilling them to make them quiesscent. Additional recordings of the behavior of undisturbed larvae were made in aquaria from the sides and through the surface water layer.

Video tapes were analyzed for orientation and movement of spines using a computerized image analysis system. The angles of spines with the body centerline along the vertical and horizontal planes were determined for both resting and swimming larvae. The vertical distance between the dorsal and pelvic spine tips was determined by adding the spine lengths and the depth of the body at the cleithrum; this was termed the effective vertical height. Additionally the volume contained within a tetrahedron formed by the snout and the tips of the dorsal and pelvic spines in their typical positions (Figure 1) was calculated.

RESULTS

Development of Spines with Age and Length

Figure 2 shows the relationships of the length of dorsal and pelvic fin spines with length (notochord length or NL in preflexion larvae and standard length or SL in post flexion larvae) and age for laboratory-reared specimens. Dorsal and pelvic fin spines began to develop at the same time, at a notochord length of about 3 mm and a post-hatching age of seven days. They are initially visible only as nubs, protruding from the myomeres into the fin fold, but subsequently protrude beyond the fin fold at eight to nine days post hatch. Subsequently their growth is rapid with the spines increasing in length during the next seven to ten days. From the initial formation of spines until reaching their maximum length, the length of the larva increased slowly, roughly doubling in the same period of time. Relative to the length of the larva, the spines reach their maximum length at only 6-7 mm NL and fifteen to eighteen days post-hatch.

From early in their development through to the juvenile stage, the spines have a sheath of tissue and fleshy lobes at their tips (see Figure 1). The fleshy tips are normally very dark as they are covered with abundant melanophores. The dark spine tips in swimming larvae are readily visible to the unaided eye and clearly indicate the end of each of the three spines.

Orientation and Movement of Spines

When the larva is not swimming forward, the second dorsal spine generally lies at an angle of 40-45° to the notochord or vertebral column, while the pelvic spines, when viewed laterally, are at an angle of 30-36° to the notochord. The angle formed by the dorsal and pelvic spines is 75-80°. When viewed dorsally the pelvic spines have an angle of 67-72° between them.

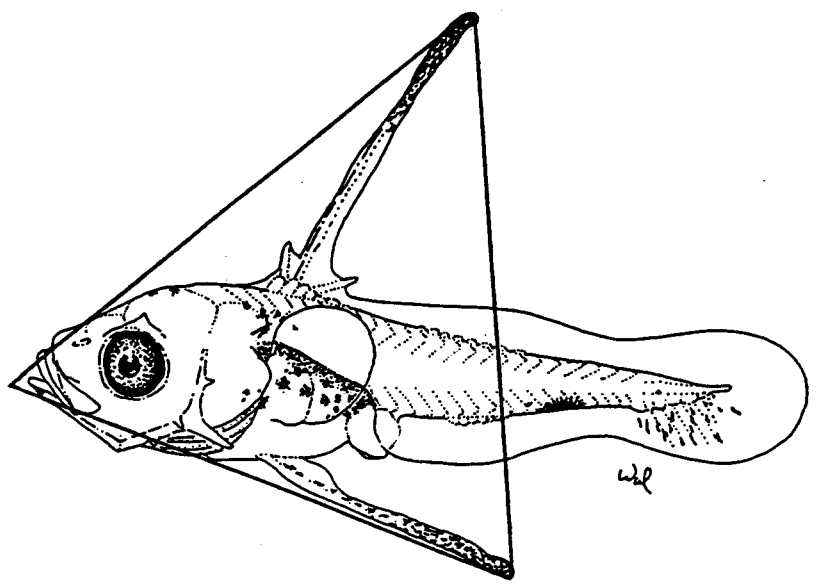

Figure 1. Lateral view of larval *Epinephelus morio* showing the triangular area formed by the second dorsal fin spine, pelvic fin spine and snout. The paired pelvic fin spines result in a tetrahedron-shaped volume, known as the spine/head volume, delineated by the dorsal spines, two pelvic spines and snout.

