CHARACTERISTICS OF SOME LARVAL BOTHID FLATFISH, AND DEVELOPMENT AND DISTRIBUTION OF LARVAL SPOTFIN FLOUNDER, *CYCLOPSETTA FIMBRIATA* (BOTHIDAE)[1]

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ABSTRACT

Pertinent literature on larval flatfish of the family Bothidae and some of the characters helpful in identifying these larvae are discussed. Helpful characters are of two types; transitory, those which are lost, and permanent, those which are retained. Transitory characters include larvae pigmentation, elongate dorsal and pelvic fin rays, and spination; permanent characters include meristic counts, placement of pelvic fin bases and fin rays, and caudal osteology.

Developmental changes in general growth patterns, formation of fins, larval spination, pigmentation, migration of the right eye, and sequence of ossification based on 171 larvae (1.7–14.5 mm. SL) collected off the south Atlantic coast of the United States is presented. Several sizes of larvae showing spination, pigmentation, and elongate fin rays are illustrated, and one illustration shows the degree of ossification.

Spawning appears to occur between April and October in waters of about 50 m. or less. Fertilized eggs have not been seen, but their size at hatching is estimated to be about 1.5 mm.

Five families of flatfish occur off the southeastern coast of the United States (Bothidae, Scophthalmidae, Pleuronectidae, Soleidae, and Cynoglossidae). Species of bothids are common in the inshore waters south of Cape Hatteras, N.C., and are more numerous (13 genera and 49 species) than are species of the other four families (Cynoglossidae, 1 genus and about 15 species; Soleidae, 3 genera and 5 species; Pleuronectidae, 1 genus and 3 species; Scophthalmidae, 1 genus and 1 species).

The spotfin and other flounders discussed in this paper are taken in industrial fish catches or are caught incidentally in shrimping. Of these flounders, only the fluke (*Paralichthys*) is removed from the catch and its flesh utilized. Flukes are also fished for sport or commercially along much of the east and Gulf coasts of the United States. Several other species of large flounders may be fished commercially in the future if stocks of sufficient size can be found.

Larvae of flatfish along the southeastern coast of the United States are poorly known; however, a few authors have illustrated and described some of these fish taken off North Carolina. Goode and Bean (1896) identified an *Ancylopsetta dilecta* larvae (listed as *Notosema dilecta*, Bothidae); Hildebrand and Cable (1930) had larvae of *Paralichthys* (Bothidae); and Deubler (1958) showed the postlarvae of *Paralichthys*. Hildebrand and Cable illustrated and described larvae of *Symphurus plagiusa* (Cynoglossidae) in 1930, and the larvae of *Trinectes maculatus* (listed as *Achirus fasciatus*, Soleidae) in 1938 from off North Carolina.

I discuss the literature pertaining to the larvae of *Syacium* (Bothidae) in some detail, because of the many similar external features between the larvae of *Cyclopsetta* and *Syacium*. Both genera have many elongate dorsal and pelvic fin rays, a single sphenotic spine, and heavy preopercular spines, but larvae of *Cyclopsetta* have more numerous elongate dorsal fin rays, and the sphenotic and preopercular spination is smaller.

This paper reports on development of larvae of spotfin flounder, *Cyclopsetta fimbriata*, that U.S. Fish and Wildlife Service vessels *Theodore N. Gill* and *Oregon* collected off the south Atlantic coast of the United States (fig. 1). It describes growth changes in the head length, body depth, eye diameter, snout length, and upper and lower

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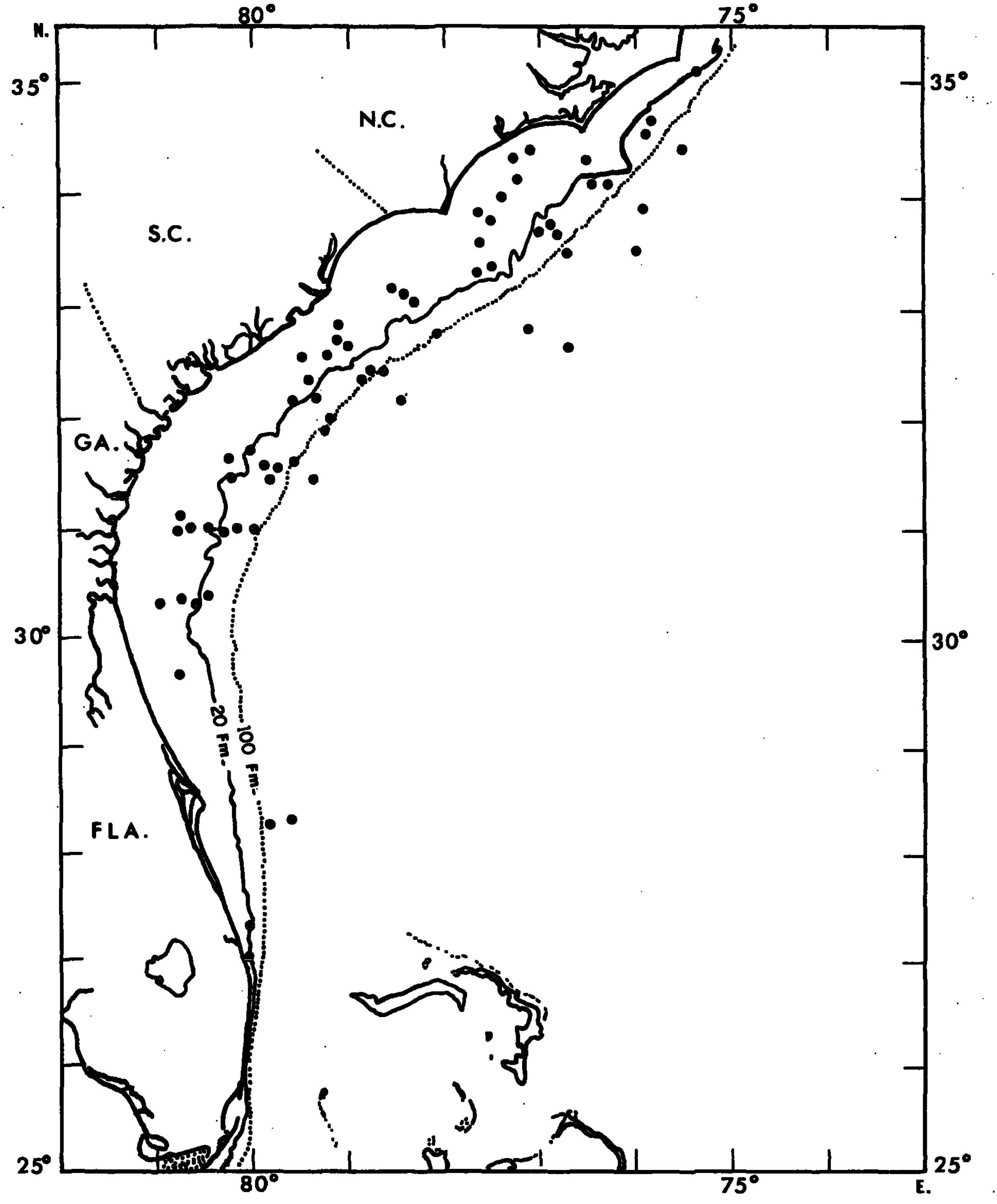

FIGURE 1.—Collection sites of *Cyclopsetta fimbriata* larvae from cruises of U.S. Fish and Wildlife Service vessels *Gill* and *Oregon*.

jaw lengths, and the development of fins, spination, pigmentation, sequence of ossification, and migration of the right eye.

REVIEW OF PERTINENT LITERATURE CONCERNING BOTHID LARVAE

In their description of *Ancylopsetta dilecta* (three-eyed flounder), Goode and Bean (1896) did not mention the larva they illustrated or any of its larval characters. The following characters are taken from the illustration: about 70 dorsal fin rays, the 9 anteriormost elongate; about 60 anal fin rays; 6 pelvic fin rays, the first three are elongate and extend almost to the caudal peduncle; ocular-side pelvic fin on median line; small eye; large mouth; origin of dorsal fin anterior to anterior edge of eyes; migrating (right) eye appears to move under the dorsal fin or through the head. All of these characters except the number of fin rays are present on large larvae of *Cyclopsetta*. Well-developed preopercular spines and a single sphenotic spine are present on larval *Cyclopsetta* but are not shown on Goode and Bean's illustration. Despite the lack of spines on their illustration, I believe their specimen is a *Cyclopsetta*.

In *Ancylopsetta*, the ocular-side pelvic fin is above the median line; the origin of the dorsal fin is above the anterior part of the eye, not in advance of it; the eyes are large, and the right side eye probably migrates over the median dorsal ridge anterior to the origin of the dorsal fin, not under it. I do not know if larvae of *Ancylopsetta* have elongate dorsal and pelvic fin rays.

Many species of Bothidae have elongate dorsal and pelvic fin rays in the larval stage, but larvae of *Syacium* are the only other bothid larvae to have numerous elongate dorsal (more than five) and pelvic (generally three) fin rays. *Symphurus* larvae (family Cynoglossidae) also have elongate dorsal rays, that can number up to seven. The numbers of dorsal and anal fin rays that Goode and Bean (1896) show are too low for *Syacium*, and the elongate pelvic fin rays they show are too long for *Syacium*.

I am unaware of any published accounts of *Ancylopsetta* larvae except those in which *Syacium*, *Cyclopsetta*, *Citharichthys*, or *Etropus* larvae have been misidentified as *Ancylopsetta*. Kyle (1913) described and illustrated (fig. 27) a 6- to 7-mm. larva he called *Ancylopsetta* sp. Regan (1916) illustrated (plate 9, fig. 3) a specimen identified as *A. quadrocellata* that he said resembles Kyle's (1913) *Ancylopsetta;* Regan's second illustration (plate 9, fig. 4) is a 4-mm. larva that he called *Ancylopsetta* sp. Both of Regan's (1916) larvae as well as the larva figured by Kyle (1913) are larvae of *Syacium*. Aboussouan (1968) discussed in detail the relation of Kyle's (1913) *Ancylopsetta* and Regan's (1916) *Ancylopsetta* to *Syacium*. Dannevig (1919) and Hsiao (1940) recorded *Ancylopsetta* larvae from eastern Canada and along the outer edge of Georges Bank that are similar to Kyle's *Ancylopsetta* sp. and these also are larvae of *Syacium*—warm-water species of vertebrates and invertebrates in this area are not uncommon (Bigelow, 1926, and Colton, 1961). Pearson (1941) listed *Ancylopsetta* sp. in plankton collections from Chesapeake Bay, but these are probably *Etropus* or *Citharichthys*. Pearson (1941: 84) stated, "The most characteristic features of the two fish are the pronounced elongation of the first two dorsal rays, the latter reaching nearly a quarter the length of the body, and the elongation of one of the ventral fins into a filament extending to the vent." These larval characters are found on larvae of *Etropus* and *Citharichthys*, and species of these two genera are known from Chesapeake Bay. *Cyclopsetta* and *Syacium* have not been reported north of Cape Hatteras, N.C., except for larvae of *Syacium* referred to as *Ancylopsetta* by Dannevig (1919) and Hsiao (1940).

Known larvae of *Etropus* have 2 elongate dorsal fin rays, and *Citharichthys* larvae have 0 to 3 elongate dorsal fin rays (5–10 in *Cyclopsetta* and *Syacium*) and 1 or 2 elongate pelvic fin rays (3 in *Cyclopsetta* and *Syacium*).

S. guineensis (Bleeker, 1862) probably is a synonym of *S. micrurum* Ranzani 1840; if so, the larvae described by Aboussouan (1968) from off Dakar are those of *S. micrurum*. Norman (1934) listed *S. guineensis* in the synonymy of *S. micrurum* and gave its distribution as "Atlantic coast of tropical America from Florida to Rio de Janeiro, tropical West Africa." Distinguishing between adult *S. guineensis* and *S. micrurum* is difficult, and they are separated by their distribution; *S. guineensis* off west Africa and *S. micrurum* off Florida, the Antilles, through the Gulf of Mexico and the Caribbean Sea, and off the Atlantic coast of South America to Rio de Janeiro.

Three species of *Syacium* occur in the western North Atlantic. *S. papillosum* (Linnaeus, 1758) and *S. micrurum* are difficult to separate as juveniles and can be separated as adults only by the width of the interorbital space. All other meristic and morphometric characters overlap. *S. gunteri* Ginsburg, 1933 can usually be separated from the other two species of *Syacium* in the western North Atlantic by the number of dorsal and anal fin rays. *Syacium papillosum* and *S. micrurum* rarely have fewer than 85 dorsal fin rays or fewer than 68 anal fin rays, whereas *S. gunteri* rarely has more than 84 dorsal fin rays and more than 67 anal fin rays (Gutherz, 1967).

Aboussouan's (1968) description of larval *S. micrurum* (listed as *S. guineensis*) is of greatest value for workers in the area off Dakar where only one species of *Syacium* is known. His paper is valuable in separating *Syacium* larvae from the larvae of other genera.

