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Generic Identification and Patterns of External Pigment in Larval Gobies (Pisces: Gobiidae) from the Belize Barrier Reef

Elizabeth D. Maddox
College of William and Mary - Virginia Institute of Marine Science

GENERIC IDENTIFICATION AND PATTERNS OF EXTERNAL PIGMENT IN LARVAL GOBIES (PISCES: GOBIIDAE) FROM THE BELIZE BARRIER REEF

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by

Elizabeth D. Maddox

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APPROVAL SHEET

This thesis is submitted in partial fulfillment of

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Elizabeth D. Maddox

Approved, May 1992

____
John E. Olney, M.A.
Committee Co-Chairman/Advisor

____
H. Jacque Carter, Ph.D.
Committee Co-Chairman/Advisor

____
George C. Grant, Ph.D.

____
John M. Brubaker, Ph.D.

____
George R. Sedberry, Ph.D.
South Carolina Marine Resources Research Institute
Charleston, South Carolina

DEDICATION

To Catherine Hall Padgett, naturalist.

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ABSTRACT

Late stage goby larvae (Pisces: Gobiidae) collected in the Hol Chan Marine Reserve off Ambergris Cay, Belize, were identified to genus or several generic possibilities out of the over 30, nominal gobiid genera from the Caribbean Sea. Twelve morphological categories of gobies, defined by patterns of pigmentation and, presumably, representing species, were found in the survey material. Evaluation of osteological and other meristic characters placed three morphological categories in the *Gobionellus* group, three in the *Priolepis* group, one in the *Bathygobius* group, and five in the *Gobiosoma* group. (Generic groupings were proposed by systematists as working hypotheses of gobiid relationships.) Larvae from seven morphological categories were identified to a single genus, including larvae of *Coryphopterus*, *Gnatholepis*, and *Gobiosoma* which were described for the first time for species known from Belize. Larvae of *Gnatholepis thompsoni* were identified to species. Patterns of melanophores within morphological categories were remarkably consistent and supported their use as taxonomic tools in the identification of larval gobies to species. Consistency of pigment patterns at the genus level and within groupings of genera suggested that patterns of melanophores are important to systematic studies of the family.

GENERIC IDENTIFICATION AND PATTERNS OF EXTERNAL PIGMENT IN LARVAL GOBIES (PISCES: GOBIIDAE) FROM THE BELIZE BARRIER REEF

INTRODUCTION

The family Gobiidae is estimated to contain 250 genera and 1500-2000 species worldwide and is the most diverse family of marine fishes (Nelson, 1984; Ruple, 1984; Thresher, 1984; Miller, 1986). In the western central Atlantic Ocean alone, over 30 nominal genera of gobies are recognized (Birdsong et al., 1988; Richards, 1990) (Appendix I). Gobies are the smallest of marine fishes, with one species reaching maturity at 6 mm total length (TL) (Randall, 1968). Most gobies are less than 10 cm TL as adults, but some attain a maximum TL of 50 cm (Nelson, 1984).

Human exploitation of goby populations is not widespread. Goby fry, however, are harvested for food in the Phillipines (Herre, 1927; Manacop, 1953; Blanco, 1958), and there is a commercial adult goby fishery in estuaries of the northwestern Black Sea and in the Sea of Azov (Miller, 1986). Brightly colored gobies, such as the neon gobies of the genus *Gobiosoma*, are captured for the aquarium trade for their beauty and cleaning behavior. Some neon gobies, such as *G. oceanops*, are cultured in large numbers to supply aquarists (G. Waugh, Aqualife Research Corporation, personal communication).

As adults, gobiids display a spectrum of lifestyles in marine, brackish, and freshwater habitats but are typically substrate-associated. Among the Gobiosoma, for example, the species G. oceanops, G. evelynae, G. illecebrosum, G. genie, G. randalli, and G. prochilos reside on coral heads where they set up "cleaning stations" to remove ectoparasites from other fishes (Colin, 1975). Gobiosoma chancei, G. horsti, G. xanthiprora, G. louisae, and G. tenox associate solely with sponges and do not clean (Colin, 1975). The plankton feeder, G. astronasum, on the other hand, hovers near steep reef faces and is occasionally found on corals (Colin, 1975). Other gobies such as Coryphopterus personatus, Microgobius carri, and Ioglossus are semi-pelagic, swimming just above the bottom (Randall, 1968; Thresher, 1984). Mudskippers, Periopthalmus and Periopthalmodon, live on wet beaches and may spend several days out of the water (Nelson, 1984). In addition to certain Gobiosoma, Evermannichthys metzelaari, E. spongicola, and Risor ruber are sponge commensals (Randall, 1968; Robins and Ray, 1986). Nes longus lives in symbiosis in snapping shrimp burrows (Randall, 1968).

Early life history of the Gobiidae

Early life history stages are known for less than five percent of the Gobioidei (Ruple, 1984). Larvae are described or documented as known for at least one species within 88 gobiid genera worldwide (Table 20), but larvae of only five western Atlantic goby genera have been described: Evorthodus, Gobionellus, Gobiosoma, Microgobius and Bathygobius (Peters, 1983; Richards, 1990). Thus, our knowledge of the early life history of gobies is probably the poorest among all teleostean fishes. The most extensive treatment of the morphology of larval gobies is provided by Okiyama, ed. (1988) who illustrated and described 66 species in 37 genera.

Literature is scarce on the spawning seasons of gobies in the Caribbean Sea. Gobiosoma oceanops is reported to spawn February to April off southern Florida (Feddern, 1967), but other Gobiosoma are ripe most of the year or are summer spawners (Colin, 1975). Gobiosoma robustum spawns early spring to early summer and late summer to fall in the Tampa Bay, Florida area (Springer and McErlean, 1961). Bathygobius soporator spawns off Florida in the summer (Tavolga, 1954). Around Puerto Rico, Sicydium plumieri, Evorthodus lyricus, and Gobionellus boleosoma males display nuptial colors from May to November (Erdman, 1976).

Gobies lay demersal, adhesive eggs which are guarded by the male of a spawning pair (Thresher, 1984). Larvae are advanced at hatching with pigmented eyes, and well developed jaws, gut, and vertical and pectoral fin folds (Thresher, 1984). The yolk sac is small or absorbed by time of entry into the plankton (Leis and Rennis, 1983; Thresher, 1984). Hatching occurs at 1.7 to 4.4 mm standard length (SL), and the majority of goby larvae settle from the plankton at $<$ 10 mm SL (Leis and Rennis, 1983). Although variable among species, gobies have a relatively long larval life, up to 47 days in some species (Brothers et al., 1983).

Ichthyoplankton surveys

Compilation of a faunal list and life history information of species creates an important foundation for biological research, particularly in unstudied geographic regions. The Hol Chan Marine Reserve, off Ambergris Cay, Belize, not only represents a location of limited research, but its park status renders it ideal for pre- and post-establishment scientific investigations, as well as a relatively undisturbed environment for observing natural populations and phenomena.

Ichthyoplankton surveys are useful in exploring the fauna and ecology of an area because they sample species that might avoid trawls or seines, such as gobies and blennies which are small, benthic, and often cryptic. In addition, plankton tows can be made over coral reefs and in other environments less conducive to trawling and seining. Although some sampling difficulties can be overcome with the use of ichthyocides, a plankton survey is less damaging to a site because it does not kill recruited juveniles or reproductive adults and can be used in sensitive or protected areas.

Despite their advantages, ichthyoplankton surveys have been constrained by catch identification. This is particularly true in regions of high species diversity, such as coral reefs, where many species are not described in their early life history stages and larval characters are often too similar among species to be distinguishing. Efforts to resolve this problem are ongoing by numerous investigators, and the compilation of a guidebook of early life history information of western central Atlantic Ocean fishes is being undertaken by Dr. William J. Richards (NOAA/NMFS/SEFC). Similar volumes are already available for other regions, but none are comprehensive for all species (Fritzsche, 1978; Fahay, 1983; Leis and Rennis, 1983; Ozawa (ed.), 1986, Okiyama (ed.), 1988; Leis and Trnski, 1989; Matarese et al., 1989).

Larval gobies frequently compose a large proportion of the catch in nearshore Caribbean ichthyoplankton studies (Dekhnik et al., 1966; Powles, 1975; Esteve de Romero, 1985, Smith et al., 1987; Powell et al.,

1989) yet, without published descriptions, they are seldom identified to genus or species level. The ability to identify larval gobies would contribute to the goals of ichthyoplankton surveys, which, in turn, would facilitate future studies involving the family.

Identification of larval gobies

Goby larvae are easily identified to family level by the following characters: moderately elongate, slightly tapering body; large and conspicuous air bladder and otoliths; pigmentation over a relatively long, uncoiled gut; united pelvic-fins that form an adhesive disc in many species; 24-27 myomeres; two early-forming dorsal fins, the first of which is spinous; a slightly upturned mouth; and small size at caudal flexion, approximately 2.7 - 3.8 mm SL (Leis and Rennis, 1983; Ruple, 1984).

Identification of larval gobies below the family level is problematic due to the large number of species, the lack of a stable classification, the need for a family revision, the likelihood of additional undescribed species, the paucity of early life history information, and considerable overlap in ranges of meristics. Certain characteristics useful in identification of adult gobies, such as coloration, patterns of facial pores, and number of scale rows (Miller, 1986), are not developed in larvae.

Patterns of melanophores in goby larvae, however, have contributed to their taxonomic identification at familial, generic, and specific levels. Almost all goby larvae have pigment on or over the gas bladder and at the anus. Most gobies have some ventral pigmentation, usually in the region of the anal-fin, and the dorsal surface, jaws, pelvic disc, and caudal region are also areas where pigment is typically located on goby larvae (Leis and Rennis, 1983; Ruple, 1984). The location, size, shape, and intensity of melanophores on goby larvae are variable within the family.

Previous studies strongly suggest that pigmentation of goby larvae is an important characteristic that delimits genera. In western Atlantic species, for example, Microgobius thalassinus and species of Gobiosoma which co-occur in the Chesapeake Bay, Virginia, have been separated as larvae on the basis of pigmentation (Richardson and Joseph, 1975). Microgobius possess a double row of seven unevenly spaced melanophores along their ventral margin between the anus and caudal fin. Gobiosoma species possess a single row of two to five unevenly spaced melanophores in the same approximate location, but one melanophore midway between the anus and caudal fin is more prominent and extends vertically (Richardson and Joseph, 1975). Gobionellus larvae are similar to Microgobius larvae in having a series of melanophores along the ventral midline from the anus to the caudal fin, but the melanophores are ovoid, expanded, and paler in contrast (Fritzsche, 1978). The larva of Bathygobius soporator is heavily pigmented over much of its body and is distinct from other described western Atlantic species (Peters, 1983). Okiyama, ed. (1988) presents further evidence of genus-level pigment patterns on larval gobies.

Patterns of melanophores on larval gobies have also been documented as species-specific, varying on a genus-level pattern. For example, within the Gobiosoma, G. bosc larvae are distinguished from G. ginsburgi larvae by the shape of the postanal melanophore that is vertically elongate in bosc and horizontally elongate in ginsburgi (Massman et al., 1963). Priolepis boreus and P. semidoliatus at 8.0 and 8.6 mm TL, respectively, are both banded vertically. However, P. boreus is banded along the entire length of the body and P. semidoliatus is banded from the snout to the pectoral fin. At 10.0 mm TL P. semidoliatus is banded from the snout to the caudal peduncle (Okiyama, ed., 1988). Chasmichthys dolichognathus and C. gulosus, at 7.4 and 6.8 mm TL, respectively, are similarly pigmented to each other. Both have melanophores at the tip of both jaws and base of the lower jaw. Dorsally-located patches of melanin begin on the head and continue to the caudal peduncle on each of these larvae, and, ventrally, melanin patches occur over the gut and along the anal fin to the caudal peduncle. Additionally, melanophores occur over the hypurals on larvae of both Chasmichthys species treated (Okiyama, ed., 1988).

Classification of the Gobiidae

The phylogeny of the Gobiidae has not been established. The Gobiidae is postulated to be monophyletic based on the possession of five branchiostegal rays and a pelvic fraenum (Hoese, 1984; Winterbottom and Burridge, 1989). However, Ruple (1984) referred to the Gobiidae as a "catch-all" group that did not not appear as cohesive as either of the gobioid families Eleotridae or Microdesmidae and suggested that larval characters may help to better define the Gobiidae.

Recently, Birdsong et al. (1988) put forth a novel scheme of grouping gobioid genera. Groups were defined by synapomorphies, when possible, and phenetics in the absence of known synapomorphies. Thus, the proposed groups were working hypotheses, not taxa. Phenetic characters that were relatively stable at the generic level were employed: dorsal-fin formula, number of vertebrae and their distribution between pre-caudal and caudal vertebrae, number of epurals, and number of anal-fin pterygiophores anterior to the first haemal spine. To date, there have been no attempts to systematically evaluate these generic groups.

Since the characters used to define generic groups in the gobiids (Birdsong et al., 1988) develop early in ontogeny, additional character states of larvae (such as pigmentation) can be used to further corroborate or refute these preliminary groupings.

The primary purpose of this research was to use the osteological characters of Birdsong et al. (1988) in an attempt to identify goby larvae collected in the Hol Chan Marine Reserve off Ambergris Cay, Belize. In the identification process, the consistency of pigment patterns within and among identified material was used to corroborate the hypothesis that pigmentation has taxonomic and phylogenetic significance in classification of gobies.

MATERIALS AND METHODS

Field Sampling:

Plankton tows were made on a near-monthly basis from February, 1985 to February, 1986 along a shore-to-sea transect in the Hol Chan Marine Reserve at the southern end of Ambergris Cay, Belize (Figures 1-2, Table 1). The transect consisted of four ecologically distinct stations: Station A) mangrove-bordered island cut, Station B) lagoon, Station C) back reef, and Station D) outer fore reef.

Sampling gear consisted of a one-meter diameter, 333 micron Nitex mesh, bridled plankton net. Horizontal surface tows were made for ten minutes at a speed of one knot from the stern of a 8 m outboard skiff. Collecting took place just after dusk to minimize visual net avoidance by fish larvae. Due to the dangers of negotiating the reef cut at low light, sampling was not always possible at the outer fore reef station. The survey resulted in 15 samples from the island cut, 14 from the lagoon and back reef stations, and 6 from the outer fore reef zone.

Laboratory Methodology:

Forty-nine plankton samples, resulting from 13 months of field collection, were sorted for fish larvae. The late stage, (post-flexion) goby larvae removed from the samples were grouped into 12 morphological categories defined by patterns of pigmentation. Some categories were tentatively identified by comparing their pigmentation to patterns described in the literature. Selected specimens from each category were cleared and differentially stained for bone and cartilage according to the method of Potthoff (1984).

The following osteological features were examined in each category: dorsal-fin formula (Figure 3), number of vertebrae and distribution between pre-caudal and caudal vertebrae (Figure 4), number of epurals (Figure 5), and number of anal-fin pterygiophores anterior to the first haemal spine (Figure 6). This combination of characters was chosen because of its significance in gobiid classification (Birdsong et al., 1988).

Following Birdsong et al. (1988), the dorsal-fin formula is defined as the interdigitation pattern of the neural spines of the vertebrae with the pterygiophores of the spinous first dorsal fin. It was expressed as a numeral indicating the anteriormost neural space into which a pterygiophore inserts, followed by a dash and the numbers of pterygiophores that insert into this and subsequent neural spaces. A zero at the end of the formula indicated that there was an empty neural space before the beginning of the second dorsal fin (Birdsong et al., 1988) (see Figure 3 for example).

Osteology of each larval category was compared to the osteological tables in Birdsong et al. (1988) that treated gobies from the western

Atlantic Ocean. To facilitate comparison of larval character combinations to the published data, tables from Birdsong et al. (1988) were input into a computerized file using dBase III plus (Ashton Tate, Inc.). The file was searched with a dBase program that matched osteological features of the unidentified larvae to adult gobies displaying the same combinations of values. Thus, the program output revealed all possible genera that each morph might represent.

When computerized matching of larval to adult osteology yielded more than one generic possibility, second dorsal and anal-fin counts were compared to meristic tables compiled from literature and museum specimen data to reduce generic possibilities and, in some cases, delimit the appropriate genus and/or species. Museum specimens were X-rayed or cleared and stained to produce reliable fin counts. Museum abbreviations used in meristic tables follow Levinton et al. (1985) and Levinton and Gibbs (1988).

Each category was described and photographed. All references to pigmentation are to melanin, as orange and yellow pigments do not persist long after preservation (Leis and Trnski, 1989). Pigmentation on the gas bladder, typical of all goby larvae (Ruple, 1984), was omitted in descriptions. Second dorsal and anal-fin spines and rays were reported as total fin elements, recognizing that the first element of both fins are spines. Standard length (SL) of larval specimens was measured as the distance from the tip of the snout to the posterior edge of the hypural plates. Descriptions of gross morphology follow definitions in Leis and Trnski (1989). Late stage larvae refer to those closely approaching estimated settlement size but retaining pre-transitional (larval to juvenile) pigmentation.

Figure 1. Map of Belize.

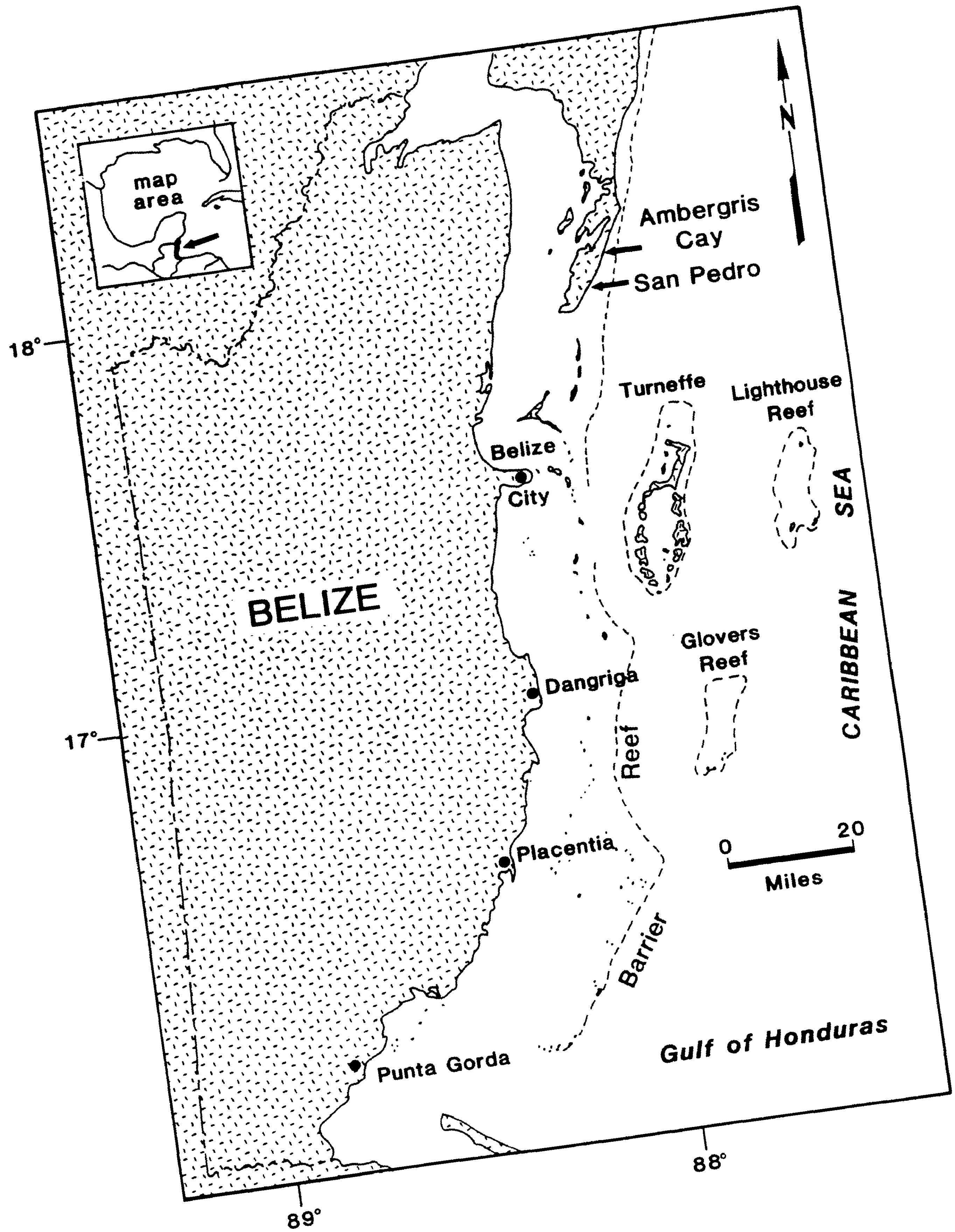

map area
Ambergris Cay
San Pedro
N
18°
17°
Turneffe
Lighthouse Reef
Belize City
SEA
BELIZE
Glovers Reef
CARIBBEAN
Dangriga
Reef
0 20
Miles
Placentia
Barrier
Gulf of Honduras
Punta Gorda
88°
89°

Figure 2. Location of stations.