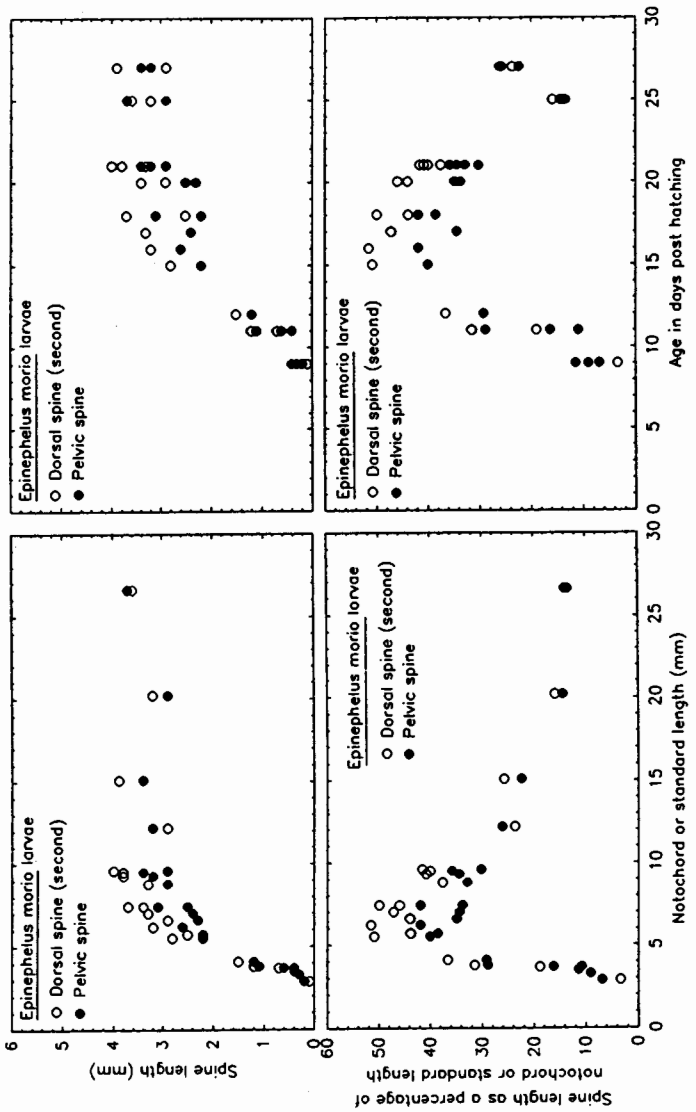

Figure 2. The relationships of the absolute and relative lengths of the second dorsal and pelvic fin spines of larval *Epinephelus morio* with the length (notochord length in preflexion larvae and standard length in postflexion larvae) and post hatch age in days.

Both the dorsal and pelvic fin spines appear to have relatively little capability for lateral movement, but do have extensive movement capability in the plane of the fin membrane. With the larval axis horizontal, the dorsal spine can be brought slightly forward of vertical to an angle of as much as 95° with the notochord and can be depressed to the point where it lays along the upper body. The pelvic fin, similarly, can be brought alongside the body and forward to just less than 90 degrees.

The larva is capable of nearly fully erecting both the dorsal and pelvic spines resulting in an effective vertical body height much greater than the body alone. Figure 3a shows the relationship between length, age and the effective height of the body with the spines.

Figure 3a considers only the apparent effect of the spines on the vertical axis, but in actuality their orientation results in the spines protruding in three dimensions. The fin spines, combined with preopercular spines, results in (for the length of the larva) a formidably-spined larval fish. The angle of the pelvic spines outward from the vertical plane of the larva results in their forming, combined with the dorsal spine, a tetrahedron shaped structure with spines at three of the corners (Figure 1). The relationship of the volume enclosed by the head/spine tetrahedron relative to length and age is shown in Figure 3b.

DISCUSSION

Once development of the spines is started, they grow very rapidly. The largest relative size of the spines is achieved in preflexion larvae of only 5-7 mm NL. Following flexion (usually fourteen to eighteen days post hatch), the relative size of the spines begins to decrease, however their actual length remains nearly constant until metamorphosis when they are reabsorbed.

There are numerous possible functions for the spines. These include, but are not limited to: 1) feeding, 2) intraspecific aggression, 3) mimicry, 4) flotation, and 5) predator deterrence. While we have not attempted to examine any of these possible functions experimentaly, based on our observations of living larvae, we feel that most of these can be eliminated as likely functions.

No use of the spines during feeding was ever observed. Qualitatively the feeding behavior of *E. morio* larvae appeared similar to all other marine fish larvae we have raised. The spines would be moved somewhat, depending on the positioning of the larvae prior to a feeding strike, but the movement of the body to make slight corrections prior to striking appeared to be controlled by the pectoral fins.