Aboussouan (1968) implied that Kyle's *Citharichthys* B. (Kyle, 1913; fig. 29) is a *Syacium* rather than a *Citharichthys*, but I disagree for the following reasons: At this stage of development larvae of *Syacium* have numerous elongated dorsal and pelvic fin rays but the known larvae of *Citharichthys* have only a few, if any, elongate fin rays; *S. gunteri* has fin ray counts similar to those given by Kyle for *Citharichthys*, but our larvae of *S. gunteri* have the heavy preopercular spination and the large sphenotic spine seen on the larvae of the other species of *Syacium;* the preopercular armature of *Syacium* is not reduced or blunted until the right side eye has reached the middorsal ridge or is turning onto the left side; the mouth of *Syacium* larvae is larger than that shown by Kyle, and the origin of the dorsal fin is more anterior; the larvae of several species of bothids have pigment patterns similar to *Citharichthys* B. I believe this specimen probably represents a *Citharichthys* or *Etropus*.

Paralichthys sp. and *P. olivaceous* larvae have been figured and described by Hildebrand and Cable (1930); Deubler (1958); Chang, Xo, and Sha (1965); and Okiyama (1967). These descriptions are based on larvae collected off the Atlantic coast of the United States, off Japan, and on laboratory-reared specimens. A high degree of similarity in the developmental pattern is noted except for Okiyama's *P. olivaceous*, which have longer elongate dorsal fin rays that seem to persist longer than the elongate dorsal fin rays on the larvae described by Chang et al. (1965). Characteristics common for the eggs and larvae of *Paralichthys* and a discussion of the relation between the migrating eye and the anterior portion of the dorsal fin are given by Chang et al. (1965).

Hippoglossina oblonga larvae have been illustrated and described by Agassiz (1879, listed as *Pseudorhombus oblongus*), Perlmutter (1939), and Miller and Marak (1962, listed as *Paralichthys oblongus*).

Citharichthys larvae have been figured by Ahlstrom (1965), and Kyle (1913, fig. 29) has illustrated what is probably a *Citharichthys* or *Etropus*.

Bothus larvae have been illustrated and described by Kyle (1913), Colton (1961), and Ochiai and Amaoka (1963) among others. These descriptions and figures of larvae collected off the Atlantic coast of the United States, the mid-Atlantic region, and off the Japanese coast show a high degree of similarity. All have only one elongate dorsal ray.

Chascanopsetta larvae have been illustrated and described by Kyle (1913) and Bruun (1937). Kyle was unable to refer his larva to any known Atlantic species, but Bruun placed it in *Chascanopsetta*.

Illustrations and descriptions of larvae in the closely related Scophthalmidae can be found in Smith (1904), Moore (1947), and Bigelow and Schroeder (1953).

MATERIALS AND METHODS

The original sampling procedures used on cruises of the FWS (U.S. Fish and Wildlife Service) vessel *Theodore N. Gill* were reported by Anderson, Gehringer, and Cohen (1956) and Anderson and Gehringer (1957).

Additional plankton samples were collected in January and June 1967 on cruises of the FWS vessel *Oregon*. Plankton and nekton samples were collected in depths of 14.6 to 45.7 m. (8–25 fath.) by 1-m. plankton and nekton nets (1-mm. mesh) and ½-m. plankton nets (1-mm. and 0.33-mm. mesh), which were towed for 15-minute periods.

A size series of specimens was cleared and stained by the procedure given by Taylor (1967).

All measurements were made with an eyepiece micrometer and a stereoscopic microscope and recorded to the nearest 0.01 mm.

MEASUREMENTS

Measurements used when working on larval flatfish require definition, because they differ significantly from those used on adult flatfish.

Standard length (SL): Tip of snout to that point on notochord where dorsal flexture takes place (dorsal and anal finfolds have a slight indentation where the notochord turns dorsally, actinotrichia are visible in the caudal region of the finfold immediately posterior to this indentation); or tip of snout to base of median caudal fin rays if these rays are developed; or tip of snout to distal end of hypurals if caudal fin rays are developed.

Head length (HL): Tip of snout to posterior edge of cleithrum on a horizontal line through center of left eye on small larvae; or tip of snout to origin of dorsalmost part of pectoral fin base; or tip of snout to posteriormost part of opercle on large larvae.

Body depth (BD): When left side pelvic fin base is not developed, vertical depth is taken immediately posterior to the cleithrum; or from origin of left side pelvic fin base to dorsal margin of body (excluding finfold or rays).

Origin of pelvic fin base to cleithrum: Least distance from origin of pelvic fin base to ventral tip of cleithrum, both left and right sides.

Eye diameter (ED): Horizontal distance across the left eye.

Upper jaw length (UJL): Anterior tip of premaxillary to distal edge of maxillary.

Lower jaw length (LJL): Symphysis of lower jaw to posterior edge of angular.

Snout length (SN): Anteriormost part of premaxillary to anterior edge of left eye.

COUNTS

Dorsal, anal, caudal, and pelvic fin rays: Total number of fin rays in which the basal portion is distinguishable.

PROBLEMS ENCOUNTERED IN WORKING WITH LARVAL FLATFISHES

The wide variation in measurements and counts of larval flatfishes may be due to distortion by preservation or to differing rates of development. When killed and preserved the larvae often curl; the pectoral fins may harden in an extended position; the mouth may open and distort some head features; and the eyes often distend, shrink, or fall out. Larval fish are fragile, and fin rays are often broken, particularly the elongate rays. Poor preserving and collecting techniques often damage or distort specimens. Fresh, well-preserved, flatfish larvae can be held in place for examination by a cover slide, but older, softer, or poorly preserved material may be damaged if handled in this manner. Older, softer specimens are often difficult to measure; however, they are often partially or completely bleached, so that the fin rays and myomeres or vertebrae are easier to count than in the fresh firmer specimens. Much of the material from the *Theodore N. Gill* is soft, but that from more recent *Oregon* cruises is in excellent shape.

Pigment patterns fade and are lost in preservative, so a knowledge of when specimens were collected is important; also the rate of development is not the same for all individuals. Larvae collected over a wide geographic area and an extended period of time may show differing rates of development. Within a species, fishes that metamorphose at small sizes probably have different rates of development from those that metamorphose at larger sizes. These differences must be recognized when working with larval flatfish.

CHARACTERS USEFUL IN IDENTIFYING BOTHID LARVAE

Characters that can be used to identify bothid larvae fall into two categories: (1) transitory, those which are present during part or all of the larval period but eventually are lost and (2) permanent, those which develop during the larval period and are retained in the juvenile and adult stages.

Transitory characters include larval pigmentation, elongate fin rays, and head and body spination. Type and intensity of these transitory characters may be of generic or specific significance. Many of the bothid genera in the western North Atlantic have elongate dorsal and pelvic fin rays in the larval stages: *Paralichthys* (Hildebrand and Cable, 1930); some *Citharichthys* (Ahlstrom, 1965; *C. stigmaeus* has no elongate dorsal fin rays); *Syacium* (Aboussouan, 1968); *Bothus* and

Chascanopsetta (Kyle, 1913); and *Cyclopsetta* (Goode and Bean, 1896). Many bothid larvae in the western North Atlantic have spines. These are more frequently seen on the preopercular margin than on the head or body. Most bothids have a swim bladder during the larval stage. Those larvae with a protracted larval stage retain the swim bladder longest. The migrating eye moves over the middorsal ridge anterior to the origin of the dorsal fin or through the head between the dorsal fin and the supraorbital bars of the cranium.

Permanent characters include meristic counts, relation of the origin of the pelvic fin bases to each other and to the cleithrum, and the arrangement of the caudal fin rays with respect to the other caudal fin rays and the bones of the hypural plate. Size at metamorphosis is important in distinguishing between genera.

MERISTIC CHARACTERS

The most important characters for identification of bothid larvae are meristics. Myomeres, which correspond in number to vertebrae, are the first countable item to develop. Those near the anterior and posterior portions of the body are difficult to count in the early stage larvae. Abdominal vertebrae usually number 10, but can be 11 (*Chascanopsetta* has 16 or 17). Caudal vertebrae are much more variable, ranging from 23 to 42. The vast majority of bothid larvae have between 34 and 40 total vertebrae or myomeres. Dorsal and anal fin ray numbers are also variable and overlap widely between species of Bothidae. The adult complements of dorsal and anal fin rays are distinguishable in larval *C. fimbriata* by about 8-mm. SL (fig. 2). The rate of fin ray development and the fin ray numbers at the various sizes may have generic or specific value. Although much meristic overlap is evident among species of bothids, several species can be separated by meristic values.

PELVIC FIN

Pelvic fin characteristics helpful in determining a genus or generic group are: the position of the fin bases in relation to the median line, size of larvae when the left fin base and rays first appear, relation of the origins of the right and left side fin bases to the cleithrum, and the number of elongate fin rays.

Four of the 13 genera of bothids in the western North Atlantic (*Paralichthys*, *Ancylopsetta*, *Gastropsetta*, and *Hippoglossina*) have the left and right side fin bases above the median line; all other western North Atlantic bothid genera have the left side fin base on the median line and the right side fin base above the median line.

I have only seen *Paralichthys* of the four genera with left and right side pelvic fin bases above the median line. In *Paralichthys* the left side fin base does not appear until the larvae are about 7 mm.

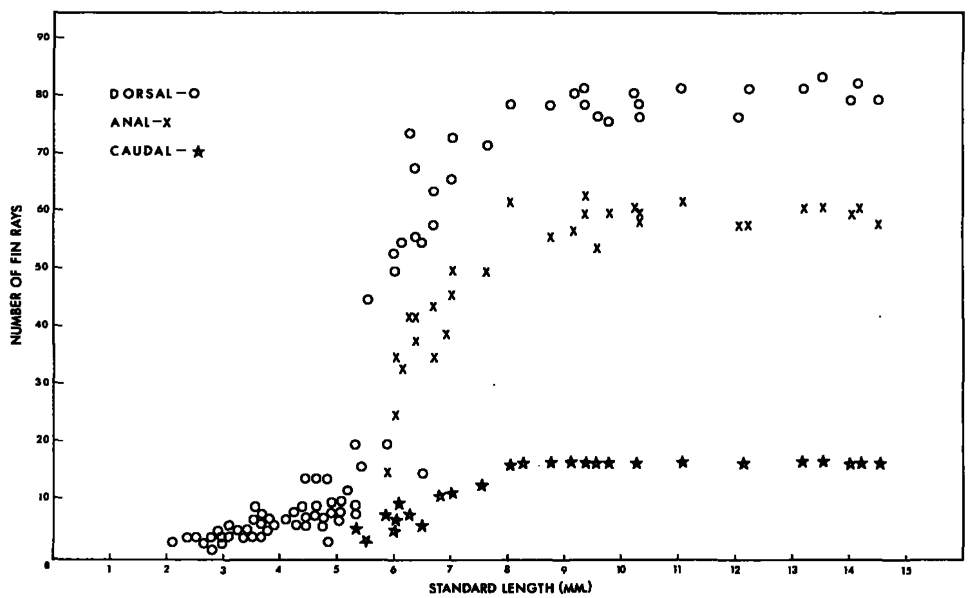

FIGURE 2.—Relation of number of dorsal, anal, and caudal fin rays to standard length of *Cyclopsetta fimbriata* larvae.

SL. I have not seen the larvae of *Ancylopsetta*, *Gastropsetta*, or *Hippoglossina*, but an illustration of a 5.7–mm. SL *Hippoglossina oblongus* by Perlmutter (1939); and illustrations of a 6.5–mm. specimen and a larger one by Agassiz, (1879, plate 9, figs. 4 and 5) do not show a left side pelvic fin. The pelvic fins of *H. oblongus* appear very much later than do the dorsal and anal fins (Agassiz, 1879).

At 5 mm. SL *Syacium*, *Cyclopsetta*, *Citharichthys*, and *Etropus* have a well-developed pelvic fin on the left side. The left side fin base appears at 2 to 3 mm. SL and is better developed than the right side base, which develops later.

I do not know at what size the pelvic fin bases first appear in *Engyophrys*, *Trichopsetta*, or *Monolene* (I have assigned larvae exceeding 8 mm. SL with well-developed pelvic fin bases to *Engyophrys* and *Monolene*). The origin of the left side fin base of adults is adjacent to the cleithrum or slightly anterior to it in *Engyophrys*, *Trichopsetta*, and *Monolene*, but the origin of the right side fin base is slightly posterior to the cleithrum.

The origins of the left and the right side pelvic fin base are posterior to the cleithrum in *Paralichthys*, *Ancylopsetta*, *Gastropsetta*, *Hippoglossina*, *Syacium*, *Cyclopsetta*, *Citharichthys*, and *Etropus*. In *Bothus* and *Chascanopsetta* the origin of the left side pelvic fin base is on the urohyal, which is well in advance of the cleithrum. The right side fin base of *Bothus* and *Chascanopsetta* is short, and its origin is well posterior to the cleithrum.

CAUDAL OSTEOLOGY

From late stage larvae to adults, the bothids show a correlation between caudal osteology and position of the pelvic fin bases (table 1). Species of *Paralichthys*, *Ancylopsetta*, *Gastropsetta*, and *Hippoglossina* have the dorsalmost principal caudal fin ray associated with an epural; the ventralmost principal caudal fin ray has a spur associated with it, and it is associated with the haemal spine of the penultimate vertebra. The count of principal caudal fin rays in this group, starting with the epural and ending with the haemal spine of the penultimate vertebra, is 1–2–6–4–3–1 or 1–2–6–5–2–1 in *Paralichthys*. In these genera neither of the plevic fin bases is on the median line and the origins of both pelvic fin bases are well behind the cleithrum.