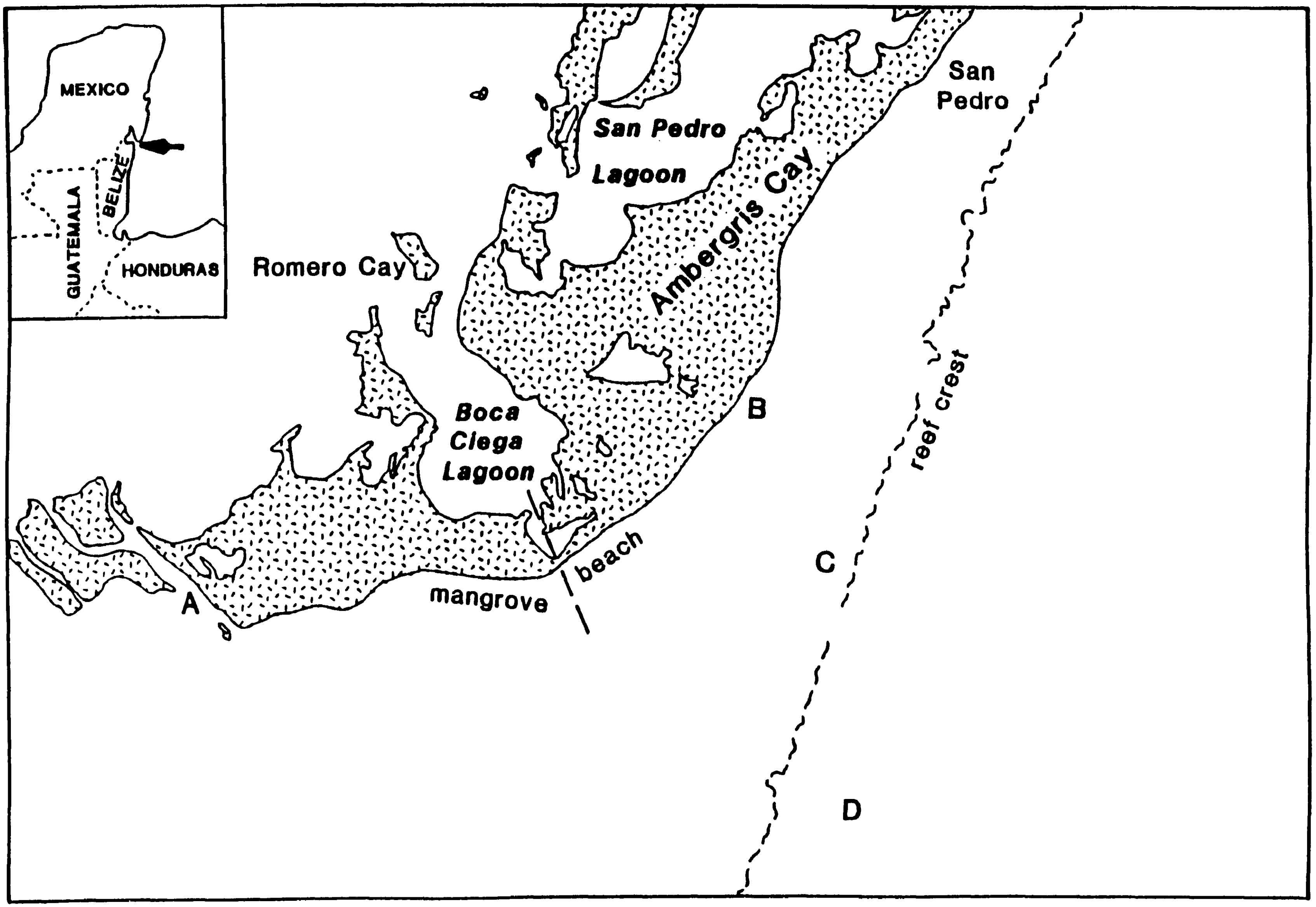

MEXICO
BELIZE
GUATEMALA
HONDURAS
Romero Cay
San Pedro Lagoon
San Pedro
Ambergris Cay
Boca Ciega Lagoon
reef crest
beach
mangrove
A
B
C
D

Figure 3. Spinous first dorsal fin of a cleared and stained goby larva possessing a dorsal-fin formula of 3-12210. The first digit indicates the anteriormost neural space into which a pterygiophore inserts. The digits following the dash represent the number of pterygiophores inserting into the third and subsequent neural spaces. The zero at the end of the formula indicates that there is an empty neural space before the beginning of the second dorsal fin.

Figure 4. Cleared and stained goby larva possessing a vertebral count of 10 pre-caudal and 16 caudal vertebrae.

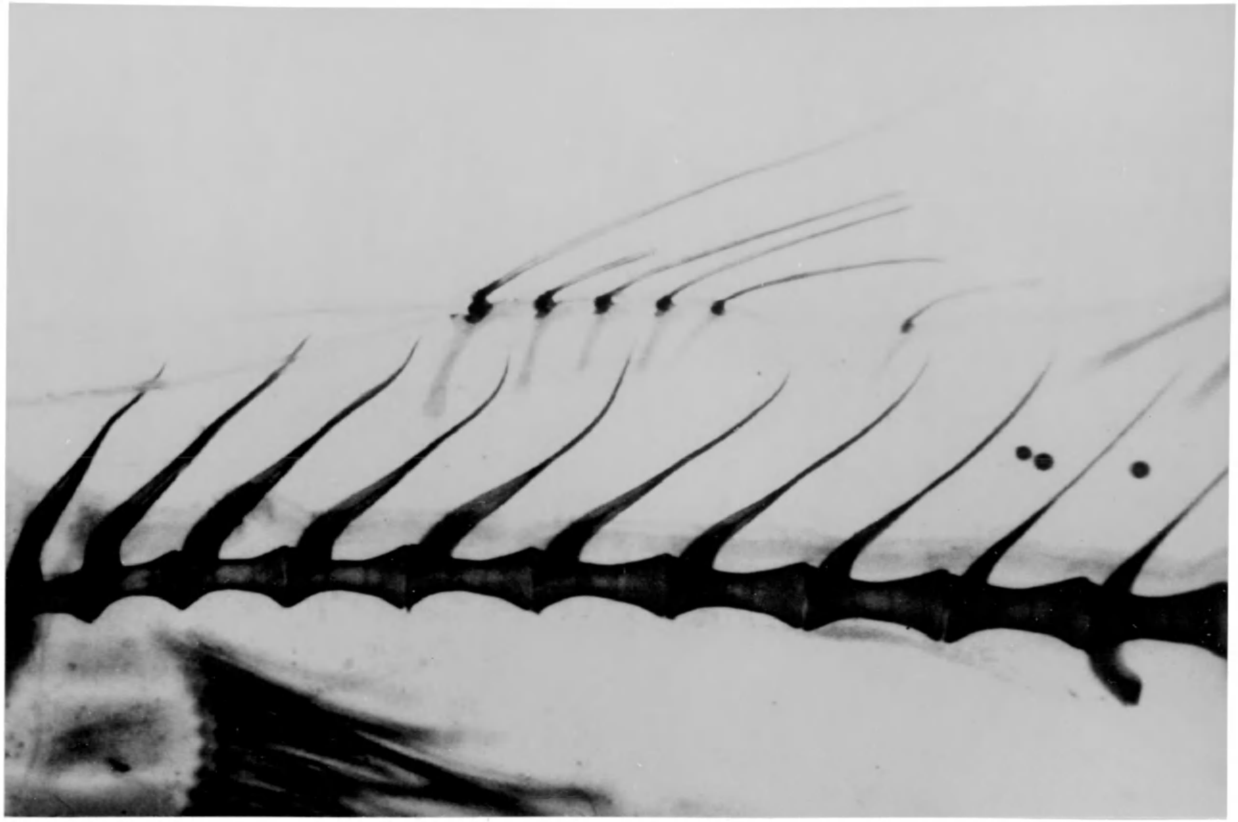



Figure 5. Caudal-fin skeleton of a cleared and stained goby larva possessing two epurals.

Figure 6. Ventral mid-body region of a cleared and stained goby larva possessing two anal-fin pterygiophores anterior to the first haemal spine.

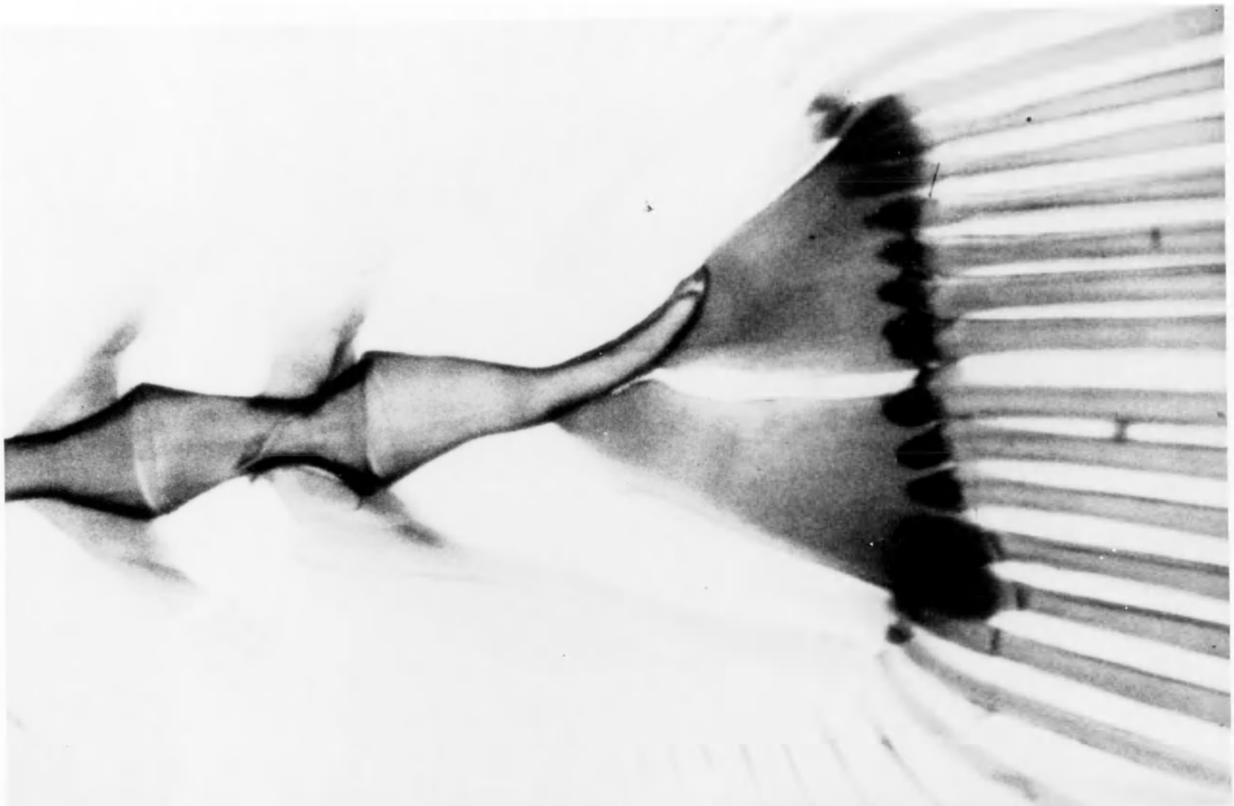


Table 1. Date and location of plankton samples

Date	# of samples	Island cut	Lagoon	Back reef	Outer fore reef
11-Feb-85	4	X	X	X	X
26-Feb-85	4	X	X	X	X
9-Mar-85	3	X	X	X	
29-Mar-85	1	X		X*	
11-Apr-85	4	X	X	X	X
28-May-85	3	X	X	X	
17-Jul-85	3	X	X	X	
13-Aug-85	2				X, X*
30-Aug-85	3	X	X	X	
9-Sep-85	4	X	X	X	X
27-Sep-85	3	X	X	X	
28-Oct-85	3	X	X	X	
30-Nov-85	3	X	X	X	
31-Dec-85	3	X	X	X	
22-Jan-86	3	X	X	X	
20-Feb-86	4	X	X	X	X

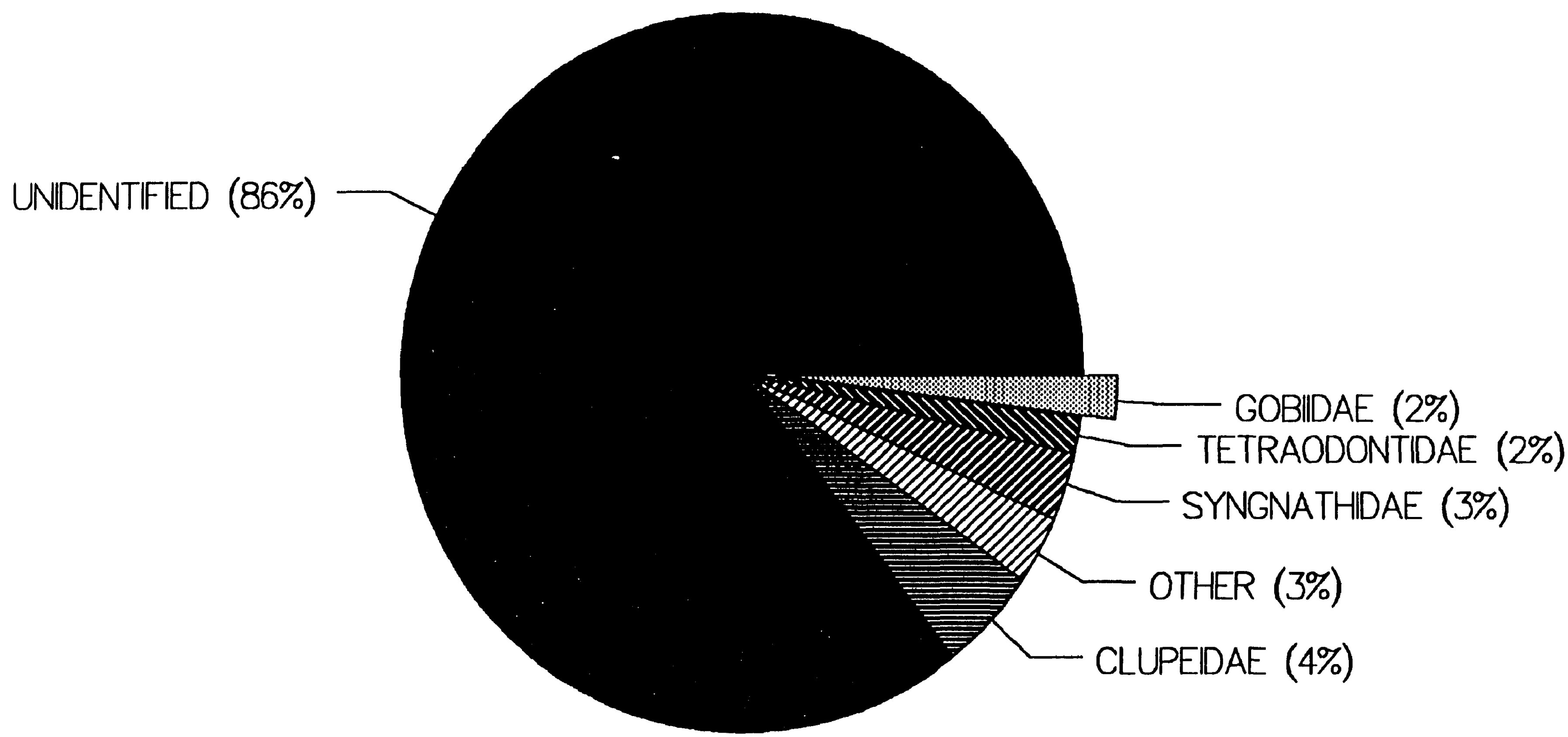
X*=partially sorted, replicate sample

RESULTS

Over 59,000 fish larvae were collected in the Hol Chan Marine Reserve during 1985-1986. Of this total, approximately 50,000 larvae were unidentified pre-flexion larvae. Larvae of gobies (n=1006) were the most abundant perciform taxon in the post-flexion material (Figure 7). Fifty-three of these goby larvae were not identified to genus due to their small size. The remaining specimens were late stage larvae near settlement, and their identification forms the basis of this report. Twenty-four additional late stage gobiid larvae were removed from partially sorted, replicate samples and are treated taxonomically.

Based on patterns of pigmentation, 12 morphological categories of larval gobies were defined in the survey material. Osteological examination and distribution of four characters placed three categories into the *Gobionellus* group of Birdsong et al. (1988), three into the *Priolepis* group, one into the *Bathygobius* group, and the remaining five categories into the *Gobiosoma* group. Seven specimens that were damaged remain unclassified.

Figure 7. Major taxa: Hol Chan ichthyoplankton survey.


UNIDENTIFIED (86%)
GOBIIDAE (2%)
TETRAODONTIDAE (2%)
SYNGNATHIDAE (3%)
OTHER (3%)
CLUPEIDAE (4%)

Identification of larvae:

Gobionellus group:

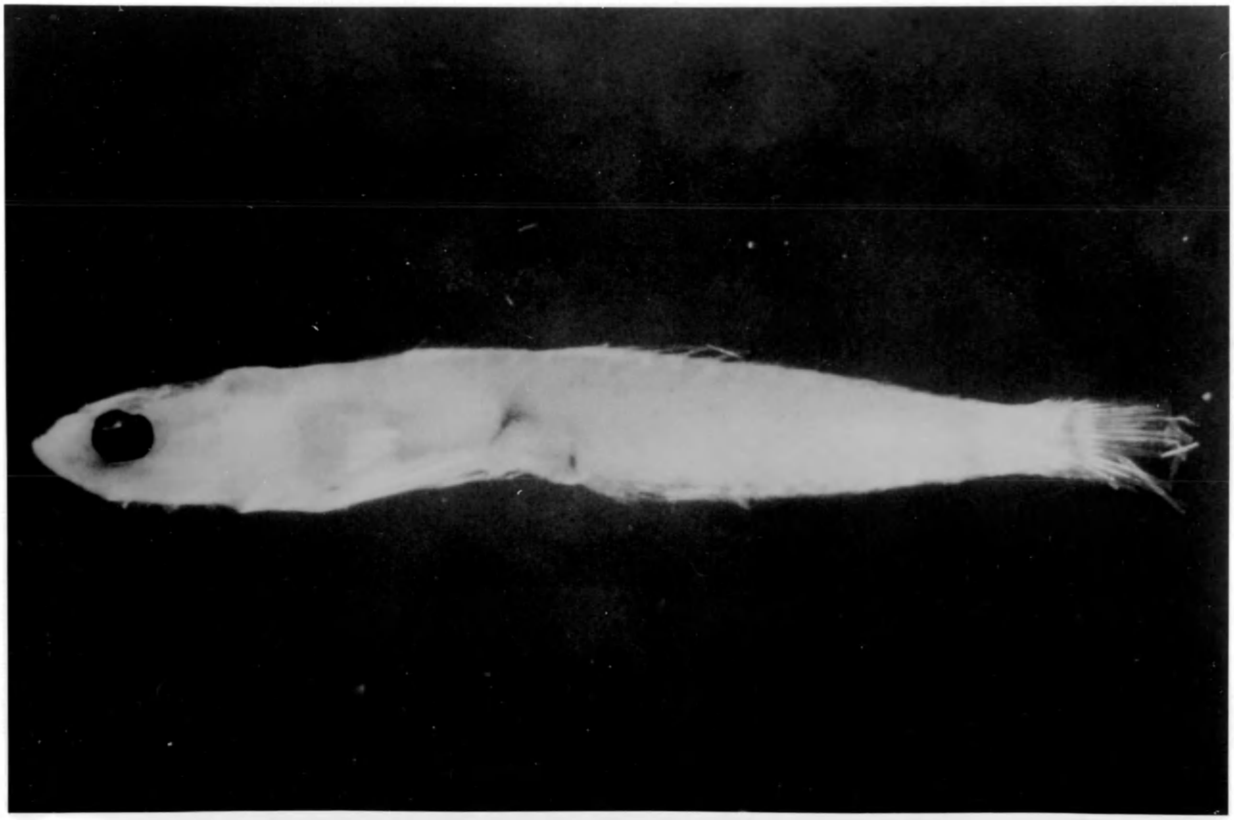
Morphological category 1: *Ctenogobius* sp.

Two-hundred eighty-nine *Ctenogobius* larvae, ranging in size from 6.6 - 11.3 mm SL, were collected. *Ctenogobius* larvae are elongate with a moderate-sized head and are characterized by three, large round melanophores on the ventral midline along the anal fin and a single, pyramid-shaped internal melanophore just anterior to the caudal peduncle, extending from the ventral midline up to the vertebral column (Figure 8a-c). Morphometrics for *Ctenogobius* are presented in Table 3.

Combinations of osteological characters examined in 33 specimens matched those of four genera within the *Gobionellus* group of Birdsong et al. (1988): *Ctenogobius*, *Gnatholepis*, *Gobionellus*, and *Oxyurichthys* (Table 2). Gross morphology and pigmentation of morphological category 1 was similar to illustrations of *Gobionellus boleosoma* in Fritzsche (1978). Pezold (1984) revised the genus *Gobionellus* and reassigned many of its species (including *boleosoma*) to the genus *Ctenogobius*, which he proposed to resurrect. Birdsong et al. (1988) recognized the resurrection of *Ctenogobius*. Examination of larval second dorsal and anal-fin elements (Table 2) narrowed the identification of morphological category 1 to a *Ctenogobius* species (Tables 4-6). *Oxyurichthys stigmalophius*, the only known western Atlantic Ocean species of *Oxyurichthys* has second dorsal and anal-fin element counts of 13 and 14, respectively (ANSP 81233, 81855, 144295, UMML 3992). At least eight species of *Ctenogobius* possess 12 second dorsal-fin and 13 anal-fin elements.

Figure 8a. A larva of Ctenogbius sp. at 9.0 mm SL.

Figure 8b. Lateral mid-body view of a larva of Ctenogobius sp. showing a series of anal-fin melanophores.