No aggressive behavior or any other distinct behavioral interaction was ever seen between larval *E. morio*, despite a relatively high abundance (up to 30-40 larvae with well-developed spines) in 80-l aquaria. Even individuals which had completed their larval development, but were still free-swimming "pelagic juveniles", did not interact aggressively with other free swimming larvae and

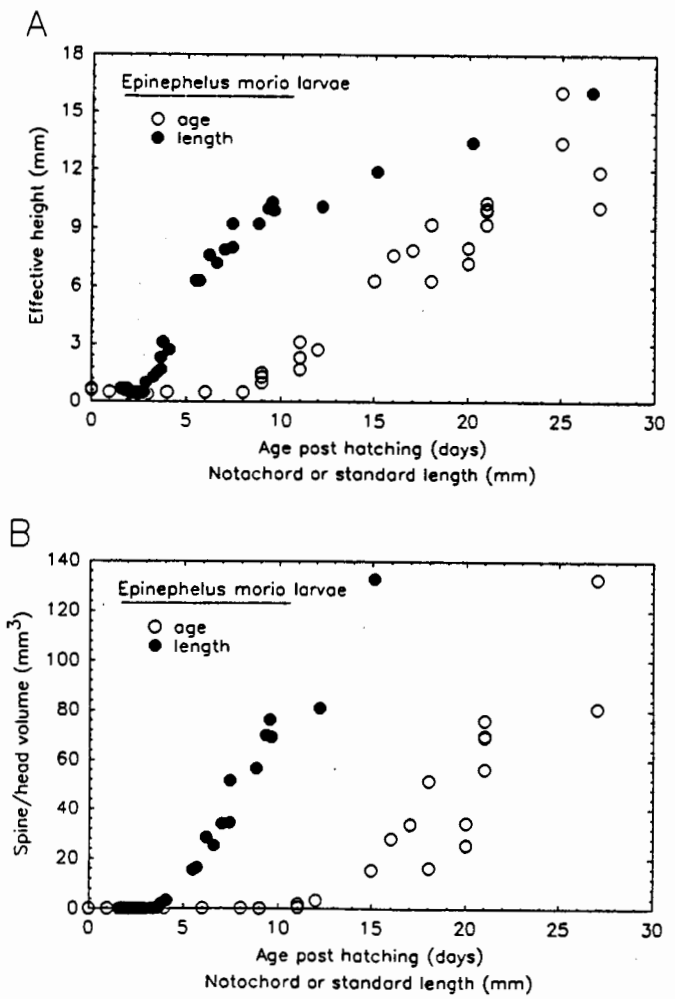

Figure 3. A. The relationship of effective height (second dorsal spine length+depth of the body at the cleithrum+pelvic spine length) of larval *Epinephelus morio* with age in days post hatch and length (notochord length or standard length). **B.** The relationship of spine/head volume, a tetrahedron formed by the tips of the second dorsal and pelvic fin spines and the snout, of larval *E. morio* with age in days post hatch and length (notochord length and standard length).

pelagic juveniles in the rearing aquaria. Juveniles which had settled to become 'benthic juveniles' were, however, extremely aggressive towards fellow benthic juveniles, but had dorsal and pelvic spines shortened to the point that their relative size was similar to those of larger juvenile and adult *E. morio*.

It is doubtful the larvae mimic any other planktonic organism. The spines of larval *E. morio* are easily visible, with the black melanophores giving the spine tips a distinct appearance. As the larva swims, the spines are pulsated back and forth slightly in a manner resembling a small medusae with dark markings pulsating its bell. The resemblence to a a pulsating medusae was destroyed, however, by the visibility of the remainder of the larva.

Possible use of the spines as flotation devices was not closely examined. The larvae develop swim bladders at about twelve days post hatch, at a time when spine development is at its maximum, but could regulate buoyancy more easily with the swim bladder. Additionally, the role of the very elongated flexible dorsal filaments of the Indo-Pacific Epinepheline *Diploprion bifasciatum* as flotation devices has been shown to be unlikely (Baldwin *et al.*, 1991) despite previous suggestions that they serve this function.

Several pieces of information included in this paper argue strongly in favor of the predator deterrence hypothesis for spine development. Both the dorsal and pelvic spines begin development at a small larval size, barely more than 3 mm NL and grow rapidly to their maximum absolute length by flexion (Figure 2). This rapid growth results in the larvae having a much greater effective height and volume (Figure 3) and probably a much reduced chance of becoming prey for predators that would typically take fish larvae from the plankton. Experimental confirmation of this hypothesis is needed.

We might also suggest that in addition to the formidable nature of the spines, the distinctively-colored fleshy tabs at their tips might play a role in enhancing their predator deterrence abilities. These fleshy tabs might be distasteful or serve to distract predators from the body of the larvae.

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