Species of *Syacium*, *Cyclopsetta*, *Citharichthys*, and *Etropus* have all 17 principal caudal fin rays associated with the four hypural elements. The dorsal-to-ventral count of principal caudal fin rays on each hypural is 4–5–4–4. In these genera the left side pelvic fin base is on the median line, and its origin is well behind the cleithrum.

TABLE 1.—*Four generic groups which show a relation between the origins of the pelvic fin bases and number of principal caudal fin rays associated with caudal elements*

[Asterisks indicate the genera for which I have no identified larvae]

Genera	Pelvic fin (P^2)	Number of principal caudal fin rays associated with caudal elements
Paralichthys	Neither pelvic fin base on median line, both short-based; origins well behind cleithrum.	1–2–6–5–2–1
*Ancylopsetta**		
*Gastropsetta**		1–2–6–4–3–1
*Hippoglossina**		
Syacium	Ocular-side P^2 base on median line; origin posterior to cleithrum. Blind-side P^2 base above median line; origin posterior to cleithrum.	4–5–4–4
Cyclopsetta		
Citharichthys		
Etropus		
Engyophrys	Ocular-side P^2 base on median line; origin slightly anterior to or below cleithral tip. Blind-side P^2 base above median line; origin posterior to cleithrum.	1–3–5–4–3–1
*Trichopsetta**		
Monolene		
Bothus	Ocular-side P^2 base on median line, extending onto urohyal; origin anterior to cleithrum. Blind-side P^2 base above median line, short-based; origin posterior to cleithrum.	1–4–4–3–4–1
*Chascanopsetta**		

Species of *Engyophrys*, *Trichopsetta*, and *Monolene* have the dorsalmost and ventralmost principal caudal fin rays associated with the neural and haemal spines of the penultimate vertebra and have a count of 1–3–5–4–3–1. In these genera the left side pelvic fin base is on the median line and its origin is slightly anterior to the cleithral tip and to the origin of the right side base.

In *Bothus* and *Chascanopsetta* the count of principal caudal fin rays associated with the caudal elements is 1–4–4–3–4–1, starting at the neural spine and ending at the haemal spine of the penultimate vertebra. In *Bothus and Chascanopsetta* the left side pelvic fin base is on the median line and its origin is on the urohyal, on the right side the base is short, above the median line, and its origin is behind the cleithrum.

The number of principal caudal fin rays associated with caudal elements shows some variation, because a fin ray may be supported in part by two elements, such as hypurals, epurals, or neural or haemal spines.

DEVELOPMENT OF *CYCLOPSETTA FIMBRIATA* LARVAE

No information is available on the fertilized eggs or the yolk sac larvae of *C. fimbriata;* however, I do have certain observations on the larger larvae, including their identification, patterns of general growth, formation of fins, spination, pigmentation, migration of eyes, and sequence of ossification.

IDENTIFICATION OF LARVAE

Larvae of *C. fimbriata* are identifiable at very small sizes. The smallest larva in my sample (1.72 mm. SL) has a large head with a well-developed mouth. Hatching size is probably about 1.50 mm. SL or slightly smaller. Larvae of this species have two prominent transitory features (they may be generic) that are readily seen on the smallest larvae (fig. 3) : a small, single spine on the sphenotic region of the cranium and several small single spines on the preopercle (*Syacium* has larger sphenotic and preopercular spines). These spines persist throughout the larval stages (figs. 3–7) and are still evident during metamorphosis (that period when the eye is migrating). No fin rays are discernible in the finfold of the smallest larva (1.72 mm. SL). At about 2.10 mm. SL the first three elongate dorsal fin rays appear. Elongate dorsal fin rays (8–11 in the large larvae) persist throughout the larval stages (figs. 4–7). At about 3.00 to 3.30 mm. SL one to three elongate pelvic fin rays appear (fig. 4) and persist throughout the larval stages (figs. 4–7).

The right side eye is migrating in the largest larva in my sample (14.51 mm. SL). The dorsal edge of the migrating eye is above the middorsal ridge of the cranium. During metamorphosis the eye moves under the dorsal fin which is attached anteriorly to the ethmoid region of the cranium. The migrating eye had not yet begun to turn onto the left side, but it appeared about ready to move under the dorsal fin. Elongate dorsal and pelvic fin rays and head and preopercular spination persist (fig. 7).

Four transitory larval features help differentiate *C. fimbriata* and *Syacium* larvae from all other bothid larvae found along the southeastern coast of the United States: (1) a single spine in sphenotic region of the cranium, (2) several single preopercular spines, (3) relatively high numbers of elongate anterior dorsal fin rays, and (4) three elongate pelvic fin rays (figs. 3–7). Compared to *Cyclopsetta*, *Syacium* has larger and heavier spines, fewer elongate dorsal fin rays, and relatively shorter elongate pelvic fin rays. The sphenotic spine is surrounded by concentric rings on large *Cyclopsetta* larvae but by a crenulated cap on *Syacium* larvae. The origins of the pelvic fin bases in relation to each other and to the cleithrum and the transitory larval characters provide the generic identity of *Cyclopsetta* larvae.

Three species of *Cyclopsetta* occur in the western North Atlantic Ocean (Gutherz, 1967). *C. fimbriata* is the only species known from the Atlantic coast of the United States, *C. decusata* is known only from the type, and *C. chittendeni* is found along the coast of the United States only in the Gulf of Mexico. The distribution of these species excludes all known species of *Cyclopsetta* except *fimbriata* from consideration for my larvae.

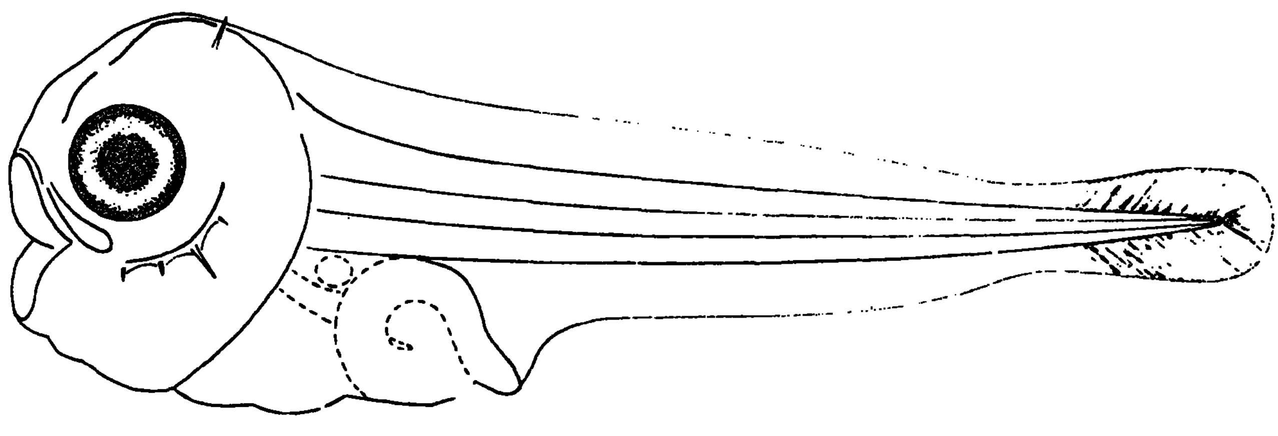

FIGURE 3.—Larva of *Cyclopsetta fimbriata*, 1.89 mm. SL. Note sphenotic and preopercular spination. Pectoral fin is omitted to show swim bladder and gut.

GENERAL GROWTH PATTERNS

Head length and body depth show a uniform rate of increase with standard length throughout the size range of my sample (figs. 8–9).

Upper jaw length shows a uniform rate of increase with standard length in larvae longer than about 4 mm. SL, but smaller larvae have a faster rate of increase (fig. 10).

Lower jaw length increases at a uniform rate with standard length in larvae between about 4 and 13 mm. SL; but larvae smaller than about 4 mm. SL and longer than 13 mm. SL have a faster rate of increase (fig. 11).

Snout length increases only slightly in specimens up to about 2.7 mm. SL; between about 2.7 and 4 mm. SL snout length increases at its fastest rate; and larvae larger than about 4 mm. SL have a uniform but slower rate of increase with standard length (fig. 12).

Eye diameter increases at a uniform rate with standard length in larvae longer than about 3.5 mm. SL; the rate is faster in smaller larvae (fig. 13). Eye diameter as a percentage of head length decreases throughout the size range in my sample (fig. 14); the fastest decrease is between head lengths of about 0.5 and 1.5 mm. (1.8 to about 4 mm. SL).

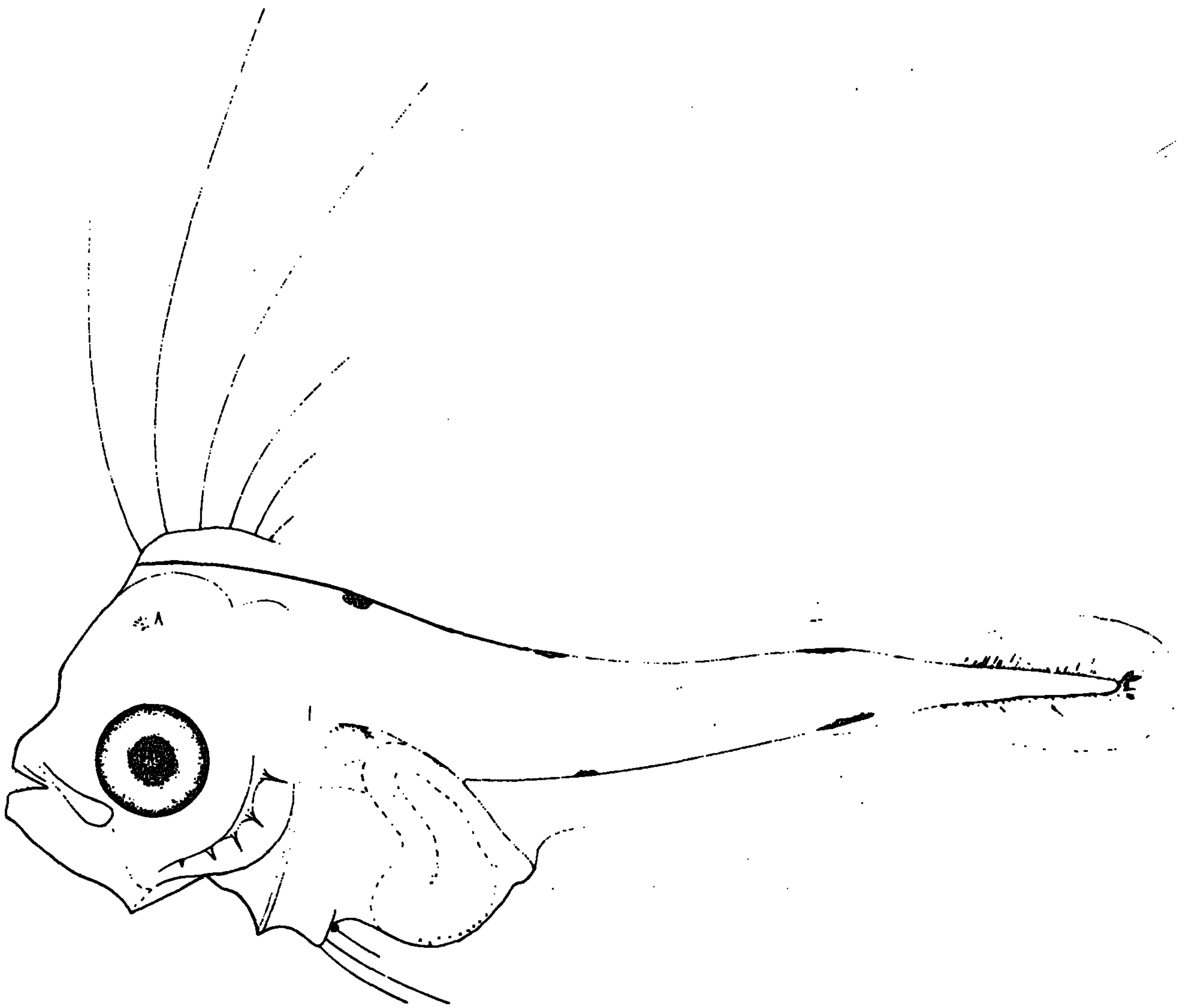

FIGURE 4.—Larva of *Cyclopsetta fimbriata*, about 3.0 mm. SL. Note sphenotic and preopercular spination, elongate dorsal and pelvic fin rays, and pigmentation. Pectoral fin is omitted to show swim bladder, gut, and pigmentation on dorsal portion of swim bladder and gut.

