

Clasping Mechanism of the Cottid Fish *Oligocottus snyderi* Greeley

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Oligocottus snyderi is a small, tide-pool fish found along part of the Pacific coast of North America. The male of this species has a well-developed penis and fertilization is internal. I studied its breeding and spawning habits under laboratory conditions during a number of years. Copulation was observed on many occasions. No definite patterns of display or courtship activities were apparent and copulation took place in an atmosphere of carefree promiscuity. Such behavior may not be normal, however, for under the conditions of these observations the fish were crowded and subject to the numerous artificialities of laboratory life.

In this species the first two rays of the anal fin of the male are set apart and the first one is much larger and longer than the others of the series (see Fig. 2*a*). This first enlarged ray is prehensile and during copulation it is bent anterolaterally around the female. The lateral curvature of the ray can be directed to either the right or left, permitting the male to seize the female from either side. Copulation takes place away from solid substrate and the embrace may last for as long as 4 or 5 seconds. The strength of the ray's grasp is sufficient to hold the male and female together as they whirl about vigorously (see Fig. 1).

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ANATOMY

Terminology of the following account is adapted from Starks (1901) and Green and Green (1915).

Figure 2*b* shows the appearance of the male fish after removal of the skin and with the lateral inclinator muscles of the unmodified rays shaded. Each inclinator originates on a myocomma and passes posteriorly across two segments to insert on the side of the head of its ray. Superficially no inclinator is visible on the first two rays.

After removal of the myotomes, the deep muscles associated with the anal fin appear as shown in Figure 3*a*. A section of the peritoneum (bordered by crosshatching) shows how the anal fin mechanism has advanced and reduced the posterior limit of the coelom to a concavity. Discussion of the muscles is deferred until after consideration of the skeleton.

The first three interhemal bones and ossicles are greatly modified as shown in Figure 3*b*. The first interhemal rests on the ossicle at the base of the first ray and arches posteriorly at its dorsal extremity. For its entire length it bears a prominent crest on each side. These crests terminate in broad lateral expansions proximal to the head of the first ray as shown in Figure 4*a*. The second interhemal likewise rests on the first ossicle but also articulates posteriorly with the second. The first ossicle is a doubled bone and in

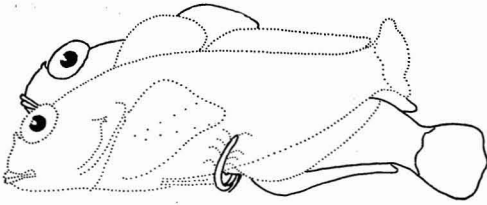


FIG. 1. Approximate positions of the male and female during copulation (male in heavy outline; female stippled outline).

lateral aspect is L shaped. The second ossicle appears to be single and is slightly concave on its dorsal side. The third interhemal articulates with the second and third ossicles. In some specimens the second interhemal has two crests on each side and in others only a single, branched crest as shown in Figure 3*b*. The third interhemal has a single crest on each side.

The left parapophysis of the eleventh vertebra is indicated in stippled outline in Figure 3*b*. The posterodorsal end of the first interhemal is firmly attached to both parapophyses of the eleventh vertebra near the centrum by short, heavy ligaments (see Fig. 4*a*). These parapophyses are in turn firmly anchored to a myocomma and to the transverse septum. Their proximal ends are hooked as shown in Figure 4*b*. I am unable to attach any particular significance to this hook.

The hemirays making up the first ray are held together loosely by connective tissue except at the distal end where they are fused for a length of about 3 or 4 mm. (see Figure 4*a*). This condition permits a degree of independent movement of the hemirays along the long axis. Figure 4*c* shows the first three interhemals and ossicles, and the first two anal rays, the latter with the left hemirays intact. A small hook on the head of the first hemiray turns medially over the dorsal surface of the first ossicle. The heads of the second hemirays are deeply excavate medially and almost completely cover the second ossicle.