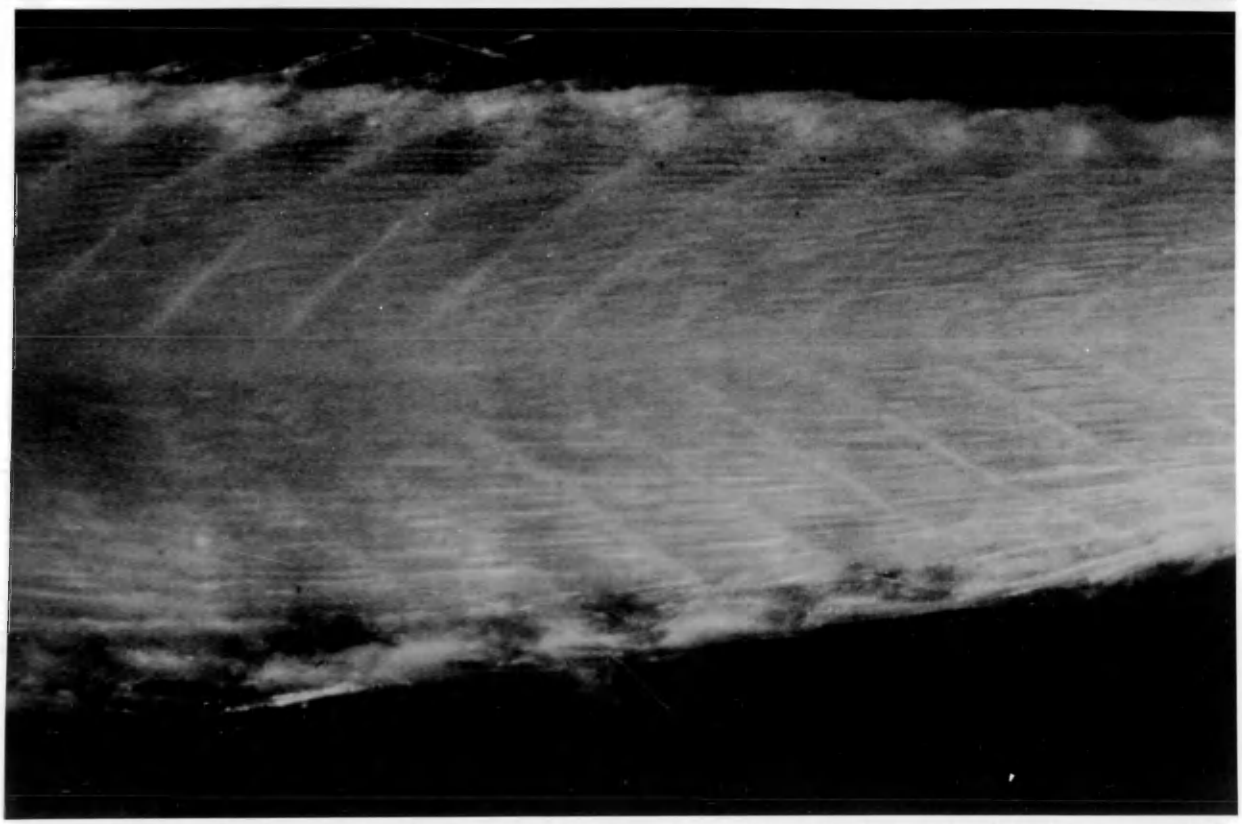
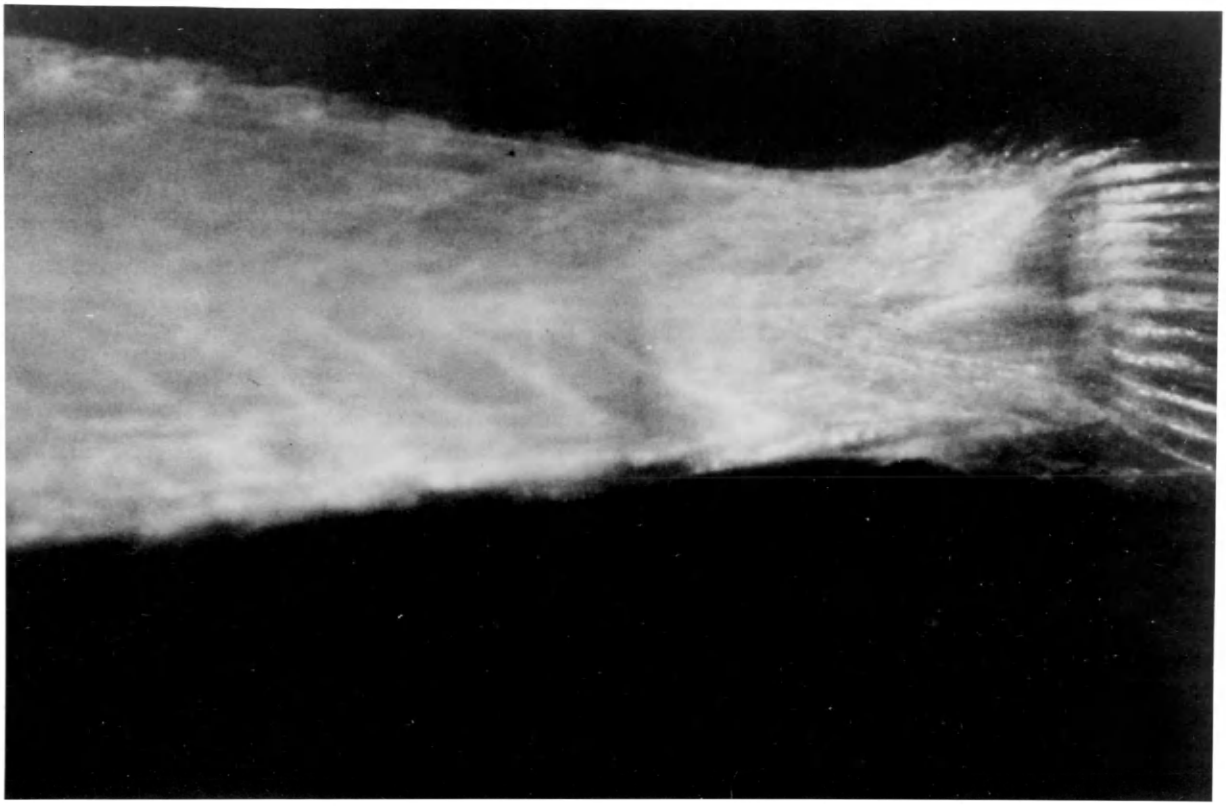


Figure 8c. Lateral caudal-region view of a larva of *Ctenogobius* *sp*. showing an internal pyramid-shaped melanophore extending from the ventral surface of the larva to the vertebral column.



Gobionellus group

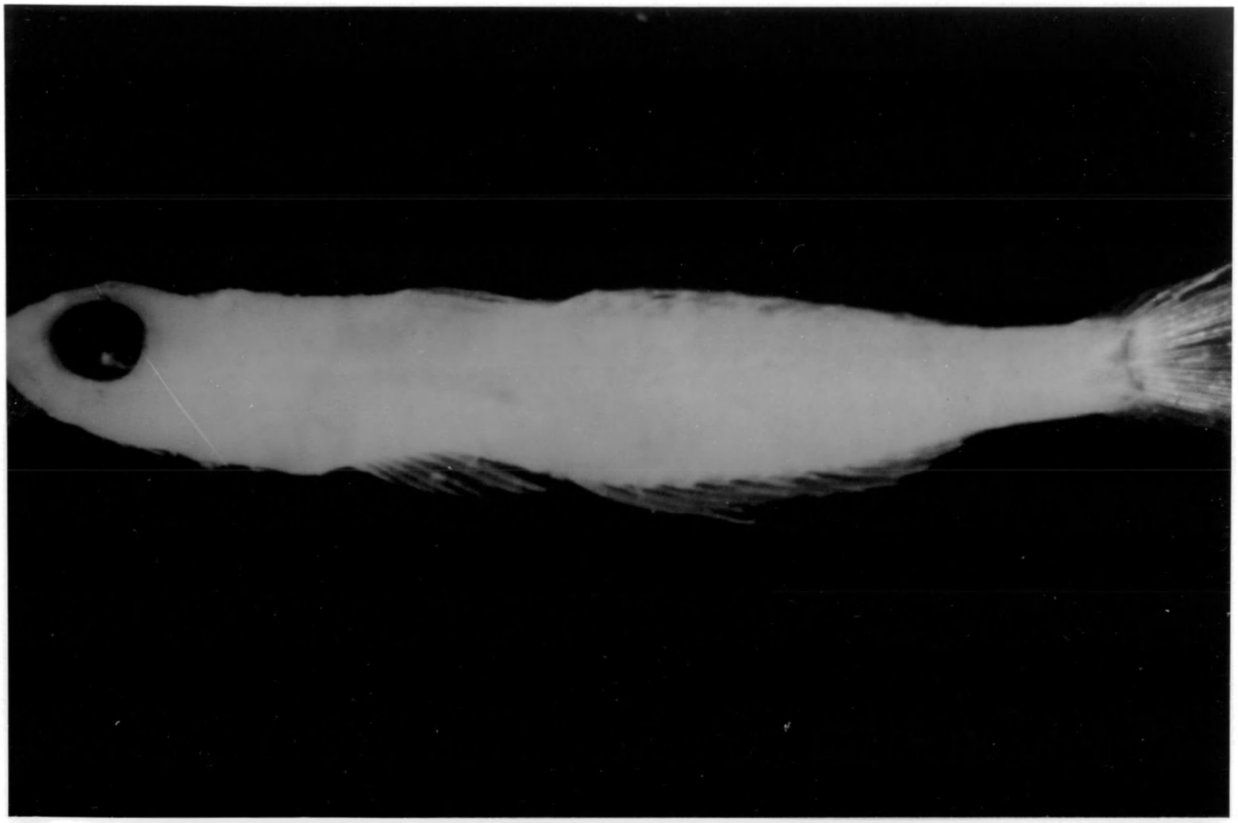
Morphological category 2: _Gnatholepis thompsoni_

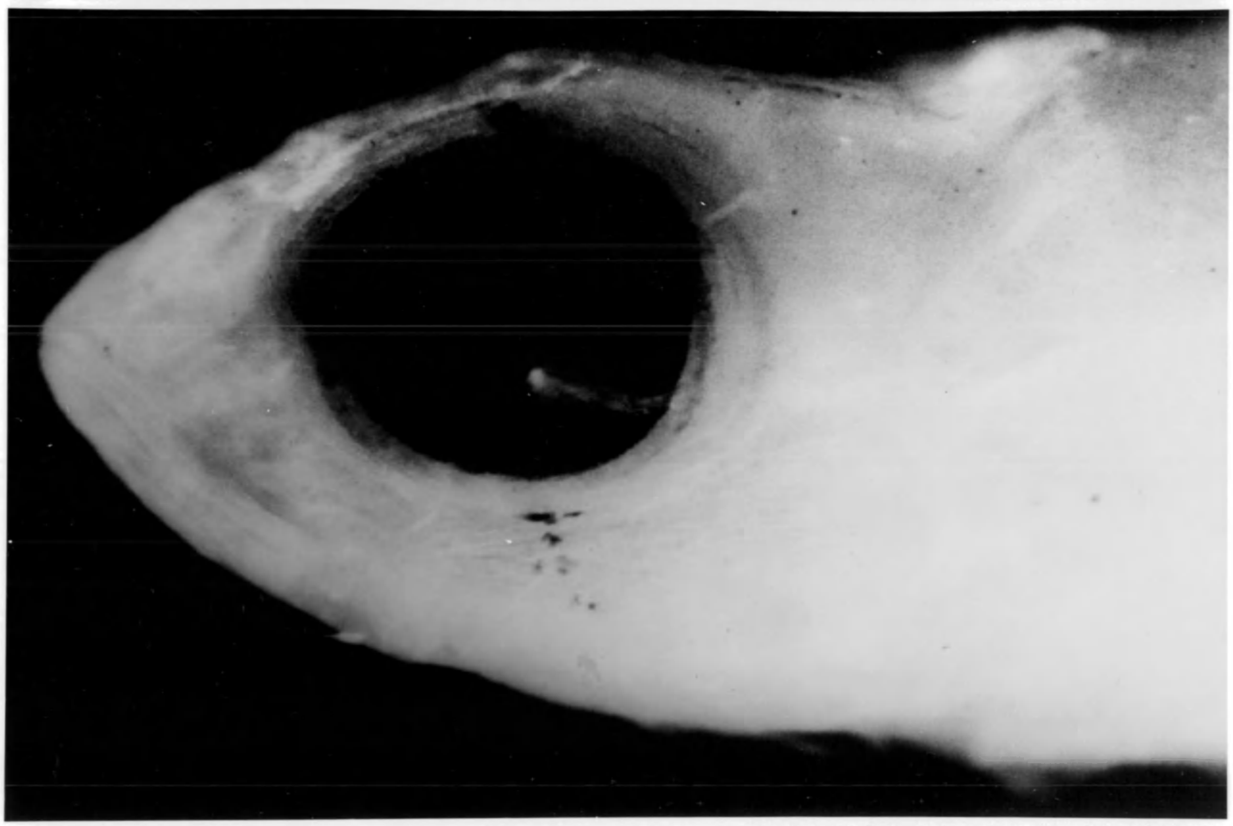
Seventy-one _Gnatholepis thompsoni_ larvae, ranging in size from 8.6 - 11.1 mm SL were collected. _Gnatholepis thompsoni_ larvae are elongate with a moderate-sized head. A distinct, vertical dotted line of melanophores ventrad to the eye distinguishes this morphological category (Figure 9a-b). In live larval specimens, an orange slash is visible near the caudal peduncle (G.D. Johnson and W.A. Laroche, personal communication). Morphometrics for _Gnatholepis thompsoni_ are presented in Table 3.

Osteological characters examined in 15 specimens of morphological category 2 matched those of four genera within the _Gobionellus_ group of Birdsong et al. (1988): _Ctenogobius_, _Gnatholepis_, _Gobionellus_, and _Oxyurichthys_ (Table 2). The eye-stripe, prominent in larval specimens, was observed to increase in prominance in a size series of juvenile _Gnatholepis thompsoni_ collected at Carrie Bow Cay, Belize (USNM 276135 and 276216). Second dorsal and anal-fin element counts of 12 and 12, respectively, (Table 2), corroborated the identification of larvae from morphological category 2 as _Gnatholepis_, for which only one Caribbean Sea species is known. Therefore, morphological category 2 was identified as _Gnatholepis thompsoni_ (Tables 4-6).

Figure 9a. A larva of *Gnatholepis thompsoni* at 10.2 mm SL.

Figure 9b. Lateral view of the head of a larva of *Gnatholepis thompsoni* on which occurs an eye-stripe ventrad to the eye.





Gobionellus group

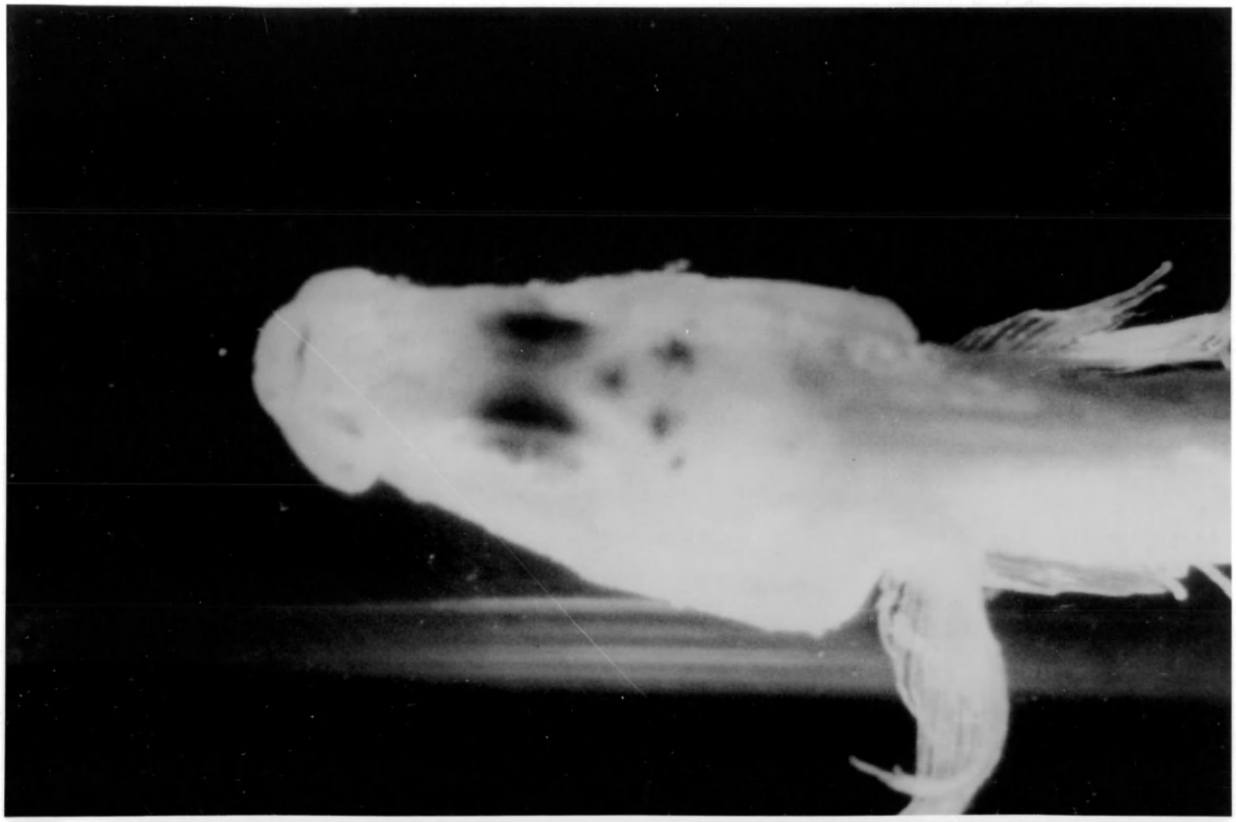
Morphological category 3: Ctenogobius sp., Gobionellus oceanicus or Oxyurichthys stigmalophius

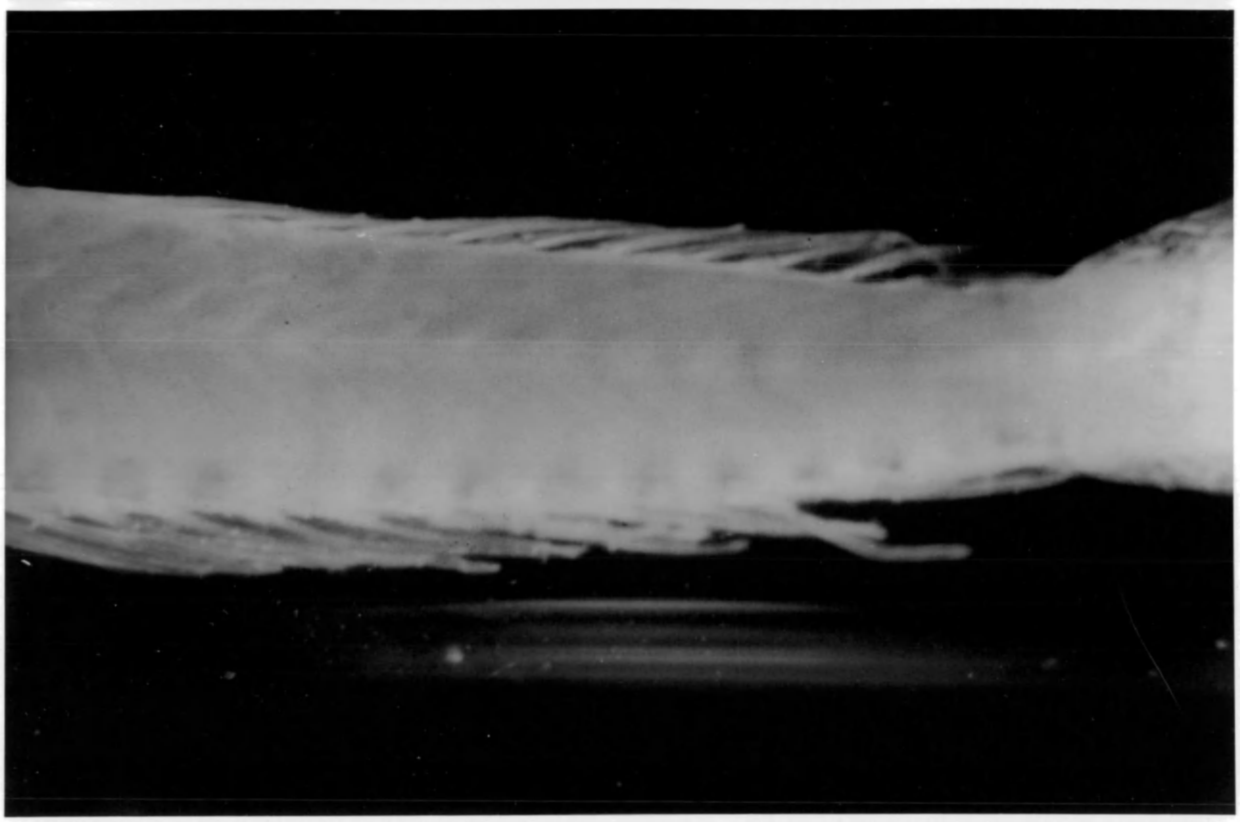
This morphological category was represented by a single specimen of 24.8 mm SL. It is elongate with a moderate-sized head and exhibits a series of large, round melanophores along the ventral midline from the beginning of the anal fin to the caudal fin. Two, external vertical pigment dashes occur over the hypural plates of the caudal fin. Three large clusters of melanophores occur over the brain, and there is a single melanin blotch on the tip of the upper jaw of this larva (Figure 10a-b). Morphometrics for this specimen are presented in Table 3.

Osteological characters of morphological category 3 matched four genera within the Gobionellus group of Birdsong et al. (1988): Ctenogobius, Gnatholepis, Gobionellus, and Oxyurichthys (Table 2). Second dorsal and anal-fin element counts of 13 and 14, respectively, (Table 2), fit for at least four species of Ctenogobius, as well as Gobionellus and Oxyurichthys, both of which contain one known Caribbean Sea species (Tables 4, 6). Oxyurichthys stigmalophius has second dorsal and anal-fin element counts of 13 and 14, respectively (ANSP 81233, 81855, and 144295; UMML 3992).

Figure 10a. Dorsal view of the head of the larva of category 3 (Ctenogobius, Gobionellus, or Oxyurichthys) at 24.8 mm SL. Three clusters of melanophores form a triangular pattern on the head, and there is a melanin blotch on the upper jaw of this larva.

Figure 10b. Posterior lateral view of the larva of category 3 showing a series of anal-fin melanophores and two, vertical pigment dashes over the hypurals.





Gobionellus group

Three-hundred eleven larval gobies, ranging in size from 7.4 - 11.4 mm SL, were non-pigmented and, therefore, could not be grouped according to patterns of pigmentation. Gross morphology of these specimens appeared similar to *Gobionellus* group specimens and suggested that these, too, might belong to that group. Clearing and staining of specimens within this non-pigmented lot (n=79) revealed that five larvae had osteological and meristic characters identical to morphological category 1, and the remaining specimens compared identically to morphological category 2. It is possible that these specimens are different *Ctenogobius* and *Gnatholepis* species than morphological categories 1 and 2 (and, therefore, *Gnatholepis* is not monotypic in the Caribbean Sea), but complete external pigmentation loss in preservation may be an equally valid explanation.