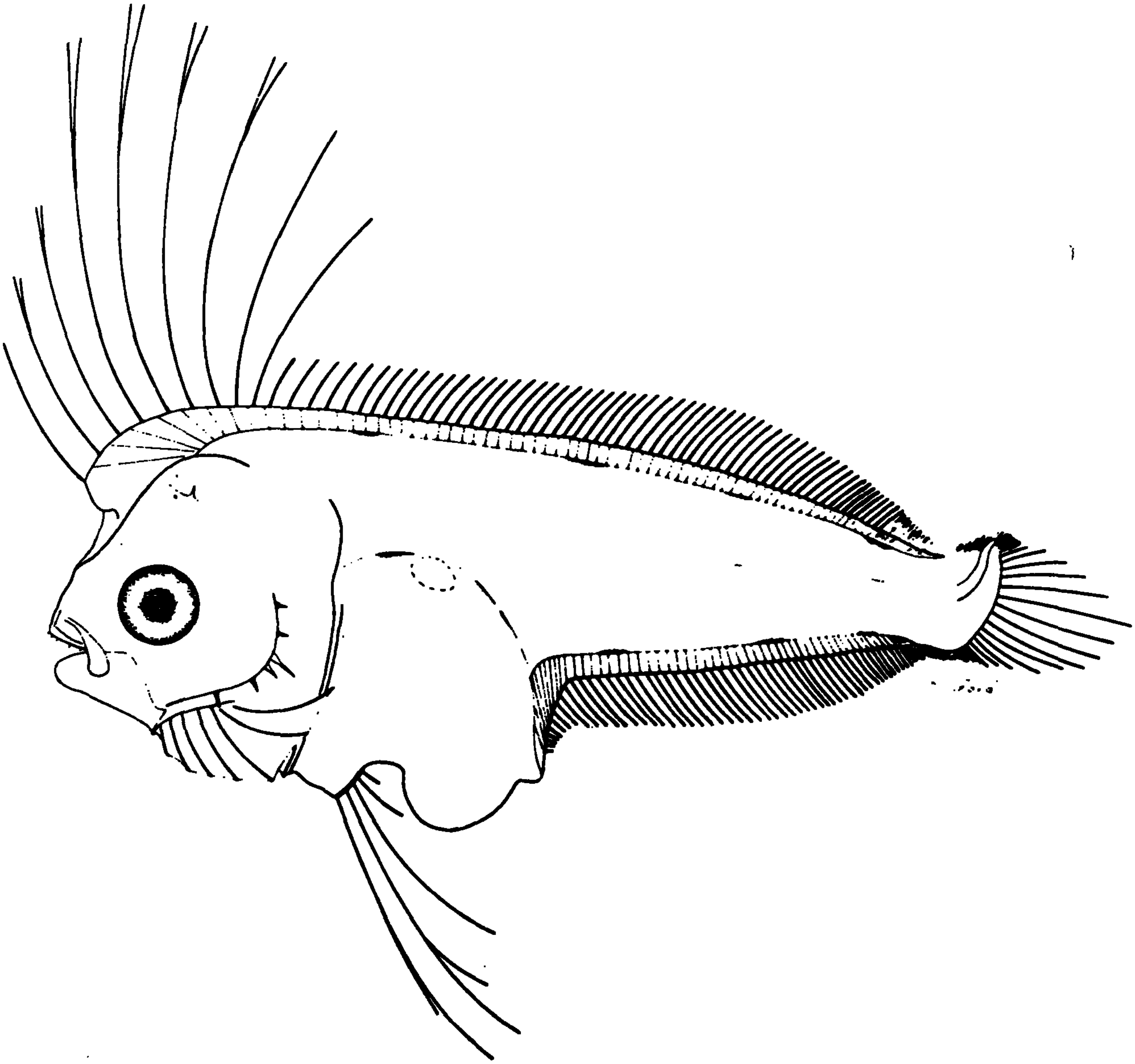

FIGURE 5.—Larva of *Cyclopsetta fimbriata*, 6.9 mm. SL. Note sphenotic and preopercular spination, elongate dorsal and pelvic fin rays, and pigmentation. Pectoral fin is omitted.

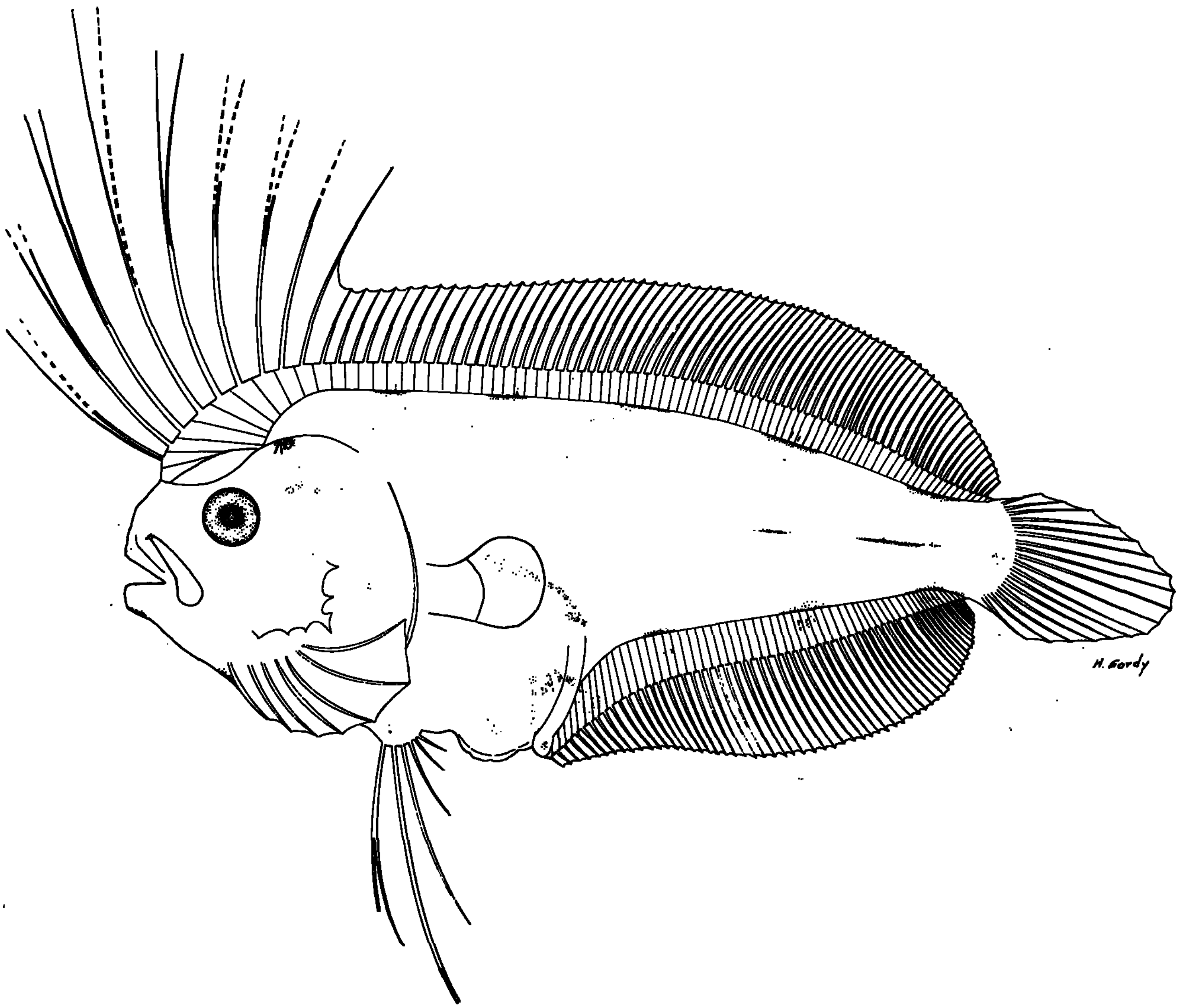

Figure 6.—Larva of *Cyclopsetta fimbriata*, 12.9 mm. SL. Note sphenotic and preopercular spination, elongate dorsal and pelvic fin rays, pigmentation, and area under anterior portion of the dorsal fin through which the right side eye will migrate.

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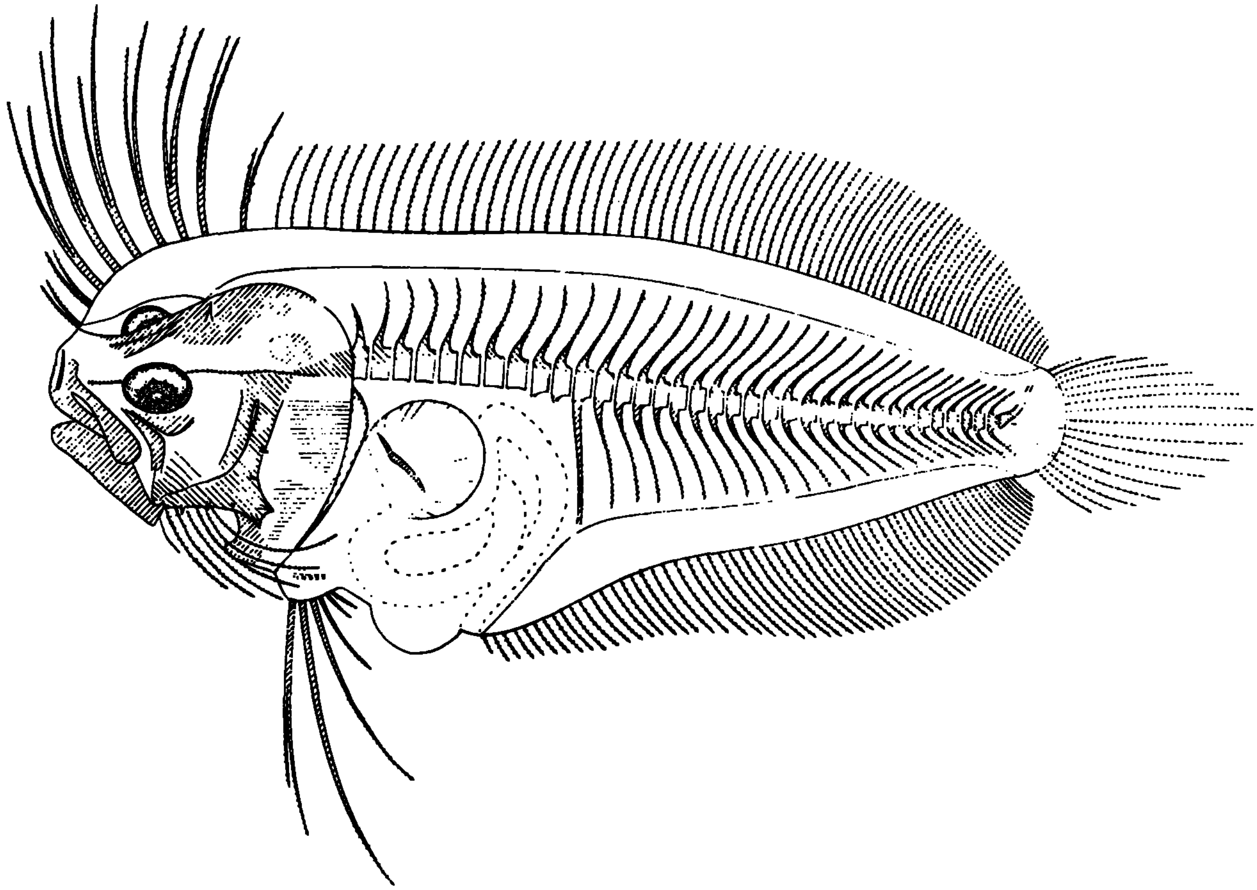

FIGURE 7.—Larva of *Cyclopsetta fimbriata*, 14.0 mm. SL. Larva has been cleared and stained, and all bone that has absorbed alizarin red S is shaded. Note sphenotic and preopercular spination, elongate dorsal and pelvic fin rays, right side eye under anterior part of dorsal fin will migrate through head. Ossification is not yet complete.

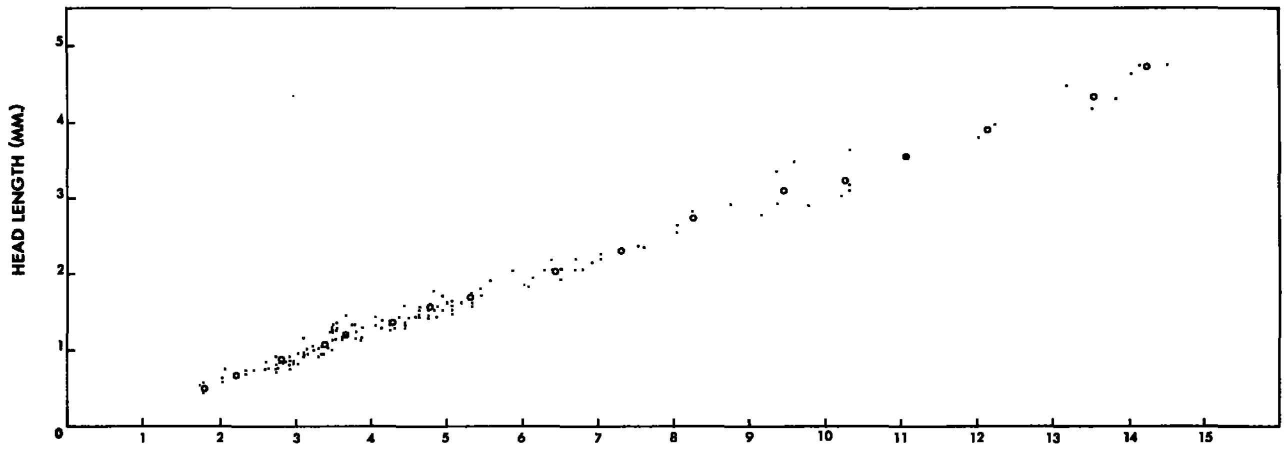

FIGURE 8.—Relation of head length to standard length of *Cyclopsetta fimbriata* larvae. Dots represent individual specimens, and open circles represent means (see app. tables 1 and 2).