Referring again to the muscles shown in Figure 3*a*, the most anterior of the series is

seen to originate above the crest of the first interhemal and is inserted on the anterior surfaces of the head of the first ray. This is the erector and is greatly enlarged. The second muscle originates below the crest along the blade of the first interhemal and some of its fibers originate on the second interhemal, in front of the crest(s). Its insertion is over the middle portion of the head of the first hemiray. This muscle appears to be a modified inclinator. The third muscle of the series is a rather narrow one which originates along the middle of the blade of the second interhemal and is inserted on the posterior surfaces of the head of the first ray. It is the depressor. All three of these pairs of muscles are thick

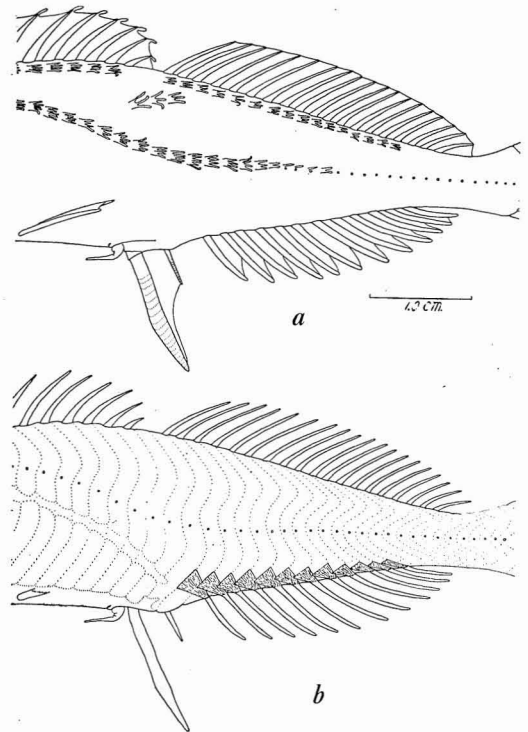


FIG. 2. *a*, Lateral aspect of a portion of the trunk and tail of the male *Oligocottus snyderi*. Protruding from the ventral profile, in left-to-right order are the: Penis, first (enlarged) anal ray, second anal ray, series of 12 unmodified anal rays. *b*, Appearance of superficial musculature after removal of the skin of the trunk and tail. Inclinator muscles of the unmodified anal rays are shaded.

and as a unit they form a subspherical mass.

I could make no distinction between any of the muscles forming the complex inserting on the head of the second ray. The elevator, inclinator, and depressor form a thick, nearly hemispherical mass on each side. This complex originates over the posterior half of the second interhemal blade and the anterior half of the blade of the third.

The erector of the third (first unmodified) ray originates on the posterior surfaces of the third interhemal and inserts on the anterior surfaces of the head of the ray. Its depressor originates on the anterior faces of the fourth interhemal and inserts on the posterior sur-

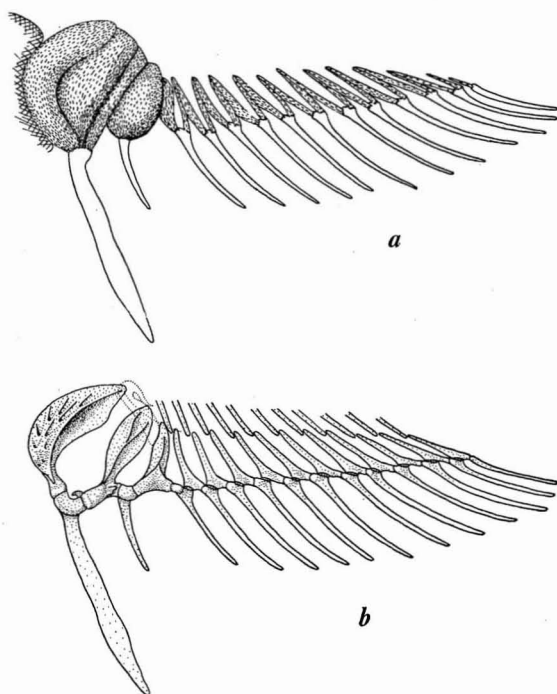


FIG. 3. *a*, Deep musculature of the anal fin. The posterior profile of the body cavity is crosshatched. In left-to-right order the muscles are: Elevator of the first anal ray, inclinator of the first anal ray, depressor of the first anal ray, muscle complex of the second anal ray, elevator of the third anal ray, depressor of the third anal ray, elevators and depressors serially repeated. *b*, Skeleton of the anal fin (with left hemirays removed). Position of left parapophysis of the eleventh vertebra is shown in stippled outline. Ends of the hemal spines of vertebrae 12 to 22, inclusive, are also shown.