Table 2. Summary of meristic variability in cleared and stained specimens of three morphological categories of larval gobies in the Gobionellus group of Birdsong et al. (1988). Values in parentheses are number of individuals that exhibited a minority trait. Abbreviations are:

N= Number of cleared and stained specimens
Dorsal-fin= dorsal-fin formula of Birdsong et al. (1988)
Vertebrae= pre-caudal plus caudal vertebrae
Anal pter= anal-fin pterygiophores anterior to first haemal spine
2nd D= second dorsal-fin elements
Anal= anal-fin elements

Morph	N	Dorsal-fin	Vertebrae	Epurals	Anal pter	2nd D	Anal
1	33	3-12210	10+16	1(1)-2	2	12	12(1)-13
2	15	3-12210	10+16	2	2	12	12
3	1	3-12210	10+16	2	2	13	14

Table 3. Summary of morphometric data for three morphological categories of larval gobies in the Gobionellus group of Birdsong et al. (1988). Measurements are expressed as percent standard length. Abbreviations are:

N= Number of specimens measured
SD= Standard deviation
HL= Head length
PDFL= Pre-dorsal-fin length
PAL= Pre-anal length
PAFL= Pre-anal-fin length
BDD= Body depth at first dorsal-fin spine
BDA= Body depth at last anal-fin ray
CPD= Caudal peduncle depth

	HL	PDFL	PAL	PAFL	BDD	BDA	CPD
Morph 1 (N=31)							
Mean	.25	.37	.52	.53	.14	.10	.06
Range	.21-.30	.29-.40	.48-.55	.49-.57	.11-.16	.07-.13	.05-.08
SD	.02	.02	.01	.01	.01	.02	.01
Morph 2 (N=25)							
Mean	.26	.37	.49	.51	.14	.11	.08
Range	.25-.30	.34-.40	.47-.51	.48-.53	.11-.16	.08-.13	.07-.09
SD	.01	.01	.01	.01	.01	.01	.01
Morph 3 (N=1)	.25	.35	.50	.52	.13	.08	.08

Table 4. Total second dorsal and anal-fin elements in Caribbean Sea species of Ctenogobius. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values. Assignment of former Gobionellus species to Ctenogobius follows Pezold, F.L. (personal communication).

Species	Second dorsal-fin	Anal-fin	Source of Data
boleosoma	10-12	11-13	181, 6, 89, 197
	11	11-13	72, 80
	11	12	182, 147, 31, 20, 194 SU 1675 UMML 13613 UMMZ 184680 USNM 287153
	11-12	9-10	144
	11-12	12-13	248
	12	13	99
fasciatus	11	10	194
	11-13	12-14	181
	12	13	UMMZ 147536 UMMZ 180655 UMMZ 199685 USNM 293437
phenacus	11-12	12-13	183
pseudofasciatus	11-12	12-13	181 USNM 293464
	12	13	ANSP 109179 UMMZ 199544
	12-13	12-13	95

Table 4. (continued).

Species	Second dorsal-fin	Anal-fin	Source of Data
saepepallens	11-13	12-14	86
	11-13	12-13	181
	12	13	ANSP 109180 ANSP 86135 USNM 167676
smaragdus	10-12	11-12	181
	11	12	89 UMML 733 UMMZ 189754
stigmaticus	11-12	12-13	181, 144
	12	13	89, 20, 99 UMMZ 210445
stigmaturus	11-13	11-14	181
	12	13	6, 89
	12-13		UMMZ 189866
thoropsis	12-13	13-14	183

Table 5. Total second dorsal and anal-fin elements in Caribbean Sea species of *Gnatholepis*. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
thompsoni	11	12	USNM Beebe coll. uncat.
	12	11	USNM 218840
	12	11-12	6
	12	12	189
			20
			CAS 31752
			USNM acc. no. 294338
			USNM 144046
			USNM 178879
			USNM 276130
			USNM 276216

Table 6. Total second dorsal and anal-fin elements in Caribbean Sea species of Gobionellus. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
oceanicus	13-15	14-15	181
	14	15	20 144 RMNH 4679 UMML 2446 UMMZ 173099 UMMZ 209794 USNM 49365 USNM 123228 USNM 205203 USNM 265066
	14	14-15	89

Priolepis group:

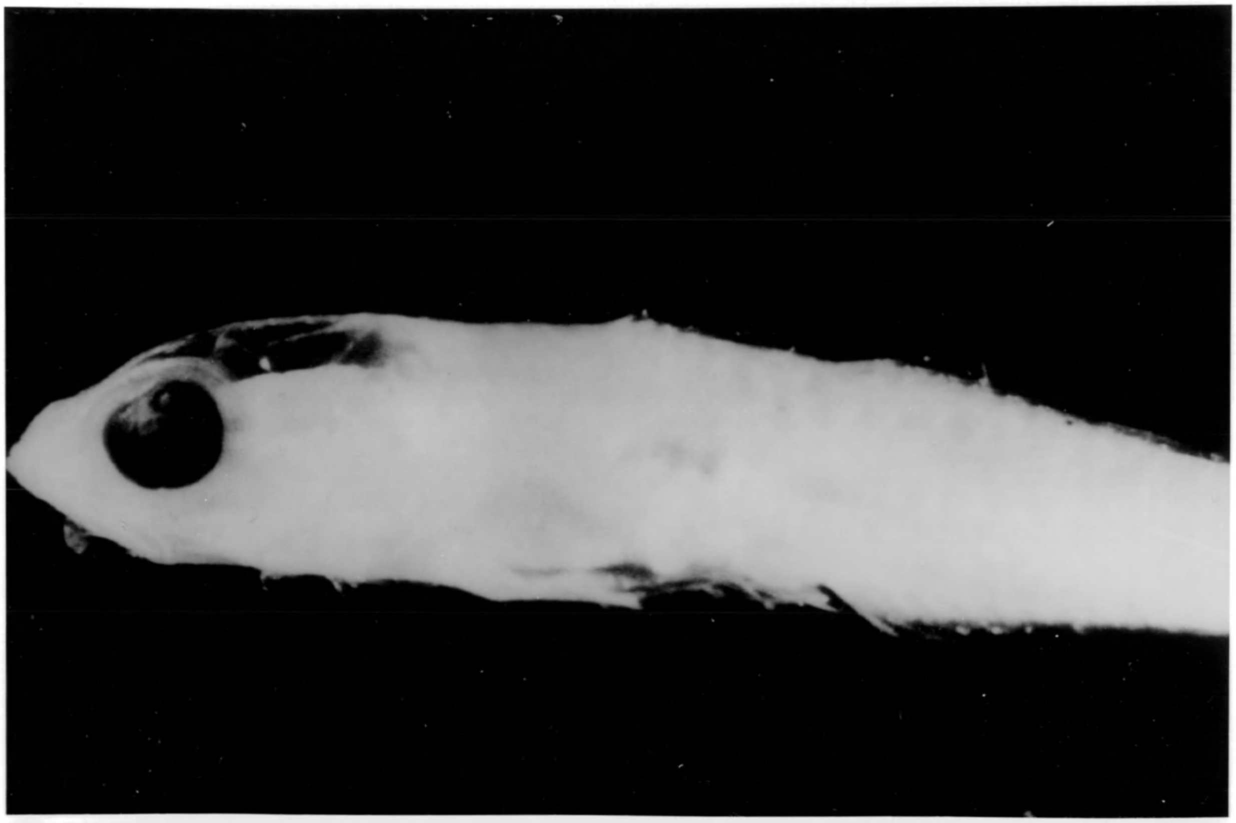
Morphological category 4: Coryphopterus sp.

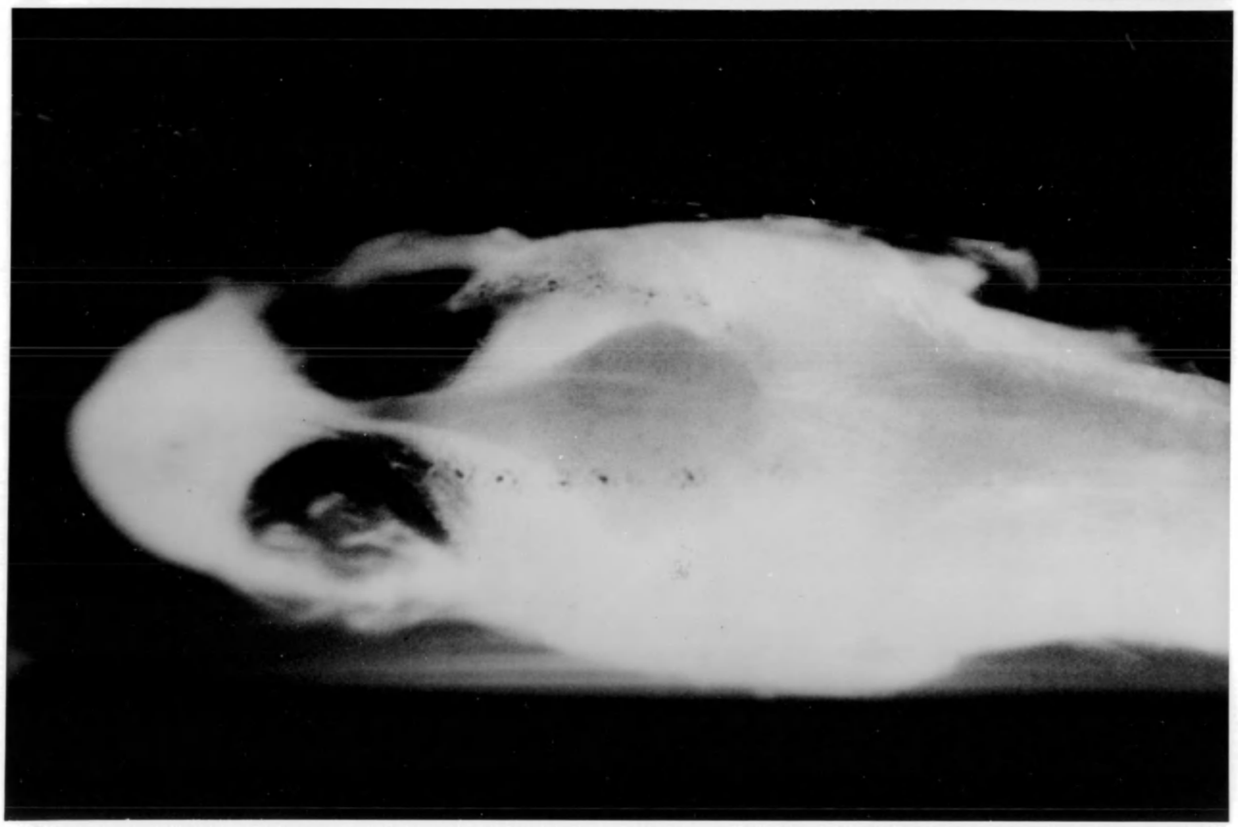
Thirty-two Coryphopterus larvae, ranging in size from 5.4 - 6.9 mm SL, were collected. Coryphopterus larvae are elongate with a moderate-sized head and possess two to three stripes of small, faint stellate melanophores that run anteriorly to posteriorly along the length of the dorsal surface of the head (Figure 11a-b). Morphometrics for Coryphopterus are presented in Table 8.

Osteological characters examined in 17 specimens of morphological category 4 matched four genera within the Priolepis group of Birdsong et al. (1988): Coryphopterus, Lophogobius, Lythrypnus, and Priolepis (Table 7). Second dorsal and anal-fin element counts of 10 and 10-11 (usually 10), respectively, (Table 7), fit for at least seven Coryphopterus species but also fall within the meristic ranges of at least one species of Lophogobius, Lythrypnus, and Priolepis. However, the pattern of cephalic stripes in morphological category 4 appeared to be the precursor of bolder, but similar, pigmentation seen on juveniles of Coryphopterus sp. (personal field observation), and, on the basis of this observation, this category was tentatively identified as Coryphopterus sp. (Tables 9-12).

Figure 11a. A larva of Coryphopterus sp. at 6.9 mm SL.

Figure 11b. Dorsal view of the head of a larva of Coryphopterus sp. at 6.2 mm SL on which occurs two stripes of small stellate melanophores.





Priolepis group:

Morphological category 5: Coryphopterus sp., Lophogobius cyprinoides, Lythrypnus sp., or Priolepis sp.

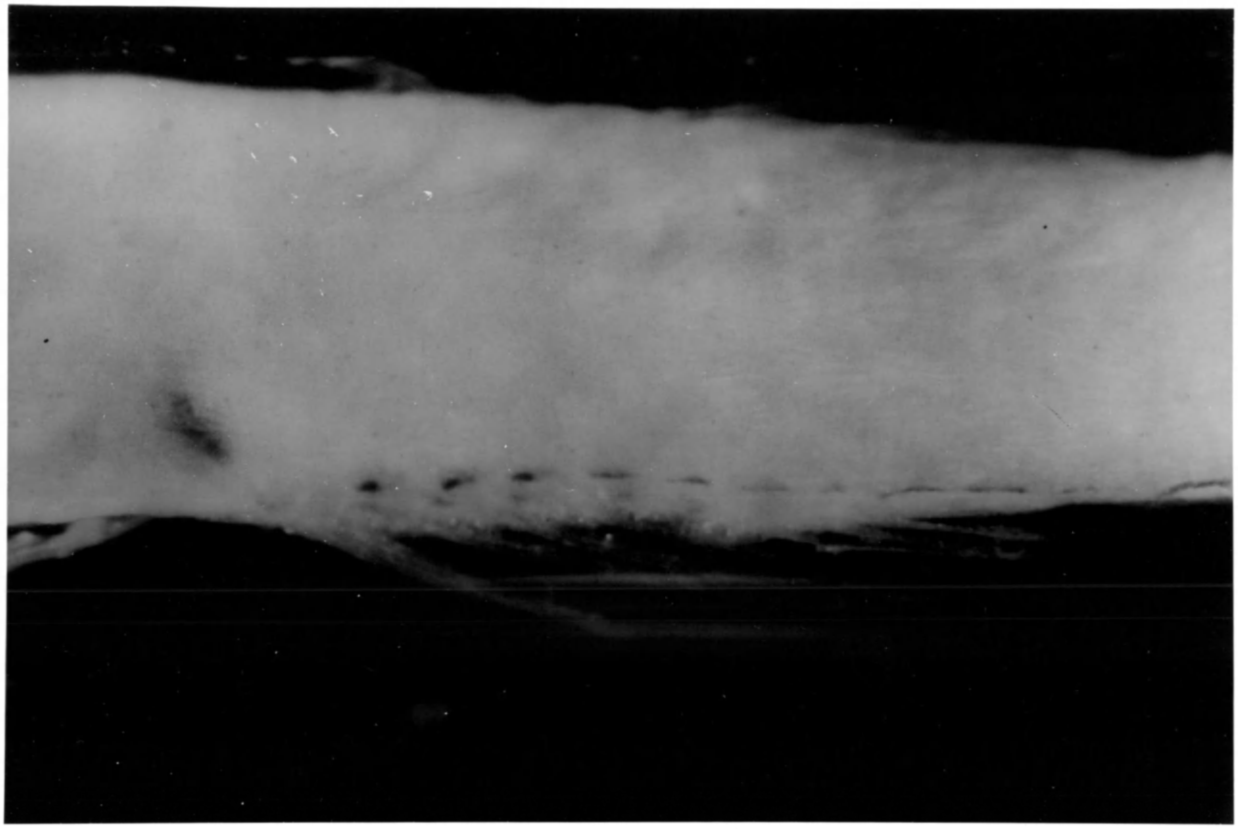
Larvae in this morphological category (n=138) ranged in size from 5.4 - 8.1 mm SL. Larvae in morphological category 5 are elongate with a moderate-sized head. Dashed lines of dark melanophores along the ventral midline of the body characterize these larvae. A dashed line occurs at the cleithrum and continues posteriorly to the region of the developing pelvic fraenum. Paired dashed lines occur along the ventral midline the length of the anal fin. A single dashed line continues from the posterior base of the anal fin to the caudal fin (Figure 12a-c). Morphometrics for this category are presented in Table 8.

Osteological characters examined in 20 specimens of morphological category 5 matched four genera within the Priolepis group of Birdsong et al. (1988): Coryphopterus, Lophogobius, Lythrypnus, and Priolepis (Table 7). Second dorsal and anal-fin element counts for morphological category 5 of 10 and 8-11 (usually 10), respectively, (Table 7), fall within the meristic ranges of at least eight Coryphopterus and Lythrypnus species, two Priolepis species, and Lophogobius, for which only one species is known from the Caribbean Sea (Tables 9-12).

Figure 12a. A larva of category 5 (*Coryphopterus*, *Lophogobius*, *Lythrypnus*, or *Priolepis*) at 7.1 mm SL.

Figure 12b. Ventral view of the head and pelvic-fin region of a larva of category 5. A dashed line of pigment occurs on the cleithrum and developing pelvic fraenum.


Figure 12c. Lateral mid-body view of a larva of category 5. A paired dashed line of pigment occurs along the anal fin. Posterior to the anal fin, a single dashed line of pigment continues to the caudal peduncle.



Priolepis group:

Morphological category 6: Coryphopterus sp., Lophogobius cyprinoides, Lythrypnus sp., or Priolepis sp.

This morphological category was represented by a single specimen of 5.4 mm SL. It is elongate with a moderate-sized head and exhibits a large, dorsal pigment patch (just posterior to the dorsal fin) which is opposed by a smaller, single, ventral melanin spot, midway between the anus and caudal fin (Figure 13a-b). Morphometrics for this specimen are presented in Table 8.

Osteological characters of morphological category 6 matched four genera within the Priolepis group of Birdsong et al. (1988): Coryphopterus, Lophogobius, Lythrypnus, and Priolepis (Table 7). Second dorsal and anal-fin element counts for morph 8 of 10 and 9, respectively, (Table 7), fall within the meristic ranges of at least eight Lythrypnus species, five Coryphopterus species, and one Priolepis and Lophogobius species (Tables 9-12).

Figure 13a. Larva of category 6 (*Coryphopterus*, *Lophogobius*, *Lythrypnus*, or *Priolepis*) at 5.4 mm SL.

Figure 13b. Posterior lateral view of the larva of category 6 showing a large, dorsal pigment patch opposed by a smaller, ventral melanin spot.

Table 7. Summary of meristic variability in cleared and stained specimens of three morphological categories of larval gobies in the *Priolepis* group of Birdsong et al. (1988). Values in parentheses are number of individuals that exhibited a minority trait. Abbreviations are:

N= Number of cleared and stained specimens
Dorsal-fin= dorsal-fin formula of Birdsong et al. (1988)
Vertebrae= pre-caudal plus caudal vertebrae
Anal pter= anal-fin pterygiophores anterior to first haemal spine
2nd D= second dorsal-fin elements
Anal= anal-fin elements

Morph	N	Dorsal-fin	Vertebrae	Epurals	Anal pter	2nd D	Anal
4	17	3-22110	10+16	1	2	10	10-11(1)
5	20	3-22110	10+16	1	2	10	8(1)-9(2)-10-11(1)
6	1	3-22110	10+16	1	2	10	9

Table 8. Summary of morphometric data for three morphological categories of larval gobies in the Priolepis group of Birdsong et al. (1988). Measurements are expressed as percent standard length. Abbreviations are:

N= Number of specimens measured
SD= Standard deviation
HL= Head length
PDFL= Pre-dorsal-fin length
PAL= Pre-anal length
PAFL= Pre-anal-fin length
BDD= Body depth at first dorsal-fin spine
BDA= Body depth at last anal-fin ray
CPD= Caudal peduncle depth

	HL	PDFL	PAL	PAFL	BDD	BDA	CPD
Morph 4 (N=14)							
Mean	.30	.39	.52	.55	.16	.12	.07
Range	.26-.33	.36-.40	.50-.54	.52-.56	.14-.17	.10-.12	.07-.10
SD	.02	.01	.01	.01	.01	.01	.01
Morph 5 (N=22)							
Mean	.30	.39	.53	.55	.17	.13	.08
Range	.28-.32	.34-.42	.49-.58	.51-.61	.14-.21	.10-.15	.06-.11
SD	.01	.02	.02	.02	.02	.01	.01
Morph 6 (N=1)	.33	.47	.56	.58	.22	.17	.14

Table 9. Total second dorsal and anal-fin elements in Caribbean Sea species of *Coryphopterus*. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
alloides	9-10	8-9	12
dicrus	9-10	9-10	USNM acc. no. 249592
	10	10	12
eidolon	10	9-10	12
glaucofraenum	9-10	10	12
	10	10	189, 20 USNM acc. no. 249592 USNM 73255 USNM 82516
hyalinus	10	9-11	13
	10	10	USNM 267844
	10	10-11	USNM 267835
lipernes	10	10	189, 13
personatus	10-11	10-11	189, 13
	11	11	USNM 088631
punctipectophorus	11	10	12
	11		189
thrix	9-10	10	174, 12 USNM acc. no. 249592
	10	10	USNM acc. no. 249592

Table 10. Total second dorsal and anal-fin elements in Caribbean Sea species of Lophogobius. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
cyprinoides	9-10	9	USNM 178729
	10	9	20, 6, 144 USNM 9767 USNM 37509 USNM 74087 USNM 122649 USNM 122650 USNM 123545 USNM 123648 USNM 133744 USNM 178728 USNM 178890 USNM 192080 USNM 192235
	10	9-10	USNM 144048 USNM 226370
	10	10	USNM 178887
	10-11	9	USNM 147632
	10-11	9-10	118 USNM 134679

Table 11. Total second dorsal and anal-fin elements in Caribbean Sea species of *Lythrypnus*. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
crocodilus	10	9	11 USNM 122614
elasson	9-10	9	174, 11
heterochroma	10	9	91
mowbrayi	10	9	11
minimus	9-10	8-9	82
nesiotes	10	8-9	20
	10-11	9	11
okapia	9	8	195
phorellus	10	9	11
spilus	9-10	9-10	11

Table 12. Total second dorsal and anal-fin elements in Caribbean Sea species of *Priolepis*. Numbers refer to the publications, cited in Appendix III, from which data were extracted.

Species	Second dorsal-fin	Anal-fin	Source of Data
hipoliti	9-10	8-10	83
robinsi	9,11	9-10	83

Bathygobius group:

Morph 7: Bathygobius sp.

One-hundred sixteen Bathygobius larvae were collected and ranged in size from 5.0 - 7.7 mm SL. Bathygobius larvae are elongate with a moderate-sized head and are the most heavily pigmented gobiids from the survey material. They possess a stellate melanophore on the tip of the dentary and two opposing lines of pigment on the ventral surface in the region of the urohyal and perpendicular to the ventral midline. Large stellate melanophores occur on the cleithrum and developing pelvic fraenum and along both the dorsal and ventral midlines of the larvae, in the region of the dorsal and anal fins, extending to the caudal fin. These melanophores are darker and larger, however, on the ventral surface. Additionally, the ventral melanophores extend internally from the anus to over the gas bladder (Figure 14a-d).