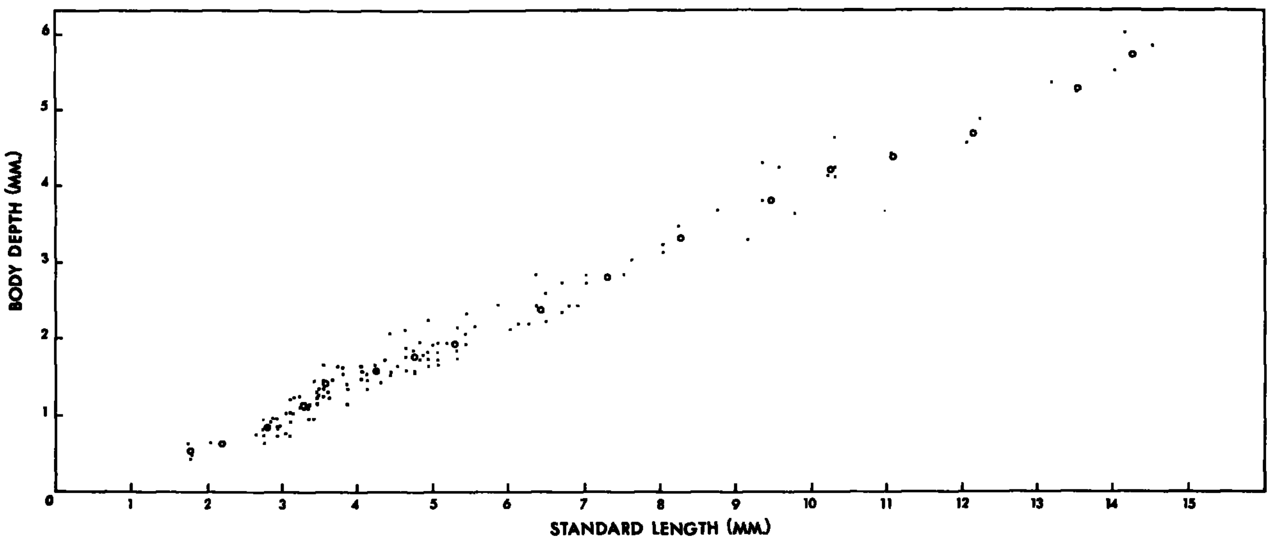

FIGURE 9.—Relation of body depth to standard length of *Cyclopsetta fimbriata* larvae. Dots represent individual specimens, and open circles represent means (see app. tables 1 and 2).

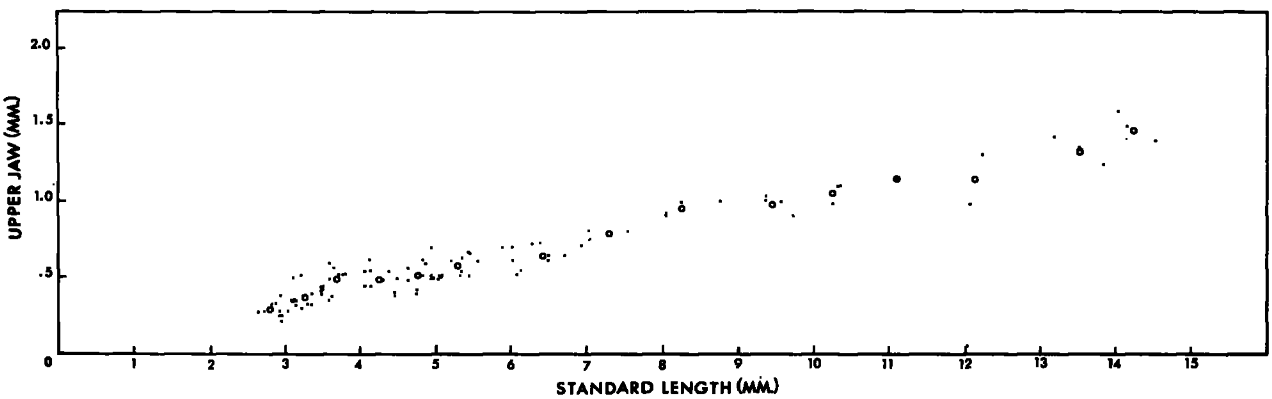

FIGURE 10.—Relation of upper jaw length to standard length of *Cyclopsetta fimbriata* larvae. Dots represent individual specimens, and open circles represent means (see app. tables 1 and 2).

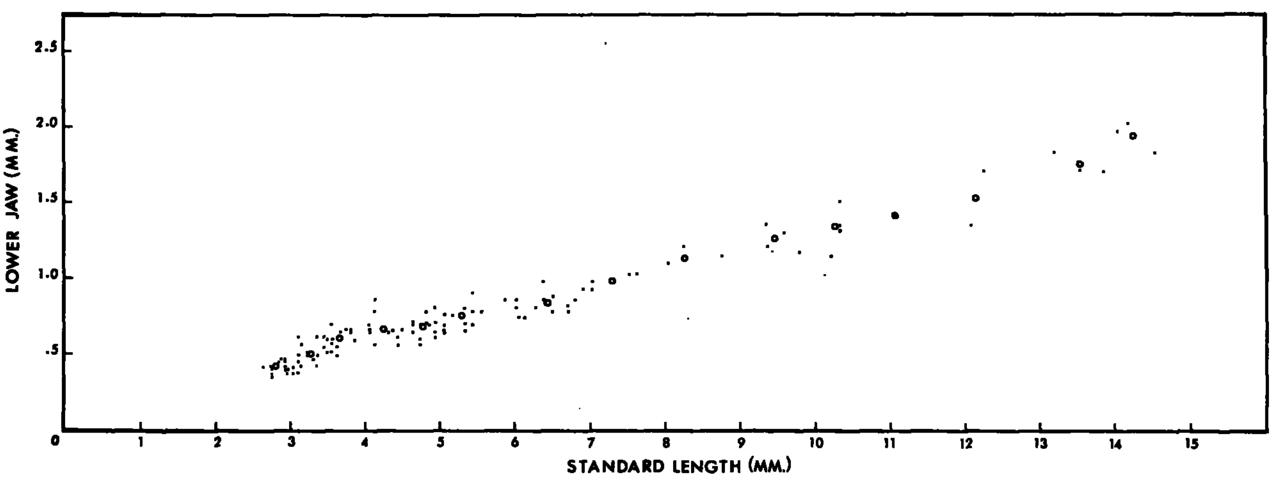

FIGURE 11.—Relation of lower jaw length to standard length of *Cyclopsetta fimbriata* larvae. Dots represent individual specimens, and open circles represent means (see app. tables 1 and 2).

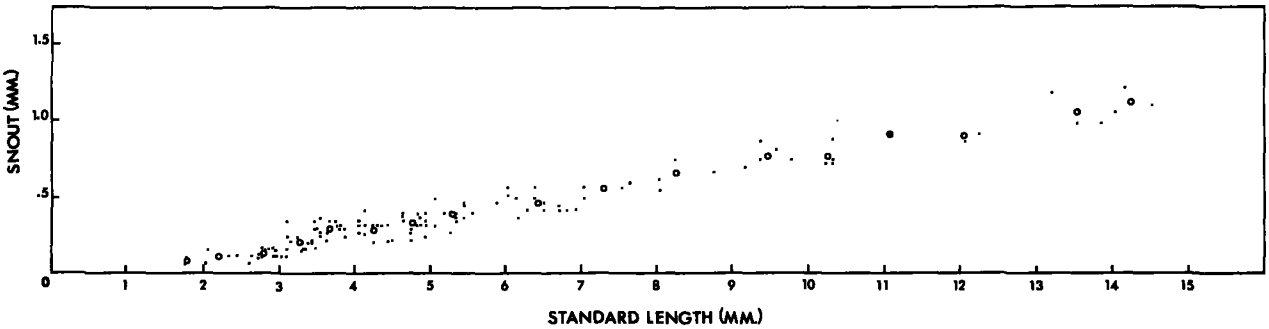

Figure 12.—Relation of snout length to standard length of *Cyclopsetta fimbriata* larvae. Dots represent individual specimens, and open circles represent means (see app. tables 1 and 2).

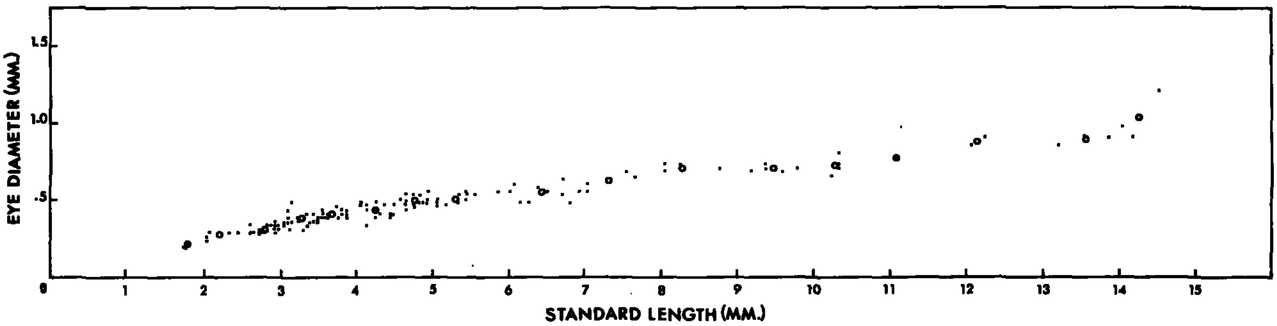

Figure 13.—Relation of eye diameter to standard length of *Cyclopsetta fimbriata* larvae. Dots represent individual specimens, and open circles represent means (see app. tables 1 and 2).

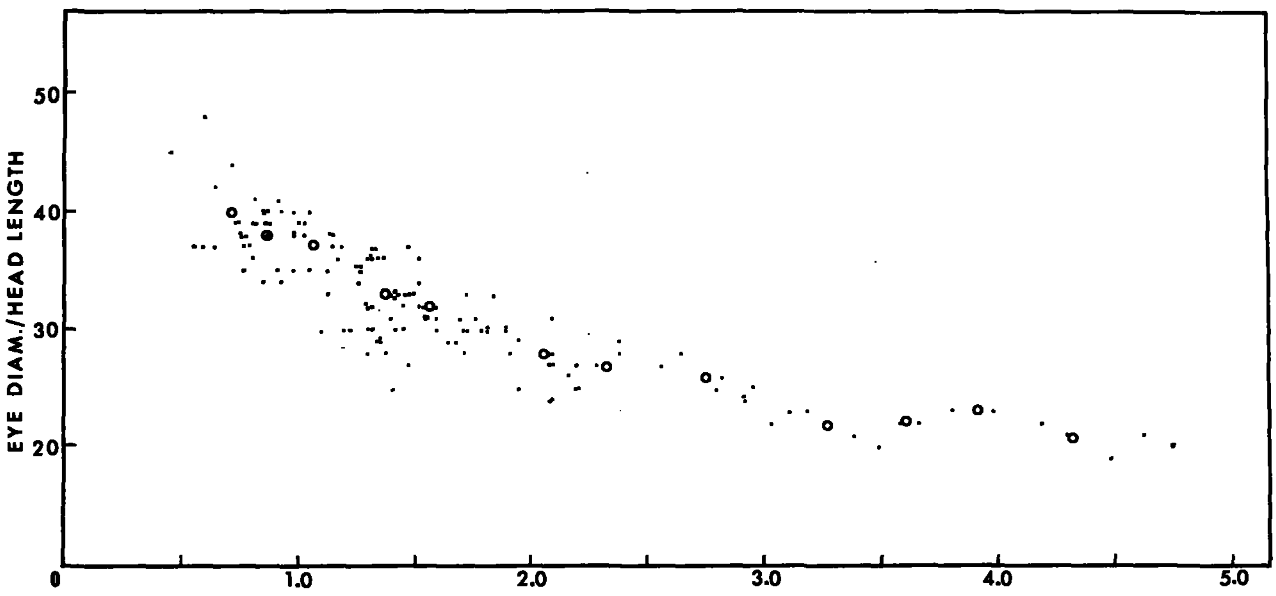

Figure 14.—Decrease in eye diameter relative to head length of *Cyclopsetta fimbriata* larvae. Dots represent eye diameter as percentage of head length of individual specimens, and open circles represent means (see app. tables 1 and 2).

Gill rakers begin to develop as elevations on the dorsal surface of the ceratobranchial. They are first seen when the larvae are about 8 mm. SL. Four or five lower-limb gill rakers are first seen on larvae about 9 mm. SL. They are short, blunt, well separated, and located on the ceratobranchial. By 10.0 mm. SL the number of lower-limb gill rakers has increased to seven and they are found on the ceratobranchials and hypobranchials. The adult complement of 8 to 10 gill rakers on the lower limb is reached at about 13.5 mm. SL. Gill rakers are first seen on the epibranchial in 13.5 mm. SL larvae, which have a single gill raker located immediately above the angle.