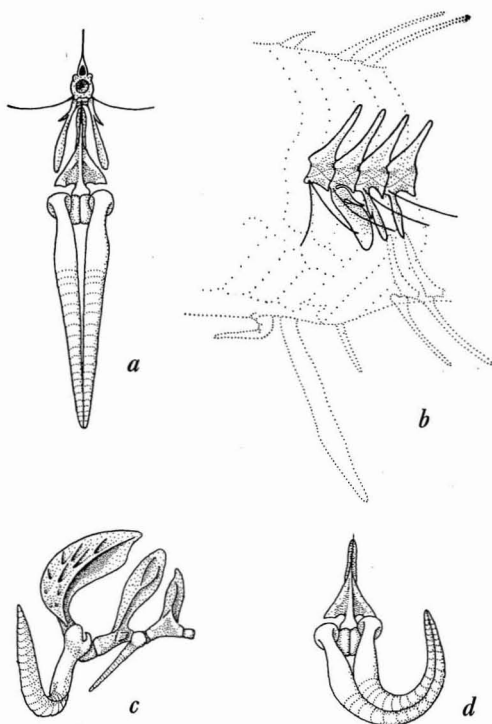


FIG. 4. *a*, Anteroventral aspect of the skeleton of the first anal ray (clasper) and the eleventh vertebra. Note the ligaments connecting the parapophyses of the vertebra with the first interhemal. *b*, Lateral aspect of vertebrae 10 to 13, inclusive. *c*, Lateral aspect of the first three interhemals and ossicles and the first two anal rays with the first ray in a partially flexed position. *d*, Anteroventral aspect of the first interhemal, ossicle, and anal ray with the latter in a flexed position.

faces of the head. As shown in Figure 3*a* the erectors and depressors diminish in size posteriorly and on the last ray I could find only a very small erector and no depressor.

FUNCTION

The clasper appears to be flexed in response to either visual or touch stimuli.

Flexion results from the following muscular activities. The first pair of erectors draw the first ray ahead so that it extends from the venter slightly anterior to the perpendicular. The ligaments from the first interhemal to the parapophyses of the eleventh vertebra help

hold the interhemal in position against this action.

The first inclinator of one side (the left for purposes of this description) contracts, drawing the blades of the first and second interhemals closer together. This action retracts the left hemiray, shortening the left side and causing the ray to bend in that direction. The medially directed hook on the head of the right hemiray engages over the first ossicle and prevents that side from being disarticulated.

During flexion, the depressors of the first ray are at rest.

The muscle complex on both right and left sides of the second ray appears to function as a single unit. During flexion of the first ray, this complex contracts, drawing the blades of the second and third interhemals together, thus stabilizing the second interhemal by opposing the action of the first inclinator.

The erector of the third (first unmodified) ray originates on the posterior surfaces of the blade of the third interhemal and inserts on the anterior surfaces of the head of the ray. Its contraction erects the third ray and stabilizes the third interhemal, opposing the action of the muscle complex of the second ray.

CONCLUSION

There are numerous accounts dealing with

modification of elements of the anal fin to form a gonopodium (see Rosen and Gordon, 1953), however, specialization of this fin as a clasping mechanism has not to my knowledge been reported among bony fishes.

Except for the "invasion" of the trunk region by the bones of the anal fin, evolution of the clasper described in this paper seems to be a rather uncomplicated matter.

From the description presented above, it can be seen that the greater the size of the male with respect to that of the female, the more effectively the clasper aids in copulation. It is interesting to consider the extent to which the trend of evolution of this species might be influenced by such a mechanism.

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