Morphometric measurements taken on 15 Bathygobius specimens are expressed as percent SL and are summarized as follows:

	Mean	Range	Standard deviation
Head length	.31	.28-.34	.02
Pre-dorsal-fin length	.42	.37-.46	.03
Pre-anal length	.54	.51-.56	.01
Pre-anal-fin length	.56	.54-.59	.01
Body depth at first dorsal spine	.17	.15-.20	.01
Body depth at last anal ray	.13	.11-.15	.01
Caudal peduncle depth	.08	.07-.10	.01

Gross morphology and pigmentation of specimens of morphological category 9 appeared similar to illustrations of Bathygobius soporator larvae in Peters (1983). Osteological and meristic characters of larvae of category 9 were as follows and corroborated identification of the larvae as Bathygobius: dorsal-fin formula= 3-22110; vertebrae= 10+17; epural= 1; anal-fin pterygiophores anterior to the first haemal spine= 2; second dorsal-fin elements= 9-10, usually 10; anal-fin elements= 9.

The species of Bathygobius represented by these specimens was undeterminable by meristic examination (Table 13), but may be soporator based on similarity to Peters' (1983) illustrations.

Figure 14a. A larva of Bathygobius sp. at 5.6 mm SL.

Figure 14b. Dorsal view of a larva of Bathygobius sp. showing the dorsal series of pigment spots.

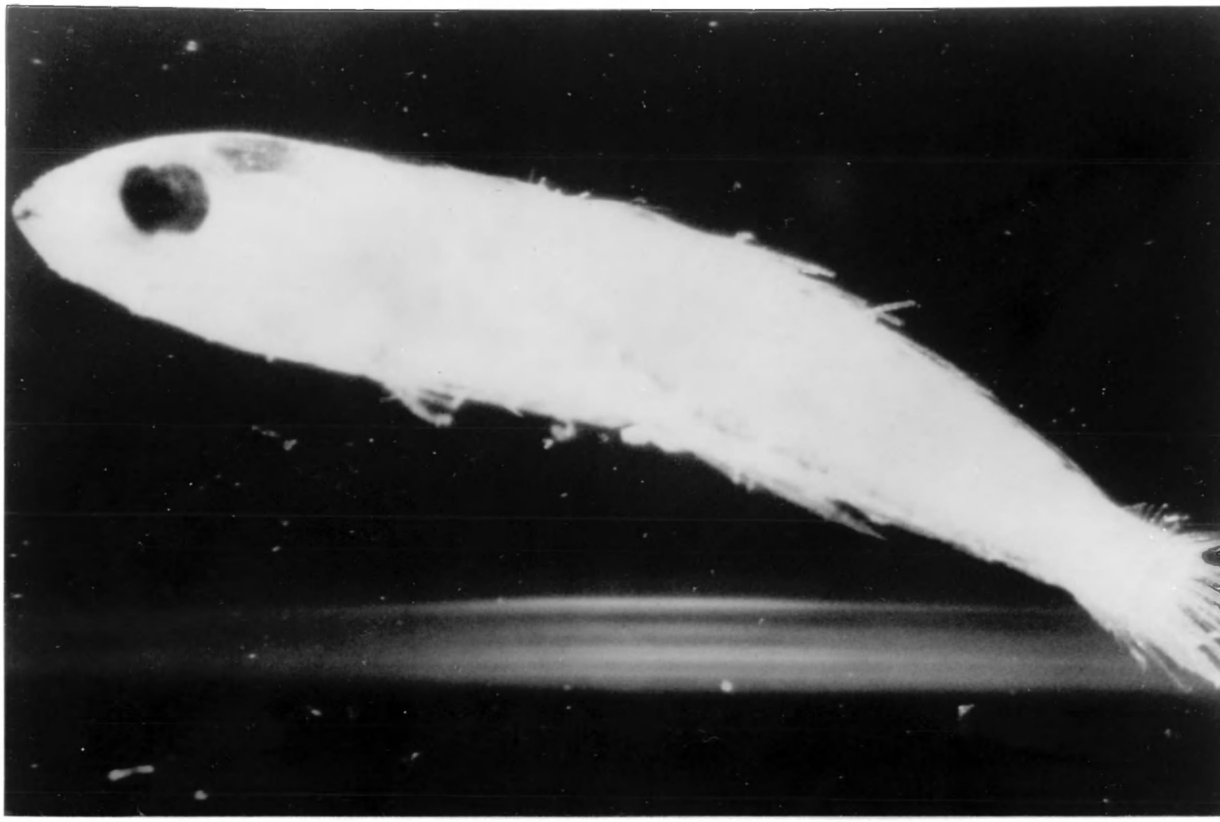
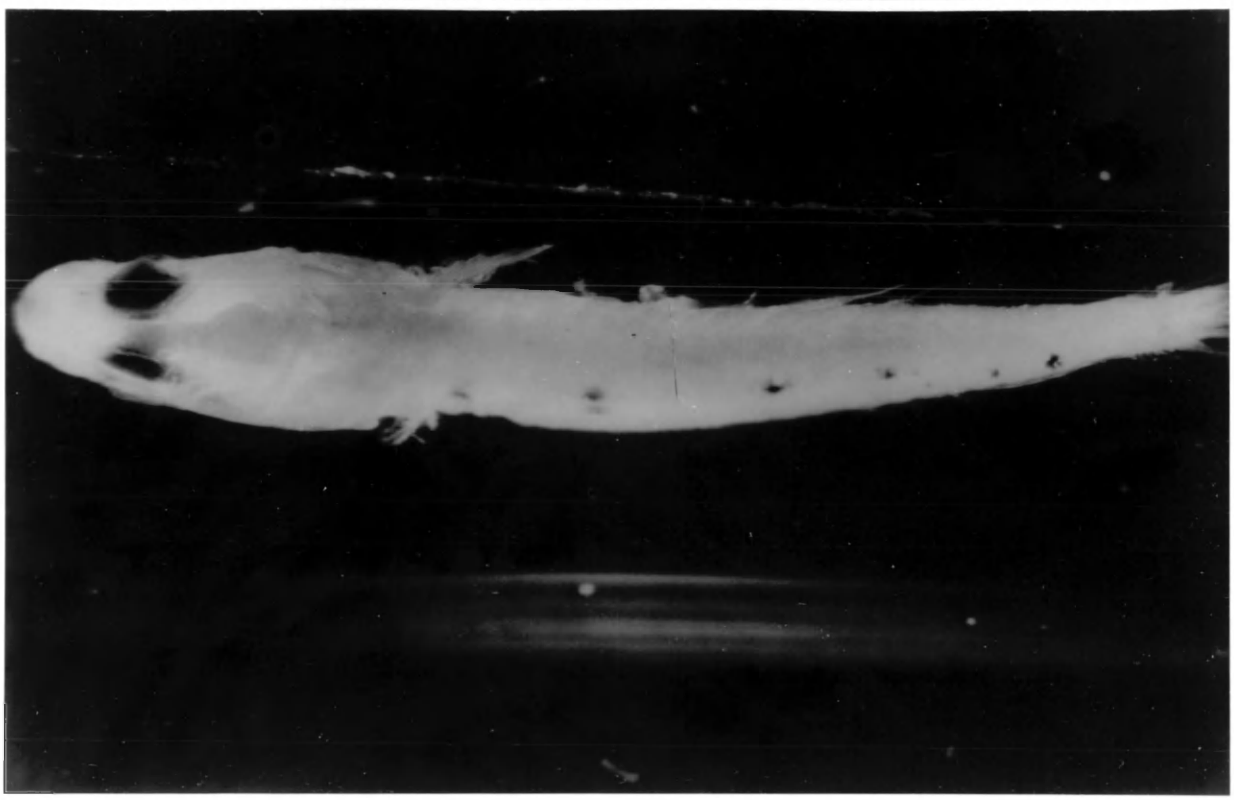
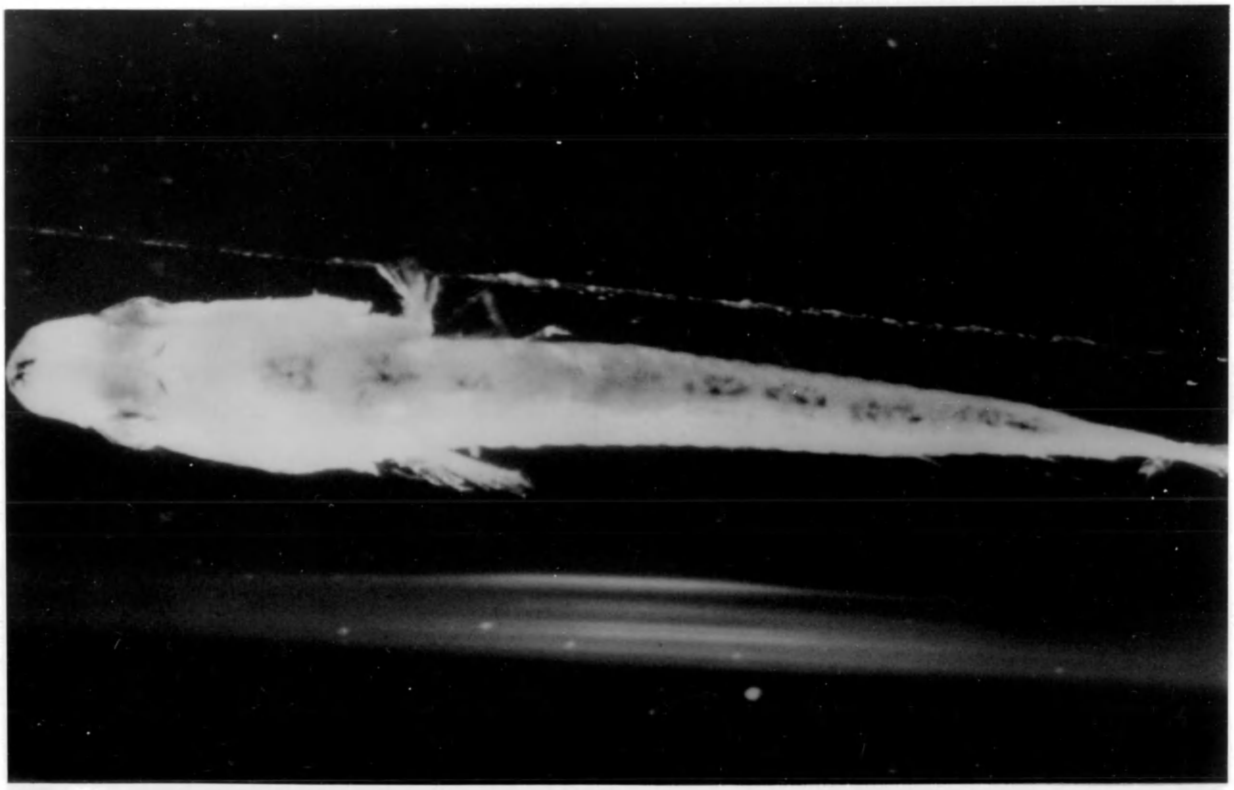



Figure 14c. Ventral view of a larva of Bathygobius sp. showing a large stellate melanophore on the dentary and two opposing lines of pigment in the region of the urohyal. A line of large stellate melanophores begins at the cleithrum and continues along the ventral midline of the larva to the caudal region.

Figure 14d. Ventral view of the head and pelvic-fin region of a larva of Bathygobius sp.



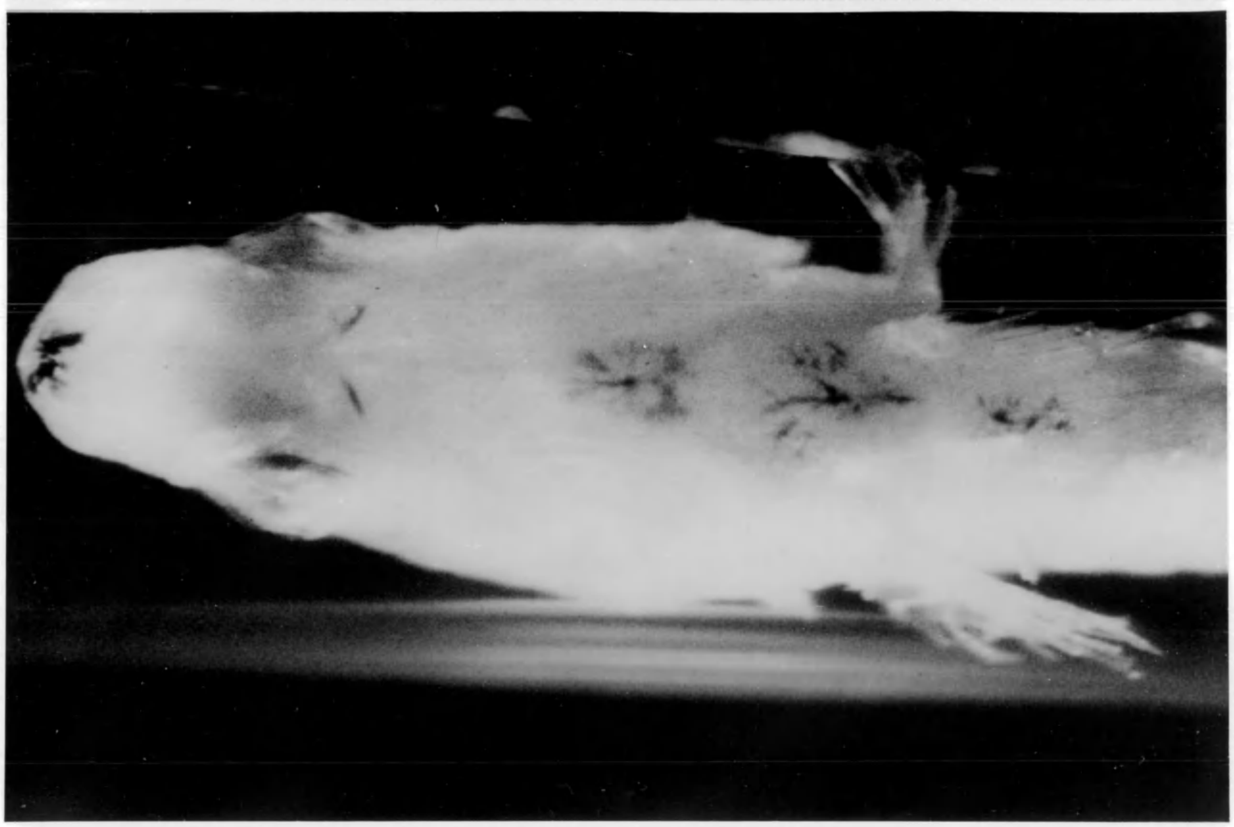


Table 13. Total second dorsal and anal-fin elements in Caribbean Sea species of Bathygobius. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
curacao	10	9	USNM 81810 USNM 119322 USNM 119324 USNM 219094
soporator	9-10	9	6, 144 USNM 121544 USNM 192320
	10	9	177, 20, 197 USNM 648 USNM 22853 USNM 81801 USNM 81815 USNM 192066 USNM 287163
	10	11	TCWC 3275.1
	10-11	8-10	189
	10-11	9	USNM 192068

Gobiosoma group:

Morphological categories 8-10: Gobiosoma sp.

Morphological category 8 consisted of two larvae, 6.6 and 6.8 mm SL. These larvae are elongate with a moderate-sized head and were grouped according to their pattern of small stellate melanophores which form three to four side-to-side lines across the brain. In addition, three to four, large stellate melanophores are present on the ventral surface of the larvae under the anal fin (Figure 15a-d). Two pairs of basi-caudal scales, one dorsal and one ventral, are present on morphological category 8 larvae (Figure 18). Morphometrics for category 8 are presented in Table 15.

Two larvae of 6.8 and 7.8 mm SL made up morphological category 9. These larvae are elongate with a moderate-sized head. A single, large, stellate ventral melanophore just posterior to the anal fin is the only pigmentation on the larvae of morphological category 9 (Figure 16a-b). Two pairs of basi-caudal scales, one dorsal and one ventral, are present on morph 11 larvae (Figure 18). Morphometrics for category 9 are presented in Table 15.

Morphological category 10 was comprised of three larvae, ranging in size from 6.5 - 7.2 mm SL. These larvae are elongate with a moderate-sized head and have three, very large stellate melanophores on the ventral surface, along and just posterior to the anal fin (Figure 17a-b). Two pairs of basi-caudal scales, one dorsal and one ventral, are present on larvae of morphological category 10 (Figure 18). Morphometrics for category 10 are presented in Table 15.

Osteological characters of morphological categories 8-10 matched at least three genera within the Gobiosoma group of Birdsong et al. (1988):

Gobiosoma, *Gobulus*, and *Risor* (Table 14). The genera *Ginsburgellus* and *Nes* were also reported by Birdsong et al. (1988) to have dorsal-fin formula= 3-221110 and number of vertebrae= 11+17, but the numbers of epurals and anal-fin pterygiophores anterior to the first haemal spine for these two genera were not reported. Larval second dorsal and anal-fin element counts for morphological categories 8-10 of 11 and 9, respectively, (Table 14), fit for species of *Gobiosoma*, *Gobulus*, and *Risor* but not for *Ginsburgellus* or *Nes* (Tables 16-19). Since the modal dorsal-fin formula for *Risor* is 3-230110 (Birdsong et al., 1988) and *Gobulus* are completely devoid of scales (Bohlke and Chaplin, 1968), morphological categories 8-10 were identified as *Gobiosoma*. It is interesting to note that, in the 48 specimens of *Gobiosoma* examined by Birdsong et al. (1988), all were from the subgenera *Garmannia* and *Gobiosoma*, and 44 had 27 vertebrae while only three had 28 vertebrae. Bohlke and Robins (1968) reported a typical vertebral count of 28 for the subgenera *Elacatinus* and *Tigrigobius*.

Figure 15a. A larva of *Gobiosoma* *sp*. (category 8) at 6.6 mm SL.

Figure 15b. Dorsal view of the head of a larva of *Gobiosoma* *sp*. (category 8) exhibiting faint side-to-side lines of small stellate melanophores across the brain.

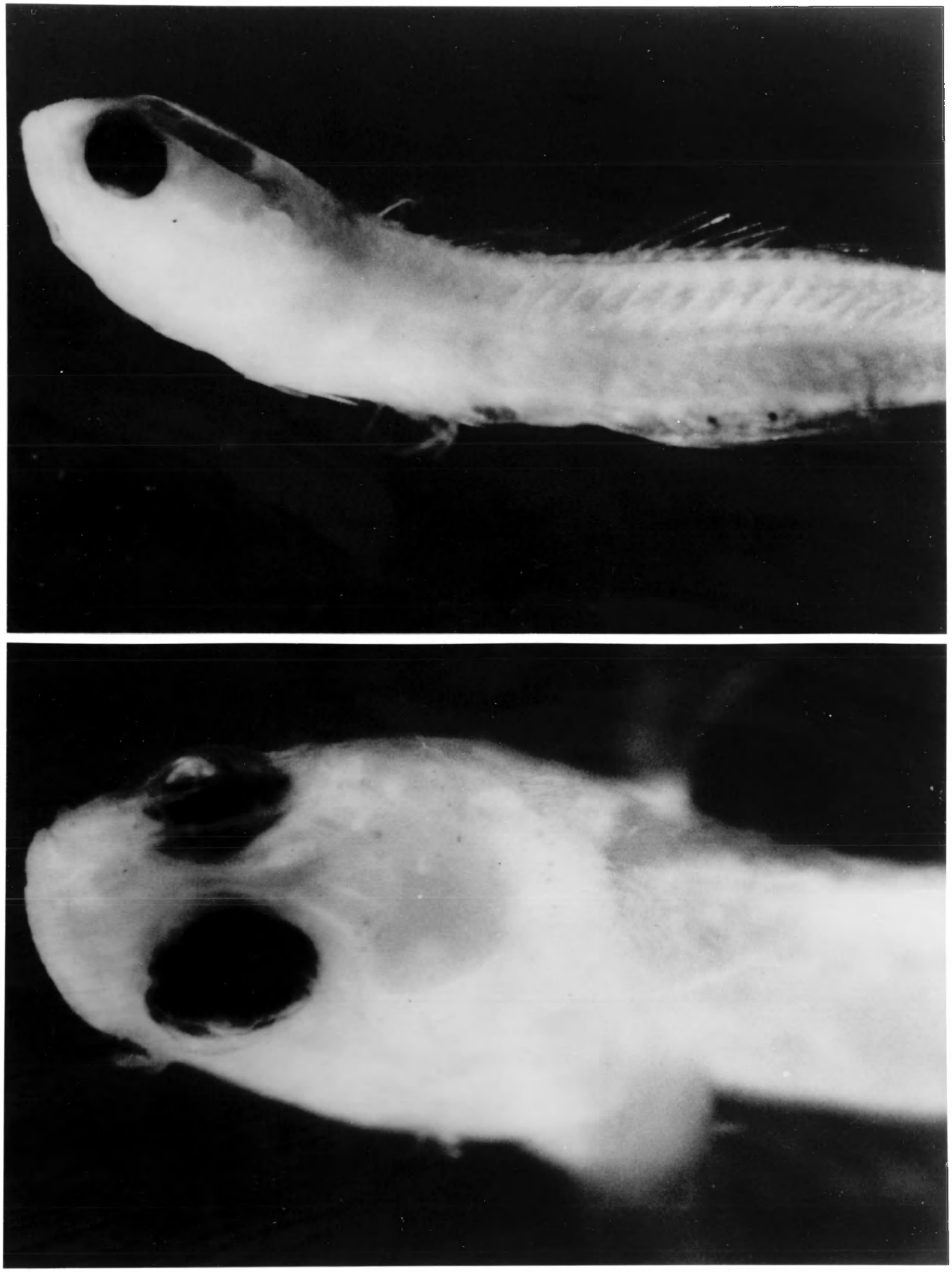
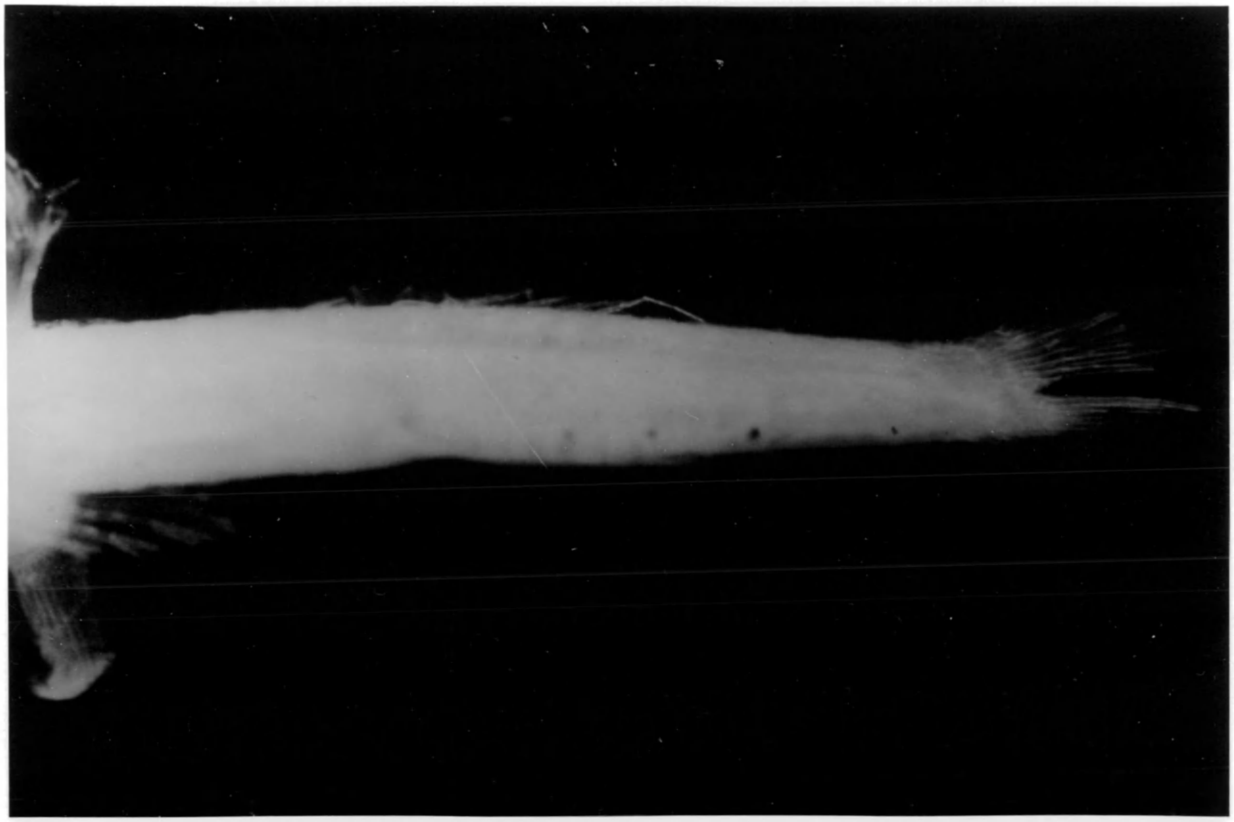


Figure 15c. Posterior ventral view of a larva of *Gobiosoma* *sp*. (category 8) showing large stellate melanophores under the anal fin.