FIN FORMATION

In the development of *C. fimbriata* the pectoral fin is the first to appear and the last to complete its development. The caudal fin completes development first, followed in order by the dorsal, anal, and pelvic fins. By about 8 mm. SL the adult complement of fin rays is present in the caudal, dorsal, and anal fins (fig. 2).

Pectoral Fin

The pectoral fin is present on my smallest larva (1.72 mm. SL) and is not fully developed on my largest specimen (14.5 mm. SL). Initially it is large and rayless.

Caudal Fin

The fully formed caudal fin has 17 principal fin rays associated with the four hypural elements. The dorsal and ventralmost caudal fin rays are simple; the remaining rays are branched. Principal caudal fin rays are separable into two groups. The nine upper rays are associated with the two superior hypurals and the eight lower rays with the two inferior hypurals (4–5–4–4). No caudal fin rays are associated with neural and haemal spines of the penultimate vertebra. A ventral thickening near the posterior end of the notochord is seen on specimens about 3.5 mm. SL. This thickened tissue develops into the two median hypural plates and their associated caudal fin rays. The first four caudal fin rays to develop are seen first on a 5.44 mm. SL specimen and appear simultaneously (fig. 2). They develop at an oblique angle to the notochord and are divided into two groups, upper and lower. This division separates the caudal fin into superior and inferior components. By about 8 mm. SL the notochord has turned dorsally, the hypurals and caudal fin rays are arranged parallel to the axis of the body, and all principal caudal fin rays are developed (fig. 2), but the caudal osteology is not fully developed until a larger size.

Dorsal Fin

Dorsal fin ray development is an important taxonomic character in larval flatfish. These fin rays begin to develop in a thickened area above the nape on specimens of about 2 mm. SL. My smallest specimen with dorsal fin rays (three elongate rays) is 2.08 mm. SL (see app. table 1). The origin of the dorsal fin base moves anteriorly on the larvae until the fin base is over the eye; at this time dorsal fin rays begin developing posterior to the nape. All elongate dorsal fin rays develop first. The origin of the dorsal fin continues to shift anteriorly until it becomes attached to the ethmoid region of the cranium ahead of the eye. The first three fin rays must develop simultaneously; all but three of the specimens between 2 and 3 mm. SL have three or four fin rays (one with two, and two with five). The number of fin rays on all but four specimens between 3 and 5 mm. SL does not exceed 10 (one with 11 and three with 14), and most of the rays are elongate. The number of fin rays increases rapidly between 5 and 8 mm. SL; at 8 mm. SL the adult complement of 78 to 87 fin rays is present (fig. 2). Three of my 19 larval specimens exceeding 8 mm. SL had 77 fin rays, and one had 76.

Anal Fin

Fifteen anal fin rays were present on a 5.9 mm. SL specimen; none were discernible on smaller specimens (fig. 2; app. table 1). The number of fin rays increased rapidly, as in the dorsal fin, and the adult complement of 59 to 67 fin rays was developed by about 8 mm. SL (fig. 2). Four of 19 specimens exceeding 8 mm. SL had fin ray counts of 58, three had fewer than 58, and the others had counts between 59 and 67 (see app. table 1).

Pelvic Fins

Pelvic fin bases develop early. The left-side fin base and its three elongate anterior fin rays develop earlier than the right-side fin base. The left-side fin base is first noted on specimens of about

2.5 mm. SL as a thickening on the ventral edge of the body immediately anterior to the gut, but the right-side base does not appear until about 3.5 mm. SL. My smallest specimen with pelvic fin rays (left side, and elongate rays) was 3.0 mm. SL. The first right-side fin ray is seen on a 5.3 mm. SL specimen. The three elongate pelvic fin rays on the left side develop simultaneously. They are present on all specimens but two (one with a single fin ray and one with two fin rays). The fourth left fin ray develops at about 5 mm. SL, and the fifth and sixth rays by about 10 mm. SL. Each fully developed pelvic fin has six fin rays. The three elongate fin rays of the left side are thickened and heavier than the other pelvic fin rays and extend posteriorly to about the caudal peduncle; they are often broken. None of the other pelvic fin rays is elongate. The origins of the pelvic fin base are equidistant behind the cleithrum.

LARVAL SPINATION

A single sphenotic spine and a series of preopercular spines (figs. 3–7) persist throughout the size series of my larval specimens (1.72–14.51 mm. SL). These spines are smaller but similar in position and shape to those reported for *Syacium* by Kyle (1913) and Aboussouan (1968). The sphenotic spine becomes relatively smaller as the larvae grow. The spine is surrounded by concentric rings that are first noted on specimens of about 4.6 mm. SL. Four to six small sharp spines are present on the preopercular margin; two or three of these are on the ventral edge, a larger single spine is at the angle, and two more small spines are on the posterior edge. The large spine at the angle of the preopercle thickens, and a spur develops on the upper posterior edge of the spine on larger larvae. These spines do not alter position or shape but become relatively smaller with increasing size of the larvae. The sphenotic and preopercular spines can be traced through the developmental series and are important in identifying this group of larvae (figs. 3–7).

PIGMENTATION

Pigment on all of the *Theodore N. Gill* material is faded, but pigment patterns are readily seen on the fresh *Oregon* material. In my sample, pigment is first seen on a 2.8 mm. SL specimen—a large melanophore over the base of each sphenotic spine, and another melanophore on the gular region between the posterior end of the lower jaws and the tip of the cleithrum. The dorsal portion of the swim bladder and the dorsal loop of the gut are heavily pigmented. On a 3.2 mm. SL specimen the melanophores at the bases of the sphenotic spines have faded, but those on the gular region and along the dorsal aspect of the gut remain. Three clusters of melanophores are present on the dorsal edge, and two are on the ventral edge of the body. The anteriormost is on the dorsal edge of the body over the pectoral fin base (there is no corresponding ventral cluster of melanophores). The other two dorsal clusters of melanophores have corresponding ventral clusters. The middle spots are immediately behind the gut region, at about the midpoint of the body (TL), and the posterior spots are slightly anterior to the caudal peduncle (fig. 4). A series of small melanophores can be seen on the ventral edge of the gut between the vent and the anterior portion of the gut cavity. Pigmentation is essentially the same on specimens up to about 4 mm. SL, but the number of melanophores increases. Specimens between 4 and 5 mm. SL have a large melanophore on each opercle behind the eye and another on the median line at the origin of the pelvic fin base. The dorsal portion of the gut has two areas of dark pigment; the anteriormost is on the upper half of the swim bladder and the other is above the loop of the intestine.

At about 5 mm. SL the melanophore on the gular region has disappeared, but additional clusters of melanophores have appeared, one dorsal and one ventral, between the middle and posteriormost cluster but nearer the posteriormost cluster. The two new clusters are of equal size and are smaller than those nearest to them. The remaining pigment is similar to that seen on the smaller larvae. Shortly after appearance of the third ventral pigment cluster the posteriormost ventral cluster increases in length and becomes longer than its corresponding dorsal area.

By 7 mm. SL a fifth dorsal cluster has appeared between the first two clusters. Two pigment clusters have developed along the lateral septum, corresponding in position with the two posterior dorsal and ventral clusters. Pigment is present over the entire swim bladder on the left side and absent on the right side. Pigmentation remains essentially the same through the rest of the larval series in my sample, except for darkening and the appearance of pigment at the distal edge of the caudal peduncle, in the branchial chambers, and around the urohyal (figs. 5 and 6).

MIGRATION OF THE EYE

Specimens of 7 mm. SL are symmetrical; the right eye has not begun to migrate (fig. 5). The dorsal fin continues its development anteriorly, and its origin is over the anterior edge of the eye. The supraorbital bars on the cranium have not begun to become modified.

By about 8 mm. SL the right eye has moved only slightly; the origin of the dorsal is above and posterior to the ethmoid region of the cranium and the origin of the fin base remains unattached. Tissue between the ventral edge of the anterior portion of the dorsal fin and the frontal region of the cranium is becoming thin, and the supraorbital bars have begun to shift onto the ocular sides as an accompanying depression begins to form above the left eye.

By 10.5 mm. SL the right eye has migrated dorsoanteriorly but its upper edge is not yet level with the supraorbital bars; the origin of the dorsal is attached to the ethmoid region of the cranium and its point of attachment has shifted onto the right side of the head, over the nostrils. The right side is the blind side in the adult. The area of thin tissue between the dorsal fin and the supraorbital bars is wider. The supraorbital bars continue their shift to the left side, and the depression of the cranium above the left eye is larger.

On a 14 mm. SL specimen the upper edge of the right side eye is visible through the thin tissue below the dorsal fin (fig. 7). The shifting of the supraorbital bars has created a large depression over the left eye. The origin of the dorsal fin remains attached. The right eye has not yet begun to move through the head onto the left side. In larger specimens the eye will move through the head in the area between the dorsal fin and the depression created by the shift of the supraorbital bars.

SEQUENCE OF OSSIFICATION

I cleared and stained several specimens to determine the sequence of ossification. The degree of ossification can be assessed by the intensity of the stain (alizarin red S) absorbed by the bone. In this discussion I consider any bone that absorbed stain to be ossified.

On a 1.7 mm. SL specimen only the cleithrum, the distal edges of the preopercle and preopercular spines, and the sphenotic spine and its base showed any ossification.

By 3 mm. SL some ossification is seen in the cranial cap, lower jaw, premaxillary, and the four elongate dorsal fin rays. By 3.5 mm. SL the three elongate pelvic fin rays, the maxillary, four branchiostegal rays, and six elongate dorsal fin rays are ossified. The palatine and parasphenoid are stained and extend from the symphysis of the upper jaw to the cleithrum; these bones will form part of the floor of the neurocranium. At this size all stained areas are in the head and pelvic fin region. Six canine teeth are present in the lower and four in the upper jaw, but none are stained. A slight thickening on the ventral edge of the posterior part of the notochord is the rudimentary hypural, and it is only slightly ossified, if at all.

Ossification is still restricted to the head and pelvic fin base region at 4.1 mm. SL. All seven branchiostegal rays, the urohyal, and the preopercle and opercle in the opercular series are now ossified. The vertebrae and neural and haemal spines have not begun to ossify. Ossification at 4.9 mm. SL is essentially similar to that of the 4.1 mm. SL specimen; again the anterior neural and haemal spines are visible but are not stained. They are not attached to the vertebrae and appear as thin lines between the vertebrae and the dorsal and anal fin rays.

At 5.5 mm. SL the right pelvic fin base, three or four caudal fin rays (but not the hypural elements), the dorsal aspect of the subopercle, and some vertebrae and associated neural and haemal spines have begun to ossify. The 16 anterior neural spines and the anterior seven haemal spines, and the dorsal rim and sides of the neural arch on the second, third, and fourth vertebrae are lightly stained. The first vertebra and its neural spine are not stained. The occipital region of the neurocranium and the scapula have begun to ossify.

The areas of ossification, as determined by absorption of alizarin red S stain, are larger and the color is more intense at 6.4 mm. SL than on smaller specimens. At this size the notochord is upturned and two hypural elements are differentiated. Ten caudal fin rays are stained, and five are associated with each hypural element. The notochord has neural and haemal spines on nearly its full length. Most neural arches, but only the anterior haemal arches, are stained. Pterygiophores of the anterior elongate dorsal fin rays are developing. About 40 dorsal and 24 anal fin rays are stained. The interopercle has begun to ossify, and all four opercular elements show some ossification. The supraorbital bars are stained and are visible as anterior extensions of the neurocranium. The auditory region of the neurocranium is partially stained, and the post cleithrum is ossifying.

By 10 mm. SL ossification has progressed considerably, and many bones in the head, vertebrae, and caudal fin can be recognized. At about 10 mm. SL ossification is noted in the hypural elements, the basal part of the urostyle, and the parapophysis of the last abdominal (precaudal) vertebra. The dorsal aspects of the posterior 14 and the anteriormost 3 or 4 vertebrae are lightly stained; the remaining vertebrae are not stained. All neural and haemal spines and arches are ossified except for those on the penultimate vertebra. There are 16 caudal fin rays: Four are associated with each of the two inferior hypurals, the superior hypurals are indistinguishable. Four to six pelvic fin rays have developed on each fin base, and the pelvic bone is beginning to ossify. The supraorbital bars extend forward; their anterior edge is above the nostril. The entopterygoid, which is immediately above the pterygoid, is lightly stained. Bones of the lower jaw suspension can be identified; the quadrate, hyomandibular, and pterygoid are lightly stained. The supracleithrum and post-temporal region of the cranium can be distinguished. The upper jaw now has about 10 teeth and the lower 16; those near the symphysis are relatively small and close together. A "cartilaginous" bar extends posteriorly along the ventral median edge of the gut from the distal edge of the pelvic fin base to below the liver. The anterior ventral edge of the urohyal is hooked and pointed forward.

Ossification has changed little at about 14 mm. SL except on the vertebrae (fig. 7). The first abdominal (precaudal) vertebra is completely ossified, and the dorsal aspect and one-third to one-fourth of the lateral surfaces of the other abdominal vertebrae are ossified. The parapophyses of the last four abdominal vertebrae are also ossified, but no ribs are seen. Ossification of the parapophyses begins with the last abdominal vertebra and proceeds anteriorly to the fifth vertebra, the last one with a parapophyses. The first through the 18th caudal vertebrae show the same degree of ossification; posteriorly they become progressively more ossified until ossification is complete on the last four vertebrae. Interneurals and interhaemals are developing between the fifth and 10th neural and haemal spines. The enlarged pterygiophore, which is associated with the first 10 to 12 anal fin rays, is now lightly stained.

My largest larva (14.5 mm. SL) is stained and shows essentially the same degree of ossification as the 14 mm. SL specimen. The vertebral column, pterygiophores of the dorsal and anal fins, and all bones of the neurocranium and branchiocranium are not completely ossified. The supraorbital bars extend forward onto the ethmoid region and form the frontals. The right side supraorbital bar appears to be partially reabsorbed as suggested by its upturned anterior medial edge in the sphenotic region and its position and thinness. The left supraorbital bar has moved closer to the left eye. After movement of the supraorbital bar is complete the left side bar and part of the right side bar form the interorbital bar, and the remaining part of the right supraorbital bar is reabsorbed. At a larger size the right eye will move under the dorsal fin and stop at the interorbital bar. The sphenotic and preopercular spines are still present at 14.5 mm. SL but will eventually be reabsorbed or broken off and leave the surface smooth.

SPAWNING AND DISTRIBUTION

Larvae were collected between Jupiter Inlet, Fla., and Cape Hatteras, N.C. (fig. 1) in surface waters over depths of 11 to 2,510 m. (6–1,372 fath.); 21 stations were in depths greater than 183 m. (100 fath.) and 54 stations in depths less than 183 m.

Specimens were collected primarily north of lat. 30° N. (70 collecting sites were north and only 5 were south of lat. 30° N.). Sixty-nine larvae were taken at 35 stations occupied at night, and 102 were taken at 38 stations occupied during the day. No larvae were collected between November and April; one larva was taken in April and one in November; and the rest in May to October (fig. 15).

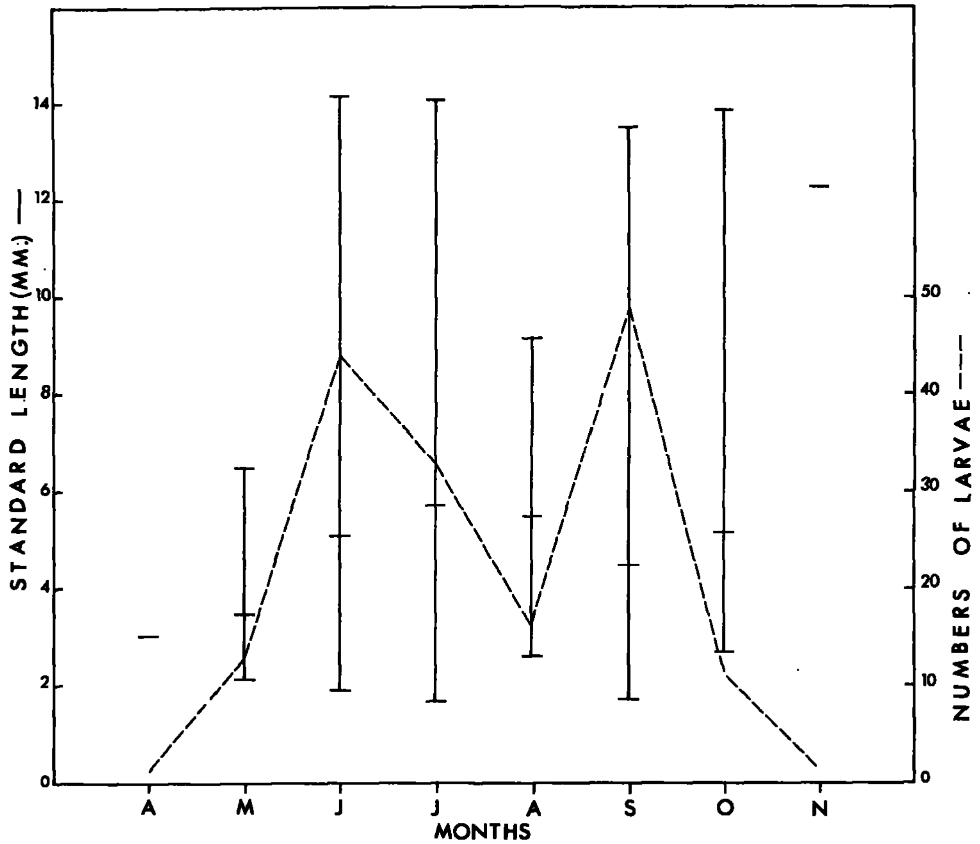

FIGURE 15.—Size range and mean size of larvae collected from April to November. Frequency of larvae per month also shown.

The *Theodore N. Gill* data by themselves show a single spawning peak in September, but the combined *Theodore N. Gill* and *Oregon* data suggest a bimodal spawning period with peaks in June and September. The first larvae appear in April, and numbers increase sharply until June; after September the numbers decrease sharply to November. Larvae 2.6 mm. SL and smaller were collected each month from May through October. I estimate that hatching size is about 1.5 mm. SL; therefore, spawning must occur throughout this period. The mean size of the larvae increases through July and then decreases in September. This size decrease is correlated with a spawning peak (fig. 15). My samples contain no larvae exceeding 9 mm. SL until the last week in June, but larvae of this size are present in succeeding months through November (fig. 15). These size data support the supposition that spawning begins in the spring.

I have not seen spawning fish, but I have examined gonads from *C. fimbriata* taken throughout the year off Cape Kennedy, Fla. None of the gonads were ripe, but the ovaries enlarged progressively from spring to fall. In the winter the ovaries are very thin and flat. My examination of gonad development indicates a spawning period from early spring to late fall—again supporting conclusions based on the samples of larvae.

I tried to determine where *C. fimbriata* spawns by analyzing the collection data for 28 smaller larvae (1.7 mm.–3.0 mm. SL). These specimens were collected at 17 stations on *Theodore N. Gill* and *Oregon* cruises. Ten of the 17 stations were occupied during daylight; of these six were in 46 m. (25 fath.) or less. Three of the seven nighttime stations were in depths of 46 m. (25 fath.) or less. Small larvae were collected from May through October from Florida to North Carolina. Because hatching size is estimated to be about 1.5 mm. SL, specimens less than about 2.0 mm. SL must have been collected close to the spawning area, but this view may be erroneous because the time required for hatching of the eggs is unknown. Six specimens (1.72–2.01 mm. SL) were collected from five stations, at the surface in 22 to 450 m. (12–246 fath.) during both day and night. These small larvae were caught from July to September from Georgia to North Carolina. It appears that *C. fimbriata* spawns from April to October throughout the entire collection area on the Continental Shelf and that most spawning is in waters of 46 m. (25 fath.) or less. Delineation of the spawning area of *C. fimbriata* must await the collection or observation of spawning fish.

ACKNOWLEDGMENT

Elbert H. Ahlstrom of the BCF Fishery-Oceanography Center, La Jolla, Calif., reviewed the manuscript and made many helpful suggestions. Assistance by various staff members of the laboratory included review of the manuscript, preparation of figures 3 through 7, and preparation of stained material.

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APPENDIX

TABLE 1.—*Selected measurements and counts of larval* Cyclopsetta fimbriata

Measurements														Counts	
Standard length	Head length (HL)		Body depth (BD)		Eye diameter (ED)		Upper jaw length (UJL)		Lower jaw length (LJL)		Snout length (SN)		Pelvic fin origin to tip of cleithrum [1] *blind-side* ocular-side	Dorsal fin rays	Anal fin rays
Mm.	*Mm.*	*HL/SL*	*Mm.*	*BD/SL*	*Mm.*	*ED/HL*	*Mm.*	*UJL/HL*	*Mm.*	*LJL/HL*	*Mm.*	*SN/HL*	*Percent*	*Number*	*Number*
1.72	0.54	32			0.20	37									
1.76			0.42	24	.20	45					0.07	16			
1.79	.59	33	.49	27	.22	37					.10	17			
1.89															
2.01	.64	32	.64	32	.24	37					.07	11			
2.01	.59	29			.27	48									
2.08	.76	37			.29	38					.15	20		3	
2.33	.69	30			.29	42					.12	17		4	
2.33	.74	32			.29	39					.12	16		4	
2.45	.74	30			.29	39					.12	16		4	
2.60	.86	33			.34	40								4	
2.60	.76	29			.29	38					.07	9		3	
2.64	.78	30	.76	29	.29	37	0.27	35	0.42	54	.12	15		3	
2.72	.81	30	.81	30	.29	36	.27	33	.39	48	.12	15		3	
2.72	.78	29	.81	30	.27	35			.34	44	.10	13		3	
2.72	.73	27	.73	27	.32	44			.37	51				4	
2.72	.93	34	.96	35					.42	45				3	
2.75	.76	28	.64	23	.29	38					.10	13		2	
2.79	.86	31	.86	31	.29	34					.17	20		4	
2.83	.86	30	.91	32	.34	40	.32	37	.44	51	.15	17		3	
2.87	.88	31	.98	34	.34	39	.32	36	.47	53	.15	17	83	5	
2.91														4	
2.91	.83	29	.86	30	.32	39	.27	33	.39	47	.17	21		3	
2.91	.78	27	.71	24	.29	37	.24	31	.42	54	.12	15		3	
2.91	.93	32	.98	34	.37	40			.47	51	.17	18	120	5	
2.91	.88	30	.83	29	.34	39	.37	42	.44	50	.12	14	85	3	
2.95	.86	29	.86	29	.34	40			.37	43	.15	17	83	4	
2.95	.83	28			.32	39	.24	29	.39	47	.12	14		3	
3.03	.83	27	.78	26	.34	41	.27	33	.37	45	.12	14		3	
3.03	.98	32	1.03	34	.37	38			.42	43	.12	12		4	
3.10														4	
3.10					.44	37	.49	42	.61	52	.34	29		6	
3.10	.93	30			.32	34	.34	37	.44	47	.24	26	100	4	
3.10	.91	29	.91	29	.37	41			.37	41	.12	13	100	4	
3.10	.98	32	1.03	33	.39	40	.34	35	.49	50	.17	17	100		
3.14	1.03	34	1.23	39	.49	48	.34	33	.56	54	.22	21		7	
3.14	.98	31	1.03	33	.37	38	.32	33	.42	43	.22	22		5	
3.22	1.00	31	1.25	39	.39	39			.51	51	.24	24		5	
3.22	1.05	33	1.10	34	.37	35	.29	28	.49	47				5	
3.30	.91	28			.32	35	.32	35	.47	52	.20	22		4	
3.30	1.03	31	1.10	33	.39	38					.15	15	100	5	

See footnote at end of table.

TABLE 1.—*Selected measurements and counts of larval* Cyclopsetta fimbriata—Continued