Figure 15d. Lateral mid-body view of a larva of *Gobiosoma* *sp*. (category 8) showing large stellate melanophores under the anal fin.



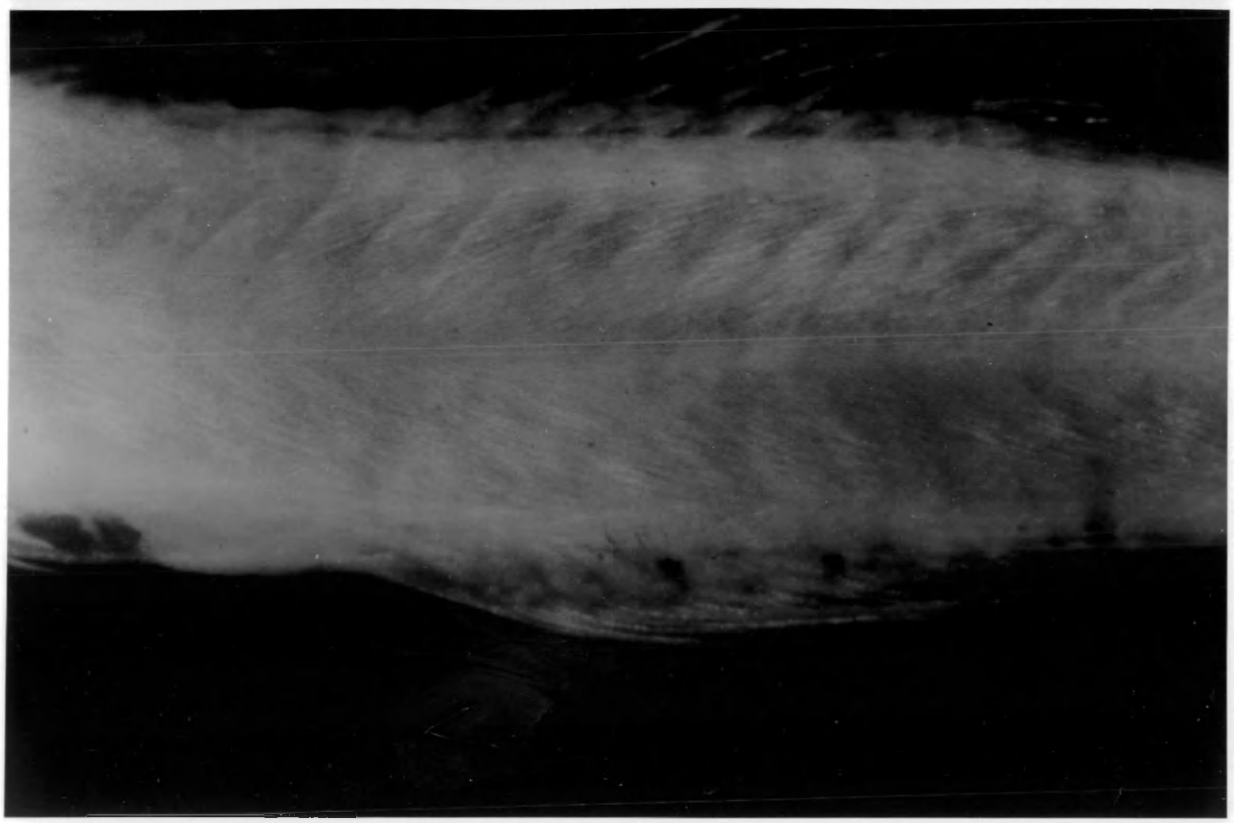
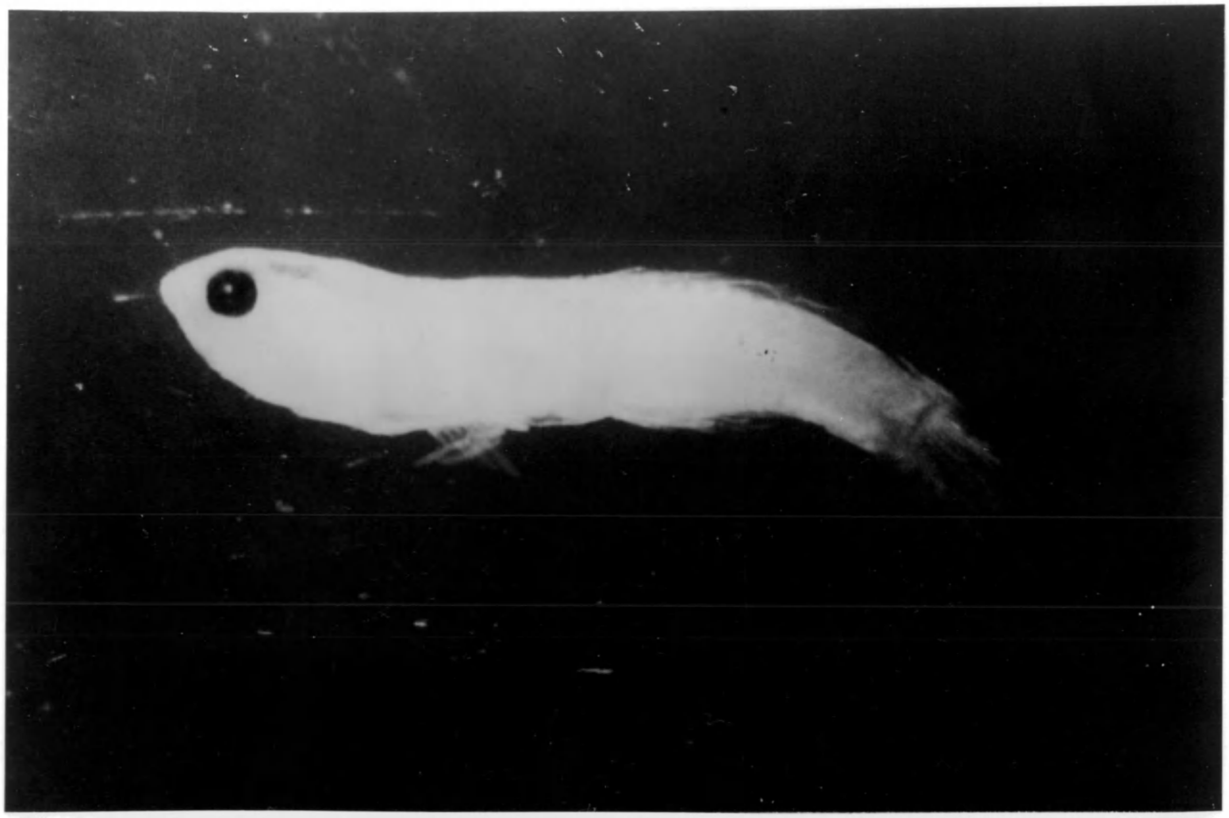


Figure 16a. A larva of a Gobiosoma sp. (category 9) at 7.8 mm SL.

Figure 16b. Ventral mid-body view of a larva of Gobiosoma sp. (category 9) showing a single, large stellate melanophore posterior to the anal fin.



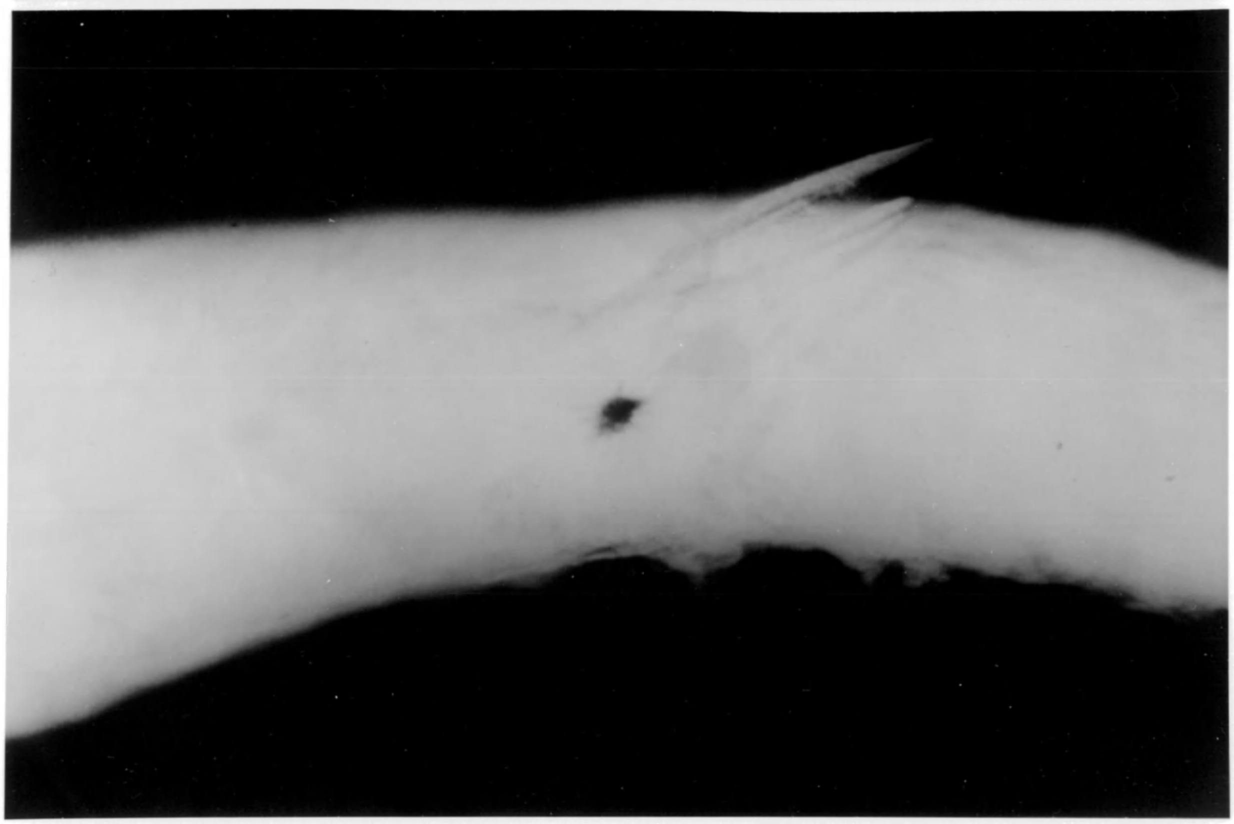
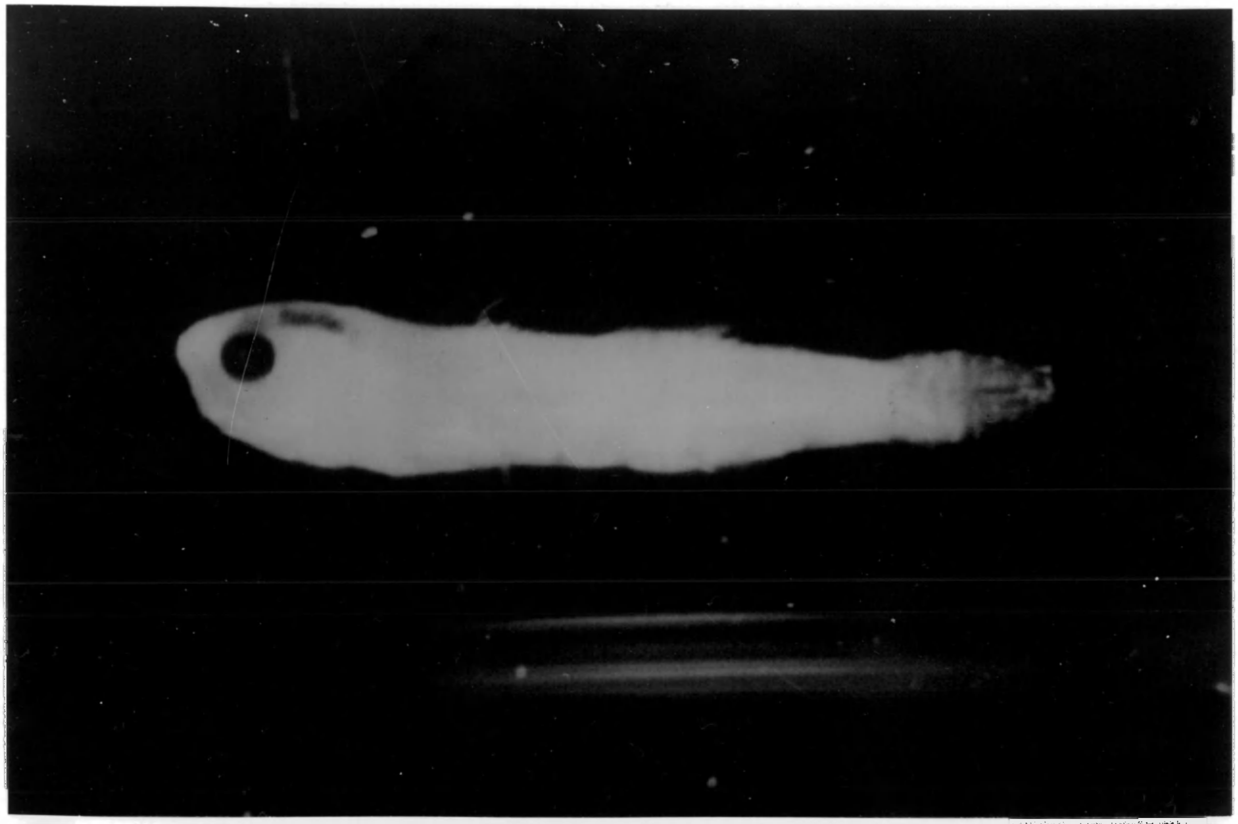


Figure 17a. A larva of a Gobiosoma sp. (category 10) at 7.1 mm SL.

Figure 17b. Lateral mid-body view of a larva of Gobiosoma sp. (category 10) showing three, large stellate melanophores along the ventral midline.



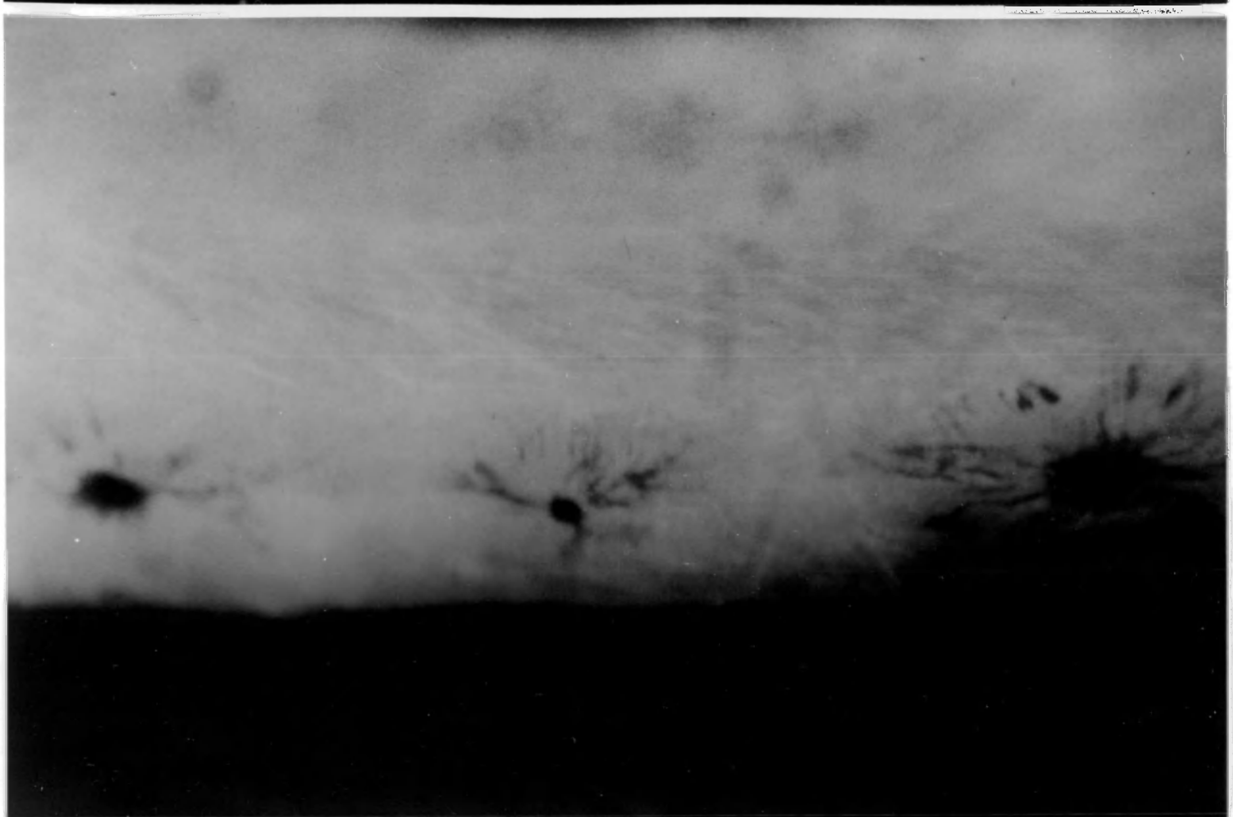
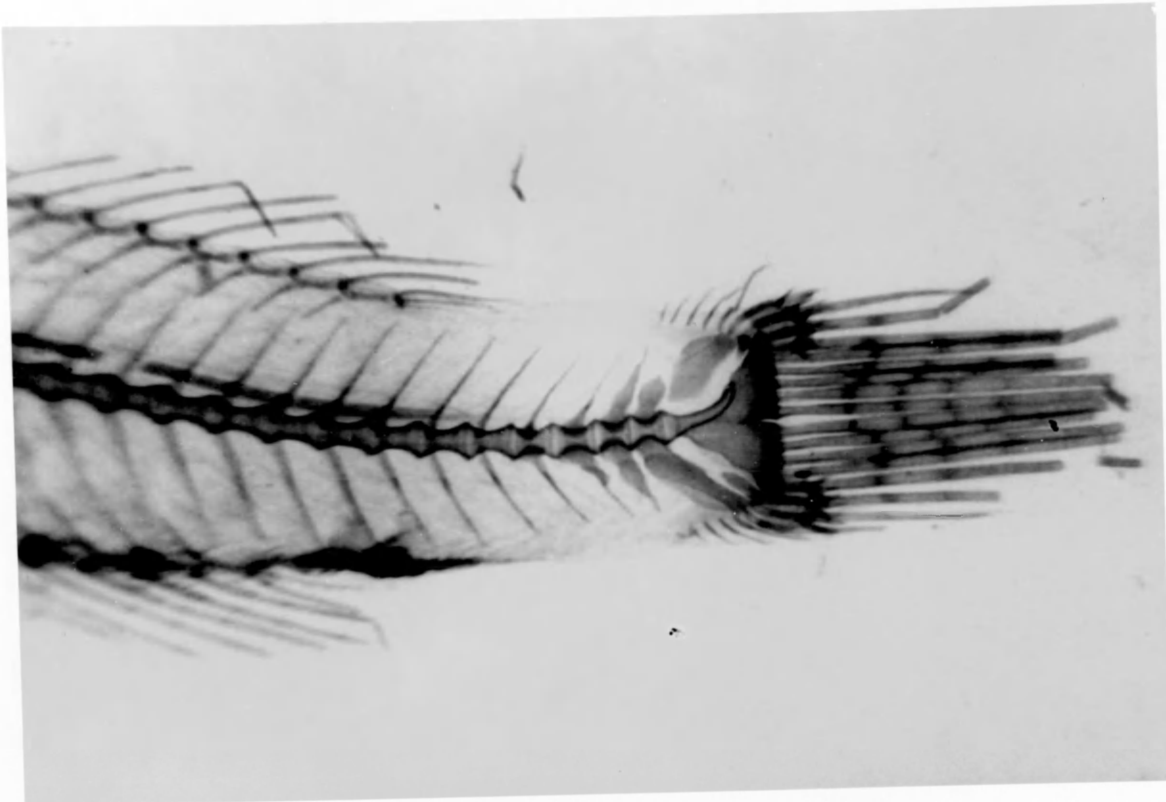


Figure 18. Posterior lateral view of a cleared and stained larva of *Gobiosoma* *sp*. (uncategorized) possessing two pairs of basi-caudal scales.