Standard length	Head length (HL)		Body depth (BD)		Eye diameter (ED)		Upper jaw length (UJL)		Lower jaw length (LJL)		Snout length (SN)		Pelvic fin origin to tip of cleithrum[1] *blind-side* / ocular-side	Dorsal fin rays	Anal fin rays
	Measurements													Counts	
Mm.	*Mm.*	*HL/SL*	*Mm.*	*BD/SL*	*Mm.*	*ED/HL*	*Mm.*	*UJL/HL*	*Mm.*	*LJL/HL*	*Mm.*	*SN/HL*	*Percent*	*Number*	*Number*
3.34	1.05	31	1.10	33	0.42	40	0.39	37	0.61	58	0.17	16	100	5	
3.35	.98	29	.98	29	.34	35	.32	33	.42	43	.17	17		4	
3.38	.98	29	1.13	33	.37	38			.49	50	.20	20	71	6	
3.41	1.03	30	.98	29	.37	36					.20	19	88	5	
3.42	1.25	37	1.45	42	.42	34			.61	49	.22	18		6	
3.48	1.22	35	1.30	37	.37	30	.42	34	.54	44	.34	28	100	6	
3.48	1.27	37	1.22	35									71	6	
3.48	1.30	37	1.30	37	.37	28	.44	34	.54	42	.29	22	75	8	
3.48	1.00	29	1.15	33									88	4	
3.49	1.36	39	1.35	39	.39	29	.39	29	.51	37	.29	21	125	7	
3.49	1.13	32	1.27	36	.37	33	.42	37	.54	48			83	6	
3.54	1.37	39	1.67	47	.39	28	.59	43	.69	50	.37	27	83	7	
3.54	1.30	37	1.35	38	.39	30	.49	38	.56	43	.27	21		7	
3.54	1.15	33	1.25	35	.42	37	.34	30	.51	44	.24	21	80	9	
3.54	1.27	36	1.47	42	.44	35	.49	39	.59	46	.27	21		7	
3.61	1.18	33	1.30	36	.42	36	.37	31	.54	46	.27	23		6	
3.61	1.13	31	1.22	34	.39	35			.49	43	.22	19	88	4	
3.67	1.20	33												6	
3.67	1.47	40	1.47	40	.39	27	.56	38	.64	44	.34	23	77	8	
3.73	1.32	35	1.64	44	.47	36	.51	39	.66	50	.34	26		5	
3.76	1.32	35			.39	30					.32	24		7	
3.80	1.15	30	1.54	41	.44	38	.51	44	.66	57	.29	25		7	
3.80	1.25	33	1.62	43	.42	34	.51	41	.64	51	.32	26		7	
3.88	1.15	30	1.15	30	.44	38			.59	51	.29	25	113	6	
3.88	1.30	34	1.35	35	.42	32					.24	18		6	
3.88	1.18	30	1.40	36	.39	33					.24	20	71	7	
4.05	1.42	35	1.64	40	.47	33	.54	38	.69	49	.32	23	88	7	
4.05	1.32	33	1.59	39	.49	37			.66	50	.27	20			
4.05	1.42	35	1.49	37	.47	33	.44	31	.64	45	.34	24		7	
4.11	1.40	34	1.46	36			.61	44	.78	56	.42	30	82		
4.11	1.40	34	1.54	37	.44	31	.54	39	.86	61	.32	23		7	
4.11	1.30	32	1.35	33	.47	36	.44	34	.56	43	.27	21	77	7	
4.24	1.27	30			.44	35					.20	16		6	
4.24	1.35	32			.39	29					.32	24		6	
4.24	1.27	30	1.59	38	.44	35					.20	16	80	8	
4.24	1.37	32	1.67	39	.49	36			.64	47	.30	22		8	
4.30	1.30	30	1.42	33	.42	32	.47	36	.64	49	.32	25	71	6	
4.37	1.45	33	1.72	39	.47	32	.54	37	.66	46	.32	22	80	9+	
4.43	1.30	29			.42	32								7	
4.43	1.32	30	1.57	34	.47	36	.37	28	.61	46	.32	24	68	6	
4.43	1.35	30	1.54	35	.39	29	.39	29	.56	41	.20	15	80	7+	
4.43	1.59	36	2.08	47										14	
4.49	1.42	32			.47	33	.49	35	.66	46	.22	15		7	
4.56	1.45	32	1.64	36	.51	35							75	8	
4.62	1.45	31	1.59	34	.44	30	.47	32	.64	44	.34	23	77	7	
4.62	1.52	33	2.11	46	.54	36	.56	37	.73	48	.39	26		14	
4.62	1.59	34	1.89	41	.47	30			.73	54	.37	23		9	
4.62	1.47	32	1.76	38	.49	33			.69	47				8	
4.75	1.47	31	1.86	39	.54	37			.69	47	.27	18	77	8	
4.75	1.54	32	1.57	33	.47	31	.42	27	.56	36	.29	19	100	7	
4.75	1.42	30	1.59	33	.47	33	.39	27	.59	42	.22	15	88	6	
4.81	1.52	32	1.72	36	.49	32	.51	34	.71	47	.32	21	77	3	
4.81	1.79	37	1.98	41	.54	30	.61	34	.78	44	.39	22		14	
4.87	1.59	33	1.79	37	.49	31	.59	37	.69	43	.37	23	77	10	
4.87	1.47	30			.49	33					.32	22		8	
4.94	1.72	35	2.25	46	.56	33	.69	40	.81	47	.39	23			
4.94	1.52	31	1.72	35	.51	34	.51	34	.71	47	.24	16	125	8	
4.94	1.72	35	1.81	37	.49	28	.49	28	.64	37	.34	20	77	10	
4.94	1.52	31	1.64	33	.49	32	.49	32	.61	40	.32	21	85	11	
5.00	1.64	33	1.91	38										7	
5.06	1.67	33	1.96	39	.49	29	.51	31	.76	46	.49	29		10	
5.06	1.54	30	1.67	33	.47	31	.49	32	.64	42	.32	21		7	
5.06	1.59	31	1.72	34	.51	32	.51	32	.69	43	.32	20	80	8	
5.06	1.49	29	1.81	36	.49	33	.51	34	.66	44	.27	19		9	
5.19	1.64	32	1.96	38	.47	29	.61	37	.76	46	.39	24		12	
5.32	1.59	30	1.86	35	.49	31	.51	32	.66	42	.37	23		9	
5.32	1.62	30	1.74	33	.49	30	.54	33	.71	44	.34	21		8	
5.32	1.76	33	2.16	41	.54	31	.64	36	.81	46	.39	22	83	20	
5.44	1.81	34	2.33	43	.56	30	.66	36	.91	49	.47	26	85		
5.44	1.81	33	2.08	38	.54	30	.51	28	.69	38	.37	20	71	16	
5.44	1.72	32	1.94	37	.51	30	.66	38	.78	45	.44	26	77	16	
5.57	1.91	34	2.16	39	.54	28	.61	32	.78	41	.39	20	85	45	
5.89	2.08	35	2.45	42	.56	27	.69	33	.86	41	.47	23	83	20	15
6.01	1.89	31	2.13	35	.56	30	.69	37	.86	46	.56	30	75	50	25
6.01	1.89	31	2.13	35	.56	30	.61	32	.81	43	.51	27	85	53	35
6.08	1.84	30			.61	33	.52	28	.74	40	.37	20	92		
6.14	1.96	32	2.20	36	.49	25	.54	28	.74	38	.49	25	77	55	33
6.29	2.08	33	2.20	35	.49	24	.73	35	.81	39	.42	20	83	74	42
6.39	2.08	33	2.45	38	.59	28			.86	41	.49	24		56	38
6.39	2.20	34	2.87	45	.59	27	.73	33	.98	45	.56	25	81	68	42
6.50	2.07	32	2.60	40	.56	27	.64	31	.88	43	.47	23	88	55	
6.50	1.94	30	2.23	34	.56	29	.61	31	.78	40	.42	22			
6.70	2.20	33	2.35	35	.54	25	.64	29	.83	38	.44	20	68	58	35

See footnote at end of table.

TABLE 1.—*Selected measurements and counts of larval* Cyclopsetta fimbriata—Continued

Standard length	Head length (HL)		Body depth (BD)		Eye diameter (ED)		Upper jaw length (UJL)		Lower jaw length (LJL)		Snout length (SN)		Pelvic fin origin to tip of cleithrum [1] *blind-side* ocular-side	Dorsal fin rays	Anal fin rays
	Measurements													Counts	
Mm.	*Mm.*	*HL/SL*	*Mm.*	*BD/SL*	*Mm.*	*ED/HL*	*Mm.*	*UJL/HL*	*Mm.*	*LJL/HL*	*Mm.*	*SN/HL*	*Percent*	*Number*	*Number*
6.70	2.08	31	2.72	41	0.64	31	—	—	0.78	38	0.42	20	69	64	44
6.80	2.08	31	2.45	36	.49	24	—	—	.86	41	.42	20	100	—	—
6.91	2.16	31	2.45	35	.56	26	.71	33	.93	43	.42	19	77	—	39
7.01	2.20	31	2.72	39	.56	25	.74	34	.93	42	.56	25	83	73	50
7.01	2.28	33	2.83	40	.61	27	.81	36	.98	43	.49	21	78	66	46
7.53	2.38	32	2.83	38	.69	29	.81	34	1.03	43	.56	24	75	—	—
7.63	2.38	31	3.03	40	.66	28	—	—	1.03	43	.59	25	84	72	50
8.04	2.56	32	3.22	40	.69	27	.93	36	1.10	43	.61	24	88	79	62
8.04	2.64	33	3.14	39	.74	28	.91	34	1.10	42	.59	22	83	—	—
8.25	2.83	34	3.49	42	.74	26	1.00	35	1.22	43	.74	26	88	—	—
8.76	2.91	33	3.69	42	.71	24	1.00	34	1.15	40	.66	23	71	79	56
9.18	2.79	30	3.30	36	.69	25	—	—	—	—	.69	25	74	81	57
9.38	3.38	36	4.30	46	.71	21	1.00	30	1.35	40	.86	25	71	79	60
9.38	2.95	31	3.80	41	.74	25	1.03	35	1.22	41	.74	25	78	82	63
9.59	3.49	36	4.24	44	.69	20	1.00	29	1.30	37	.81	23	92	77	54
9.79	2.91	30	3.61	37	.71	24	.91	31	1.18	41	.74	25	65	76	60
10.21	3.03	30	4.11	40	.66	22	.98	32	1.15	38	.73	24	71	81	61
10.31	3.65	35	4.62	45	.81	22	—	—	1.52	42	.88	24	69	77	58
10.31	3.10	30	4.24	41	.71	23	1.10	36	1.35	44	.73	24	61	78	60
10.31	3.18	31	4.11	40	.74	23	1.10	35	1.32	42	.74	23	74	79	59
11.08	3.57	32	4.43	40	.78	22	1.15	32	1.42	40	.91	25	100	82	62
12.06	3.80	32	4.56	38	.86	23	.98	26	1.35	36	.86	23	79	77	58
12.23	3.99	33	4.89	40	.91	23	1.32	33	1.71	43	.91	23	78	82	58
13.20	4.49	34	5.38	41	.86	19	1.42	32	1.84	41	1.18	26	73	82	61
13.53	4.18	31	5.25	39	.93	22	1.35	32	1.72	41	.98	22	82	84	61
13.86	4.30	31	—	—	.91	21	1.25	29	1.71	40	.98	23	65	—	—
14.02	4.62	33	5.51	39	.98	21	1.59	34	1.98	43	1.05	23	92	80	60
14.18	4.75	33	6.01	42	.93	20	1.49	31	2.03	43	1.22	26	73	83	61
14.51	4.75	33	5.87	40	1.22	26	1.40	29	1.84	39	1.10	23	78	80	58

[1] Distance between the origin of the right side pelvic fin base and the tip of the cleithrum divided by the distance between the origin of the left side pelvic fin base and the tip of the cleithrum.

TABLE 2.—*Average values for selected measurements and counts (½-mm. size intervals to 5.0 mm. SL; 1-mm. intervals for larger sizes); all specimens in a given size series were not necessarily used to compute the mean*

Standard length		Specimens	Head length (HL)		Body depth (BD)		Eye diameter (ED)		Upper jaw length (UJL)		Lower jaw length (LJL)		Snout length (SN)		Pelvic fin origin to tip of cleithrum [1] *blind-side* ocular-side	Dorsal fin rays	Anal fin rays
			Measurements													Counts	
Range	*Mean*		*Mean*		*Mean*		*Mean*		*Mean*		*Mean*		*Mean*				
Mm.	*Mm.*	*Number*	*Mm.*	*HL/SL*	*Mm.*	*BD/SL*	*Mm.*	*ED/HL*	*Mm.*	*UJL/HL*	*Mm.*	*LJL/HL*	*Mm.*	*SN/HL*	*Percent*	*Number*	*Number*
1.50–1.99	1.79	4	0.50	28	0.52	29	0.21	40	—	—	—	—	0.09	17	—	—	—
2.00–2.49	2.20	6	.69	32	.64	32	.28	40	—	—	—	—	.12	16	—	3.8	—
2.50–2.99	2.80	18	.83	30	.84	30	.32	38	0.28	33	0.41	49	.13	16	93	3.4	—
3.00–3.49	3.28	23	1.06	32	1.12	34	.38	37	.37	35	.50	47	.21	20	92	5.2	—
3.50–3.99	3.68	15	1.25	34	1.42	39	.42	34	.49	38	.60	48	.29	23	85	6.6	—
4.00–4.49	4.25	17	1.37	32	1.59	37	.44	33	.48	35	.66	48	.29	21	78	7.5	—
4.50–4.99	4.78	16	1.55	32	1.79	38	.50	32	.52	33	.68	44	.33	21	86	12.1	—
5.00–5.99	5.30	16	1.70	32	1.98	38	.51	30	.57	33	.75	44	.39	23	81	14.3	15.0
6.00–6.99	6.42	13	2.04	32	2.40	37	.56	28	.64	32	.84	41	.46	23	81	54.8	37.0
7.00–7.99	7.30	4	2.31	32	2.85	39	.63	27	.79	35	.99	43	.55	24	80	70.3	48.6
8.00–8.99	8.27	4	2.74	33	3.38	41	.72	26	.96	35	1.14	42	.65	24	82	79.0	59.0
9.00–9.99	9.46	5	3.10	33	3.85	41	.71	23	.98	31	1.26	40	.77	25	76	79.0	58.8
10.00–10.99	10.28	4	3.24	32	4.27	42	.73	22	1.06	34	1.34	42	.77	24	69	78.8	59.5
11.00–11.99	11.08	1	3.57	32	4.43	40	.78	22	1.15	32	1.42	40	.91	25	100	82.0	62.0
12.00–12.99	12.14	2	3.90	32	4.72	39	.88	23	1.15	30	1.53	40	.88	23	78	79.5	58.0
13.00–13.99	13.53	3	4.32	32	5.32	40	.90	21	1.34	31	1.76	41	1.05	24	73	83.0	61.0
14.00–14.99	14.24	3	4.71	33	5.80	40	1.04	22	1.49	31	1.95	42	1.12	24	81	81.0	59.7

[1] Distance between the origin of the right side pelvic fin base and the tip of the cleithrum divided by the distance between the origin of the left side pelvic fin base and the tip of the cleithrum.