Gobiosoma group:

Morphological categories 11-12: Gobiosoma sp. or Nes longus

One larva in each category (11-12) was collected. One specimen measures 10.8 mm SL, is elongate with a moderate-sized head and is heavily pigmented in various regions on the head. On the dorsal surface of the head, pigment spots are found in two lines between the eyes, on either side of the brain, and lightly scattered posterior to the brain. A line of pigment spots occurs anterior to the eye from upper to lower jaw, ventrad to the eye, and in several more vertical rows along the operculum. A single, large ventral melanophore is located just posterior to the anal fin, with a smaller, lighter stellate melanophore slightly anterior (Figure 19a-d). Morphometrics for category 11 are presented in Table 15.

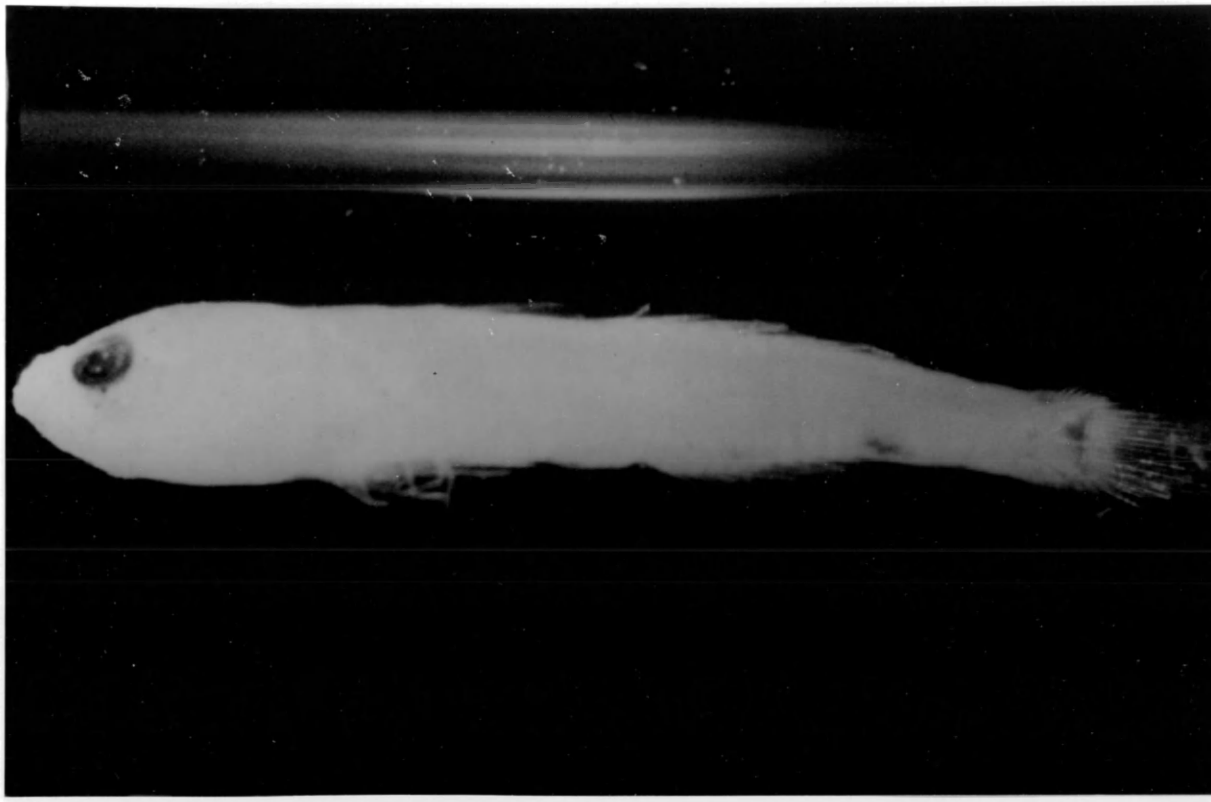
The other specimen measured 11.3 mm SL, is elongate with a moderate-sized head and exhibits a large, stellate melanophore posterior to the anal fin and a smaller, stellate melanophore midway between the anus and the larger melanophore. A line of pigment parallel to the ventral midline is found on the developing pelvic fraenum (Figure 20a-c). Morphometrics for category 12 are presented in Table 15.

Osteological characters of these larvae matched at least three genera within the Gobiosoma group of Birdsong et al. (1988): Gobiosoma, Gobulus, and Risor (Table 14). The genera Ginsburgellus and Nes were also reported by Birdsong et al. (1988) to have dorsal-fin formula= 3-221110 and number of vertebrae= 11+17, but the numbers of epurals and anal-fin pterygiophores anterior to the first haemal spine for these two genera were not reported. Counts of second dorsal- and anal-fin elements (13 and 11, respectively, for morphological categories 11 and

12 (Table 14)), fit for species of Gobiosoma and Nes longus (Tables 16-19). Examination of a radiograph of an adult specimen of Nes longus (USNM 116362) revealed a single epural and two anal-fin pterygiophores anterior to the first haemal spine, and is, therefore, a possible identification for either category 11 or 12. The species longus was, formerly, considered to belong to the Gobiosoma until Bohlke and Robins (1968) assigned it to Nes based on a lack of head pores in adult specimens.

Figure 19a. The larva of category 11 (*Gobiosoma* or *Nes*) at 10.8 mm SL.

Figure 19b. Dorsal view of the head of the larva of category 11 showing pigment spots in two lines between the eyes, on either side of the brain and lightly scattered posterior to the brain.



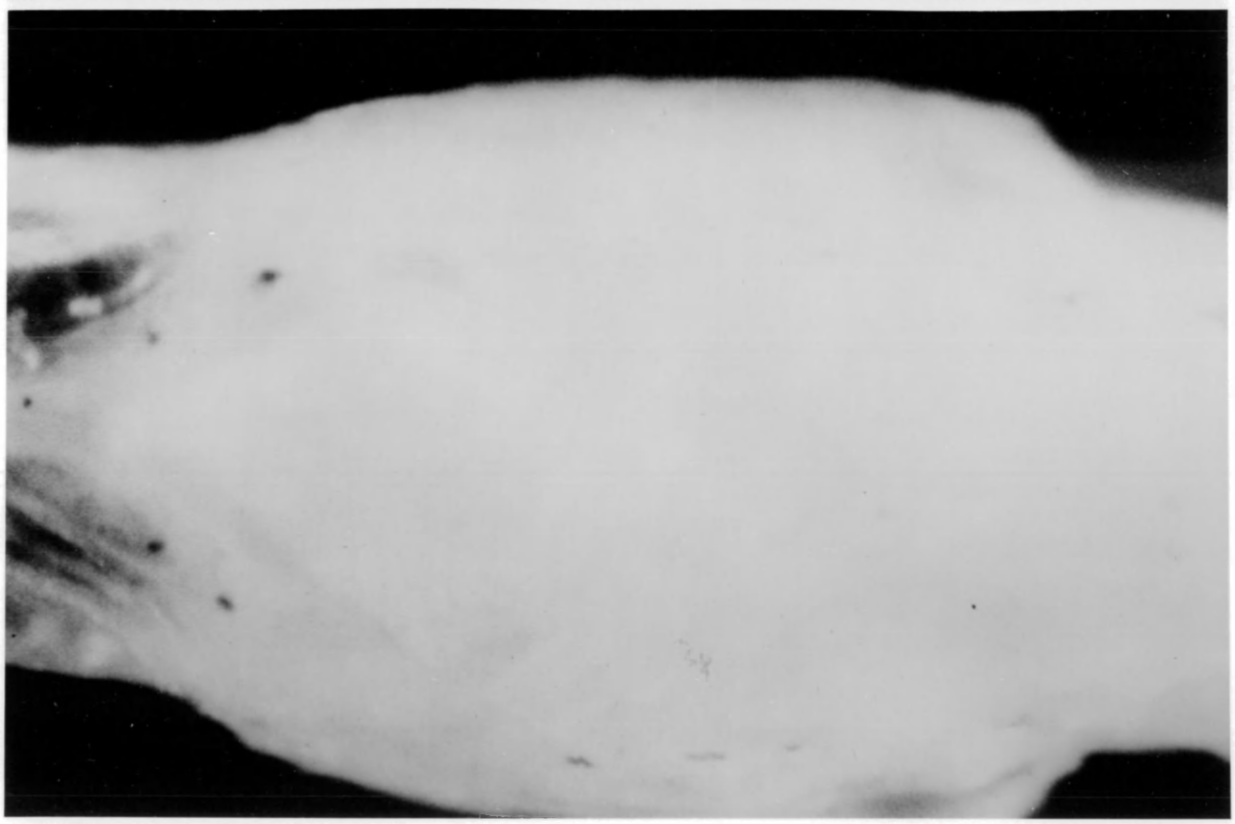
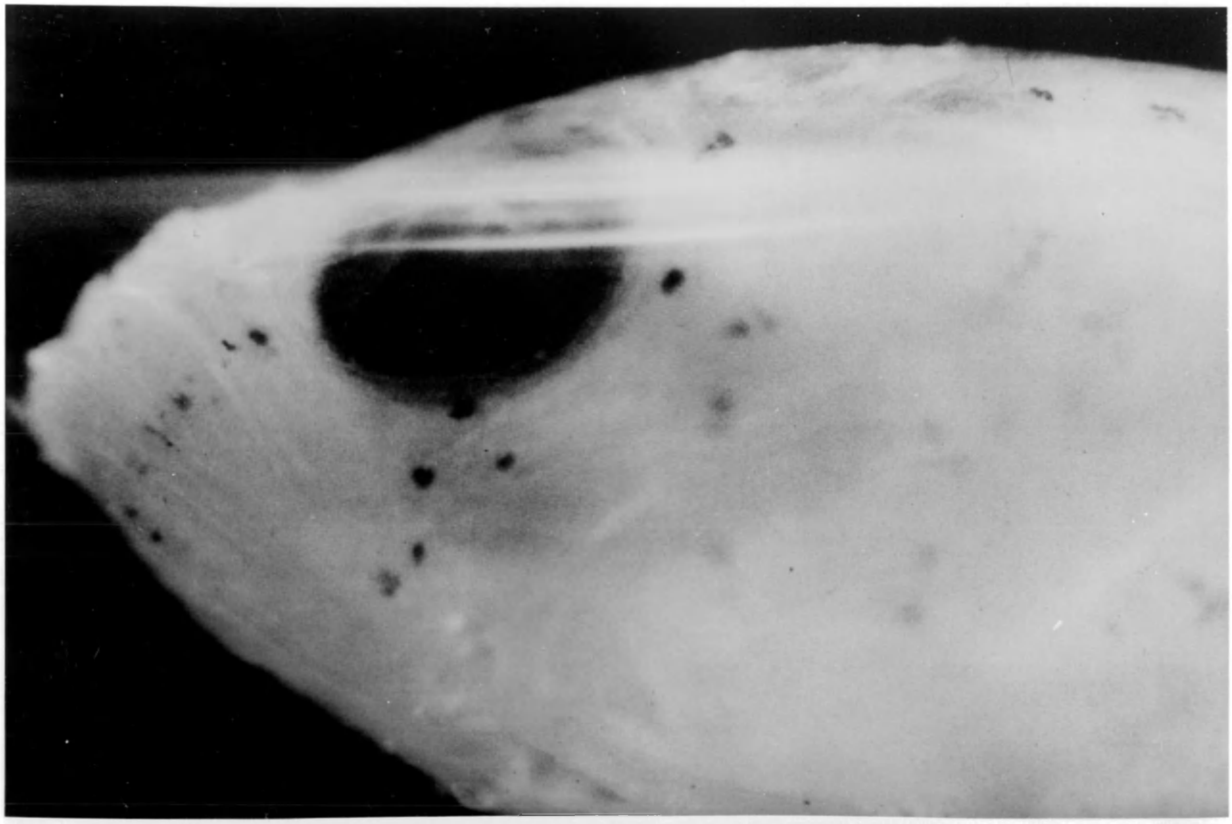


Figure 19c. Lateral view of the head of the larva of category 11 (Gobiosoma or Nes) showing a line of pigment spots anterior to the eye from the upper to lower jaw, ventrad to the eyes and in several more vertical rows along the operculum.

Figure 19d. Ventral mid-body view of the larva of category 11 showing a large ventral melanophore posterior to the anal fin and a smaller stellate melanophore slightly anterior.



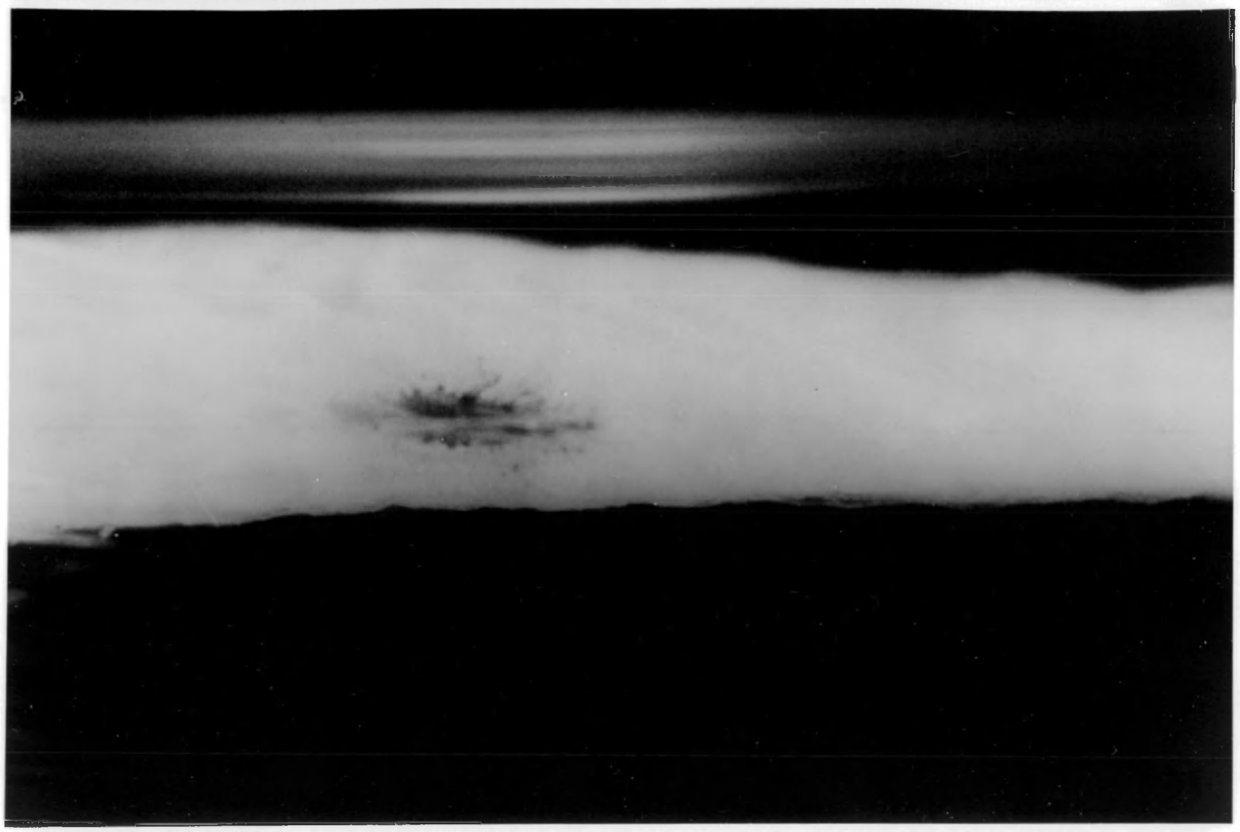
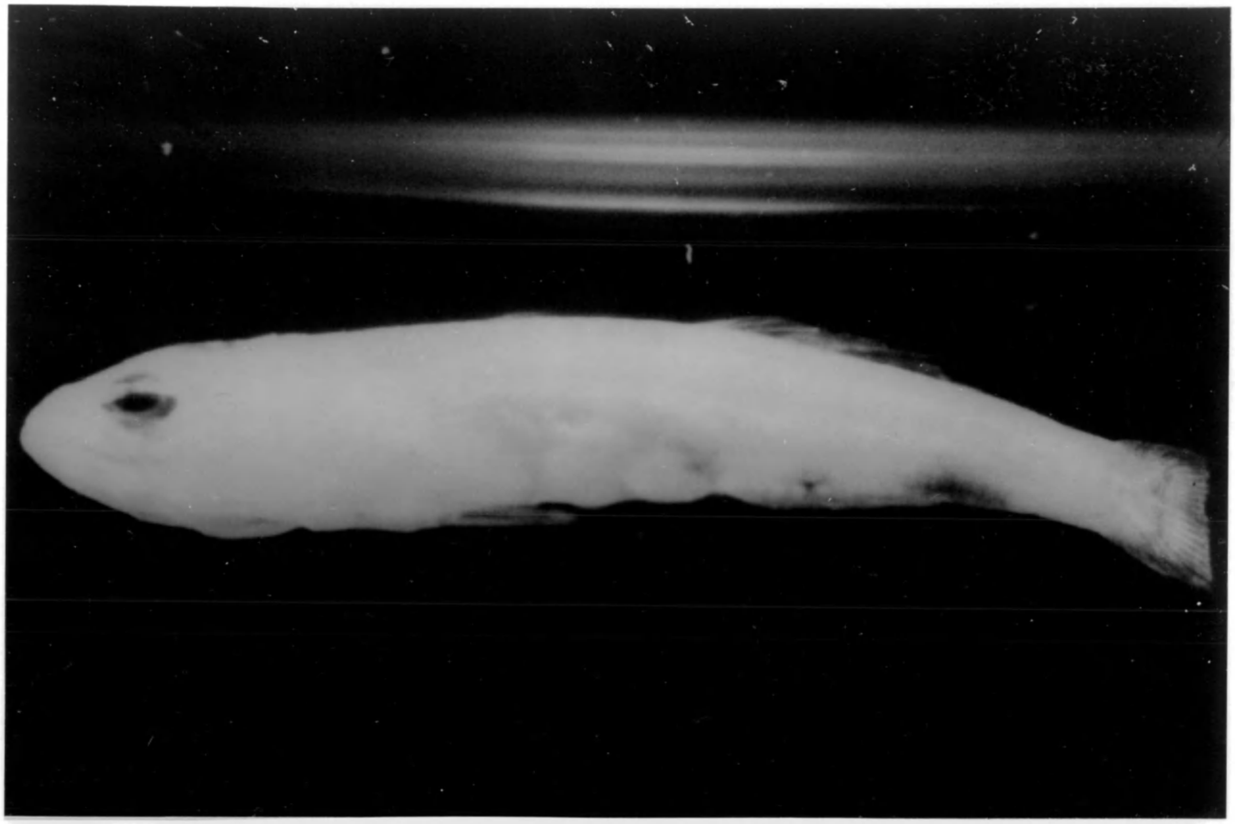


Figure 20a. The larva of category 12 (Gobiosoma or Nes) at 11.3 mm SL.

Figure 20b. Posterior lateral view of the larva of category 12 showing a large stellate melanophore posterior to the anal fin and a smaller stellate melanophore midway between the anus and the larger melanophore.



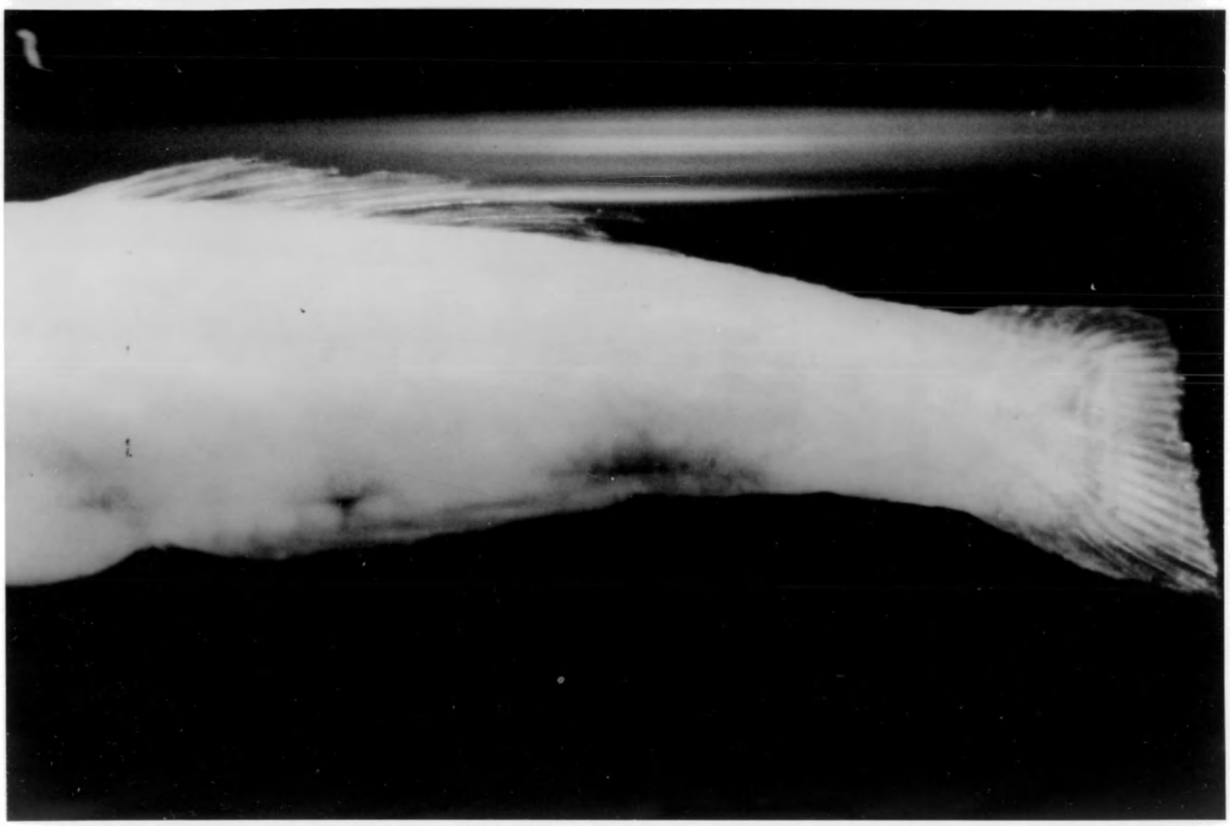
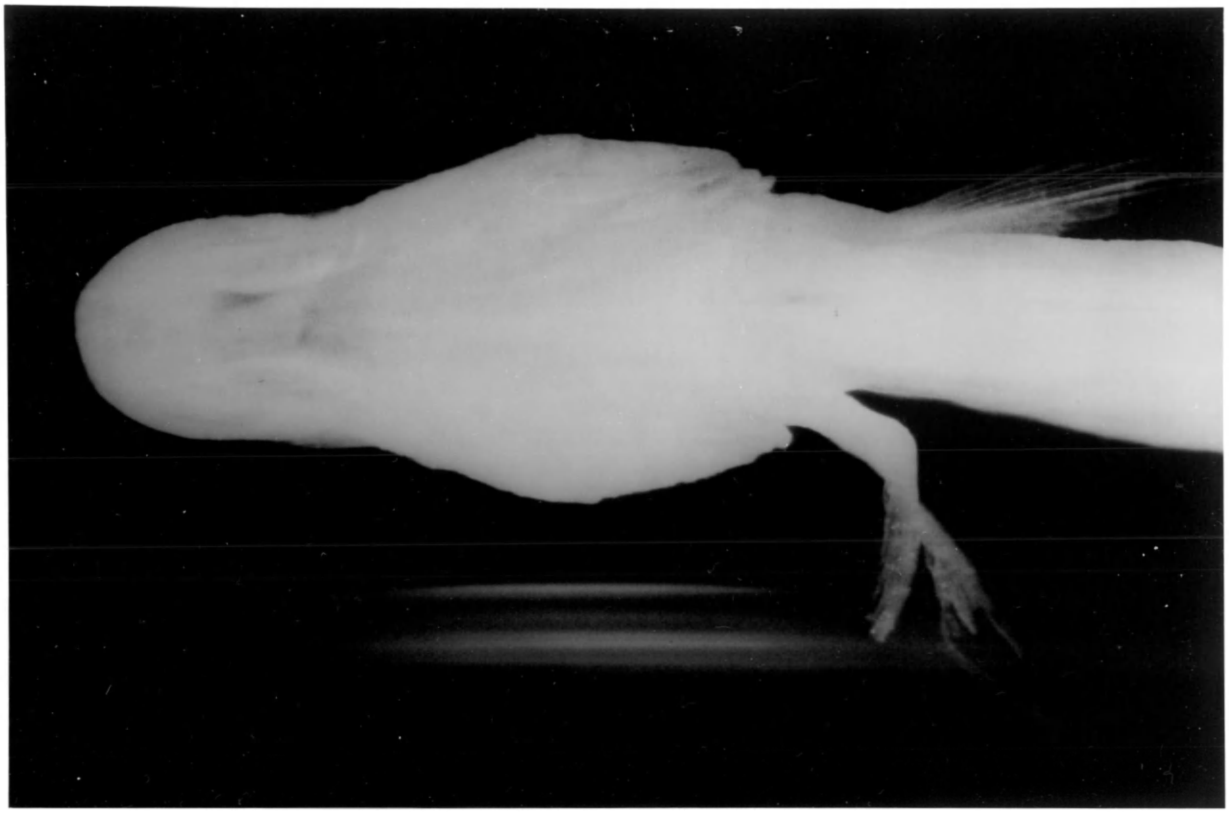


Figure 20c. Ventral view of the head and pelvic-fin region of the larva of category 12 showing a line of pigment parallel to the ventral midline on the developing pelvic fraenum.



Gobiosoma group:

Two additional *Gobiosoma* group specimens, of 7.2 and 7.4 mm SL, were cleared and stained early in the study before patterns of pigmentation were described. Both additional *Gobiosoma* group specimens are elongate with a moderate-sized head and have a dorsal and ventral pair of basi-caudal scales. One specimen, based on meristics identical to morphological categories 8-10 and the presence of caudal scales, may belong in morphological categories 8-10 and is, therefore, a species of *Gobiosoma*. The other specimen differs in its second dorsal and anal-fin element counts of 10 and 8, respectively, which fit for *Gobiosoma* and *Gobulus*. The presence of basi-caudal scales, however, is inconsistent with *Gobulus*.

Table 14. Summary of meristic variability in cleared and stained specimens of five morphological categories of larval gobies in the *Gobiosoma* group of Birdsong et al. (1988). Abbreviations are:

N= Number of cleared and stained specimens
Dorsal-fin= dorsal-fin formula of Birdsong et al. (1988)
Vertebrae= pre-caudal plus caudal vertebrae
Anal pter= anal-fin pterygiophores anterior to first haemal spine
2nd D= second dorsal-fin elements
Anal= anal-fin elements

Morph	N	Dorsal-fin	Vertebrae	Epurals	Anal pter	2nd D	Anal
8	1	3-221110	11+17	1	2	11	9
9	1	3-221110	11+17	1	2	11	9
10	1	3-221110	11+17	1	2	11	9
11	1	3-221110	11+17	1	2	13	11
12	1	3-221110	11+17	1	2	13	11

Table 15. Summary of morphometric data for five morphological categories of larval gobies in the Gobiosoma group of Birdsong et al. (1988). Measurements are expressed as percent standard length. Abbreviations are:

N= Number of specimens measured
SD= Standard deviation
HL= Head length
PDFL= Pre-dorsal-fin length
PAL= Pre-anal length
PAFL= Pre-anal-fin length
BDD= Body depth at first dorsal-fin spine
BDA= Body depth at last anal-fin ray
CPD= Caudal peduncle depth

	HL	PDFL	PAL	PAFL	BDD	BDA	CPD
Morph 8 (N=2)							
Mean	.27	.40	.56	.58	.17	.14	.11
Range		.39-.40	.55-.56	.58-.59	.16-.18	.13-.14	
SD	.00	.01	.01	.01	.01	.01	.00
Morph 9 (N=2)							
Mean	.28	.39	.57	.59	.19	.13	.13
Range	.27-.29	.37-.40	.56-.58	.58-.60	.17-.20	.11-.15	.12-.13
SD	.01	.02	.01	.01	.02	.02	.01
Morph 10 (N=3)							
Mean	.28	.40	.57	.59	.21	.15	.11
Range	.27-.28	.38-.42	.56-.60	.58-.62	.19-.23	.15-.16	.10-.12
SD	.00	.02	.02	.02	.02	.00	.01
Morph 11 (N=1)	.28	.36	.58	.61	.15	.13	.08
Morph 12 (N=1)	.27	.40	.57	.60	.20	.11	.09

Table 16. Total second dorsal and anal-fin elements in Caribbean Sea species of Gobiosoma. Numbers refer to the publicatons, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
astronasum	11-12	10-12	25
bosc	12	11	USNM 306262
	12-13	11	147, 197, 72, 238, 80, 14, 30, 90
	14	10	116, 118, 117
	14	11	USNM 167048
chancei	11-12	9-12	25
	11-12	10-11	14
dilepis	10-12	9-10	14
	11	10	USNM 219137
evelynae	11-13	11-13	25, 189, 14
gemmatum	11-12	10-11	14
	12	10	USNM 194003
genie	11-12	11-12	14
	11-13	11-12	25
ginsburgi	10	11	238
	11-13	10-12	80
	12	11	147
	12-13	10-12	197, 14, 30, 90
grosvenori	10	9-10	14

Table 16. (continued).

Species	Second dorsal-fin	Anal-fin	Source of Data
hemigymnum	12-13	10	14
hildebrandi	11	10	14
	11-12	9-10	102
horsti	10-13	11-12	USNM 178887
	11-12	12	99
	11-13	10-12	25
	11-13	11-12	14, 90 USNM 178885
	12	11	USNM 178884
	12	11-12	USNM 178886
	12	12	USNM 267834
	12-13	11-12	USNM 203834
	13	11	20
illecebrosum	11-12	10-12	25
	12	11-12	14
longipala	7-12	10	90
	10-13	9-11	197, 14, 30
	12	10	90
louisae	11-13	10-12	25
	12-13	10-12	14
macrodon	11-12	9-11	14
multifasciatum	11	10	117
	11	11	145
	11-12	9-10	14
	11-12	10	90

Table 16. (continued).

Species	Second dorsal-fin	Anal-fin	Source of Data
nudum	11-13	9-10	102
	12	10	90
	12-13	9-11	14
oceanops	7-13	13	90
	11-14	10-13	25, 14
pallens	10-12	8-9	14
parri	11-13	9-11	14
	11-13	10-11	90
prochilos	11-12	11	25, 14
randalli	11-12	10-11	25
	11-13	10-11	14
robustum	11-12	9-11	USNM 184205
	11-12	10	USNM 030854
	11-12	10-12	147
	11-13	8-10	107
	11-13	9-11	197, 14, 30
	11-13	10-11	90
	11-14	9-12	80
	12	10	90 USNM 287147
saucrum	11	9-10	14
schultzi	11-12	8-10	32, 14
spes	10-12	9-11	32, 14
spilotum	11-12	9-10	14
	12	10	USNM 274857

Table 16. (continued).

Species	Second dorsal-fin	Anal-fin	Source of Data
tenox	12	10-11	25
	12	10	174, 14
xanthiprora	11-13	10-11	25
	11-13	11	14
zebrella	11-12	10	14

Table 17. Total second dorsal and anal-fin elements in Caribbean Sea species of Gobulus. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
myersi	10	9	UMML 4927
	10-11	8-10	96
	11	10	20, 91

Table 18. Total second dorsal and anal-fin elements in Caribbean Sea species of *Risor*. Numbers refer to the publications, cited in Appendix III, from which data were extracted. Original data from X-rayed or cleared and stained museum specimens are reported as modal values.

Species	Second dorsal-fin	Anal-fin	Source of Data
ruber	11	9	USNM 267836
	11	10	USNM 134289 USNM 274925
	11-12	9-10	USNM 170233
	11-12	9-11	14
	11-12	10	USNM 267830

Table 19. Total second dorsal and anal-fin elements in Caribbean Sea species of Ginsburgellus and Nes. Numbers refer to the publications, cited in Appendix III, from which data were extracted.

Species	Second dorsal-fin	Anal-fin	Source of Data
G. novemlineatus	11-13	10	14
N. longus	11, 13-14	11-13	14
	13	12	USNM 116362
	13 1/2	12 1/2	145
	13-14	12-13	90
	14	13	6

Table 20. Goby genera for which eggs or larvae (of at least one species) are described or implied as known in scientific literature. Numbers refer to publications cited in Appendix III. An asterisk indicates that an early life history stage is described and/or depicted (by illustration or photograph) in that paper. Parentheses around a genus name indicate the uncertainty of inclusion as a genus with a described or known larva. Some attempt has been made to account for name changes and reassignment of species. Citations are chronological and are not meant to be exhaustive.

Genus	Citation
Aboma	*54
Acanthogobius	*59, 55, *231, 113, *163
Acentrogobius	*1, *115, 175, *51, *234, *231, *163
Amblychaeturichthys	*163
Aphia	104, 67, *68, *131, *132, *180, 173, *198
Apocryptodon	*163
Asterropteryx	61, 146, *163, 122, 22
Astrabe	55, *63, *163
Bathygobius	*18, 226, 227, 228, 229, 241, 74, 146, *177, *163, 122, 22, *197
Boleophthalmus	*115, *163
(Bollmania)	*197
Buenia	131, 225, *198
Caffrogobius	5, 243
(Caspiosoma)	187
Chaenogobius	40, *43, 55, *94, *56, *223, 239, 240, 120, *163

Table 20. (continued).

Genus	Citation
Chaeturichthys	55, *62, 219
Chasmichthys	160, *163
Chonophorus	98, 9, 139
Clariger	*163
Clevlandia	23, *185, 134
Coryphopterus	245, 24, 16
Cryptocentrus	*163
Crystallogobius	186, *68, 131, 132, *180, *198
Ctenogobius	*128, *53, *129
Ctenotrypauchen	52, *163
Deltenosteus	10, 235, 250
Eleotriodes	*224
Eutaeniichthys	*41, *163
Eviota	146, *202, *218, *163, 22
Evorthodus	*248, *79, *197
Expedio	*205
Favonigobius	84
Gillichthys	34, 35, 36, 37, 38, 134
Glossogobius	*188, 98, 175, *111, 2, 155, 9, 200, *163, *220
Gnatholepis	146, 114
Gobioides	75, *197
Gobionellus	128, 66, *80, 75, 242, *72, *129, 26, 108, 171, *197
Gobiopterus	*184, *21

Table 20. (continued).

Genus	Citation
Gobiosoma	*128, *208, 101, *17, 15, *217, 215, *244, 140, *73, 66, *232, 28, *148, *158, 237, *80, 170, 27, 75, *72, 201, 26, 108, 171, 19, 137, *197
Gobius	125, 136, 103, 178, 104, *143, *69, *68, *97, 247, 29, 192, 7, 87, *179, *188, 71, 88, *131, *132, *180, *133, 3, 127, *211, 212, 196, *213, 221, 162, 236, 225, *161, *214, *42, 173, *45, *4, 85, 156, 92, 126, *198, 135, *109, 153, 150, 250
Gobiusculus	178, 131, 180, 173, 198
(Gymnogobius)	149
Heteroployomus	55, *163
(Hyrcanogobius)	187
Ilypnus	134, 113
Istiogobius	*203, *163
Kellogella	146, 22
(Knipowitschia)	187
Lebetus	71, *180, *33, *198, *190
Lepidogobius	176, 93
Lesueurigobius	250, 165, *166, 167
Leucopsarion	55, *141, *163
Lubricogobius	*57, *163
Luciogobius	*46, 55, *60, *206, *163, 110
Lythrypnus	*195, 246, 216
Mesogobius	153
Microgobius	66, *80, 170, 75, 26, 171, 137, *197

Table 20. (continued).

Genus	Citation
(Mirogobius)	8
(Mistichthys)	209, 230
Mugilogobius	*106, *119, *163
Nematogobius	168, 169, 166, 167
Neogobius	39, 153, 157, 151, 152, 187
Odontamblyopus	*47, *64
Ophiocara	98
Ophiogobius	*100
Oxyurichthys	*188, 241, 146, 122
Paleatogobius	*49, 55
Pandaka	*163
Parachaeturichthys	*163
Paragobiodon	130, *163
Periopthalmus	142, 123, *163
Pomatoschistus	178, 179, 71, 131, 180, 133, 127, 173, 76, *77, 78, 124, *198, 193, 191
Priolepis	*163
Proterorhinus	*207, 187
Psammogobius	5, *243
(Pseudapocryptes)	105
Pseudogobius	*163
Psilogobius	241, *146, 122, 22
Pterogobius	*160, *44, 65, 55, *204, *163
Quietula	134, 113
Redigobius	*163

Table 20. (continued).

Genus	Citation
Rhinogobius	55, *199, 81, *163, 110
Rhyacichthys	9
Sagamia	55, *163
Sicydium	*58
Sicyopterus	98, *139, 9, *163, 110
Silhouettea	*163
Stigmatogobius	221, 222, 233, *159
Sufflogobius	*172, 164, 165
Surga	*163
Taenioides	52, *163
Triaenipogon	*48
Tridentiger	*50, 112, 121, *163, 110
Typhlogobius	70, *138
Valenciennea	*163
Zonogobius	*210

DISCUSSION

Identification of Hol Chan goby larvae

Examination in Hol Chan larval gobies of the four osteological characters employed by Birdsong et al. (1988) to group gobioids, allowed each of 12 kinds of goby larvae to be identified to a maximum of four generic possibilities from over thirty nomimal genera of gobies from the Caribbean Sea. Meristic characters (second dorsal and anal-fin element counts) then permitted identification of seven kinds of goby larvae to a single genus. Of the remaining goby larvae from the survey, two kinds were identified to two generic possibilities, and one was identified to three possibilities. Identification to genus of only two kinds of goby larvae was unaided by second dorsal and anal-fin meristic values, and those larvae were reported to four generic possibilities. The larva of *Gnatholepis thompsoni* was described for the first time in this study, and its description was the first for a larva of a western Atlantic species of *Gnatholepis*. A *Coryphopterus* larva was also described for the first time from the Caribbean Sea. Although descriptions have been made of the larvae of some species of *Gobiosoma* from the western Atlantic, three additional larvae of *Gobiosoma* species were identified in this study. *Ctenogobius* and *Bathygobius* were the only genera identified in this effort for which descriptions of larvae already existed for species known to occur in Belize (see Appendix II).

Photographs and descriptions of each kind of goby larva were presented to facilitate future investigations into larval morphologies of gobies from the Caribbean Sea.

The significance of pigment patterns in goby taxonomy

Kinds of goby larvae collected in the Hol Chan Marine Reserve were defined according to patterns of melanophores. Each morphological category presumably represented a species of goby. This assumption was based on numerous descriptions in the literature of wild-caught goby larvae, all of which reported consistency in patterns of pigmentation on larvae of the same species at the same size. (See Introduction and Table 20 for citations of larval goby descriptions.) Clearing and staining of specimens within morphological categories revealed that combinations of osteological and other meristic characters were uniform within categories. Combinations of the characters examined were repeated, in some instances, between or among categories. However, this only occurred with categories that belonged to the same generic group (as defined by Birdsong et al., (1988)), and therefore, were proposed to be related. For example, morphological categories 8-10, presumably representing three species of _Gobiosoma_, each had identical states of the characters examined. Likewise, morphological categories 5-6, representing two _Priolepis_ group species (category 5 is _Coryphopterus_; category 6 may be _Coryphopterus_, _Lophogobius_, _Lythrypnus_, or _Priolepis_), had combinations of characters that were identical to each other. Since overlap in meristic characters of related goby taxa is well-documented (see Tables 4-6, 9-12, 13, 16-19), the fidelity of pigment patterns at the species level was not considered to be challenged by identical character states among related taxa. Therefore, the data from this project support the usage of patterns of melanophores as taxonomic tools in the identification of larval gobies to species.

At the genus level, fidelity of patterns of melanophores on goby larvae was more difficult to evaluate. Comparisons of pigment on identified larvae from this study and larvae depicted in the literature indicated the presence of genus-wide pigmentational "themes" that manifested themselves somewhat differently among species of certain genera. For example, larvae of Gnatholepis thompsoni (this study) and G. knighti (described in Miller et al., 1979) possessed a bar of melanophores below the eye. The three Gobiosoma species identified in this study shared a character of at least one large stellate melanophore on the ventral surface in the region of the anal fin. (See Introduction for examples from the literature.) However, in other instances, the validity of such themes was challenged by multiple species of a single genus bearing little resemblance to each other in their patterns of pigmentation. For example, Bathygobius soporator (illustrated in Peters, 1983) and Bathygobius sp. (this study) did not closely resemble illustrations of B. fuscus and B. cotticeps in Okiyama, ed. (1988). Coryphopterus sp. (this study) had pigmentation unlike that in illustrations of C. nicholsi in Matarese et al., 1989. The larvae of the three species of Gobiosoma identified in this study had different patterns of melanophores than G. bosc and G. ginsburgi larvae (Massman et al., 1963; Richardson and Joseph, 1975). Only 88 of over 200 goby genera worldwide have one or more species described in their larval stages (Table 20). Therefore, it cannot be concluded that generic-level pigmentational themes are common and exceptions to the themes are rare.

However, it is possible that, given the chaotic state of gobiid taxonomy, discrepancies in patterns of melanophores on larvae from the same genus may reflect artificiality in existing classifications.

The significance of pigment patterns in studies of gobiid systematics

Within the Gobiidae, similar patterns of melanophores on larvae may indicate common ancestry and help substantiate or refute the groupings of Birdsong et al. (1988). Larval pigmentation has been treated in phylogenetic analyses of other groups of fishes. For example, Markle and Olney (1990) utilized three larval pigment characters in their systematic study of the pearlfishes (Gadiformes, Carapidae).

The *Gobionellus* group of Birdsong et al. (1988) contains ten genera and was represented in the Hol Chan material by a minimum of two genera. Ventral pigmentation on larval *Ctenogobius sp*. (this study) and category 3 (a species of *Ctenogobius*, *Gobionellus*, or *Oxyurichthys*) was similar in the serial occurrence of large round melanophores along the anal fin. However, the number of ventral melanophores in category 3 exceeded that of category 1 and, although category 3 was larger and, presumably, more developed than category 1, it possessed bold pigmentation on the head, upper jaw and over the hypurals that is not developed in *Ctenogobius sp*. In addition, the sub-cutaneous pyramid-shaped melanophore seen in the caudal peduncle region of category 1 specimens was not visible in category 3. Pigmentation of larval *Gnatholepis thompsoni* was limited to an eye-stripe, although in unpublished illustrations by W.A. Laroche, a series of seven, small, diffused melanin spots was visible along the anal fin of this larva. Serial ventral pigmentation along the anal fin may be shared by members of the *Gobionellus* group, but the size and shape of the melanophores differed in specimens from the Hol Chan survey. Ctenogobius dotui (from illustrations in Dotu, 1958) repeated the pigmentational theme of serial ventral melanophores but possessed smaller and more diffused spots than those of Ctenogobius sp. (this study). Mugilogobius abei (Kanabashira et al., 1980) also supported a larval pigmentational theme for the Gobionellus group since its pattern of melanophores included (but was not limited to) five, large, diffused melanin spots along the anal fin.

Of the three morphological categories from the survey material that fell into the Priolepis group of Birdsong et al. (1988) (composed of 55 genera), only category 4 was identified to a single genus, Coryphopterus. Categories 5 and 6 were Coryphopterus, Lophogobius, Lythrypnus, or Priolepis. With regard to pigment, each of the morphological categories was unique: head stripes characterized category 4, a ventral dashed line characterized category 5, and category 6 had a single, opposing dorsal and ventral patch. Literature illustrations of Istigobius campbelli, I. hoshinonis (Shiobara and Suzuki, 1983), Asterropteryx semipunctatus, Eviota abax, Priolepis boreus, P. semidoliatus, and Silhouettea dotui (Okiyama, (ed.), 1988), each Priolepis group species, did not strongly resemble any of categories 4-6. (Among these depicted species, however, a pigmentational theme including dorsal, ventral and, often, lateral series of pigment patches was recognizable. In A. semipunctatus, P. boreus, and P. semidoliatus, dorsal, ventral and lateral pigments merged into vertical bars along the body in the 8.0 - 8.6 mm TL size range.) Acentrogobius pflaumi (Okiyama (ed.), 1988) and Psilogobius mainlandi (Miller et al., 1979), on the other hand, possessed ventral midline melanophores extremely similar to category 5 pigmentation. It should be noted that the ventral view in illustrations of *Acentrogobius* and *Psilogobius* larvae revealed a consistency in pigment pattern that would not be recognizable in the lateral-view illustrations of the other species treated here.

The *Bathygobius* group of Birdsong et al. (1988) contains eight genera. The complex was represented in the survey material by a single *Bathygobius* species which resembled *B. soporator* in illustrations by Peters (1983). When *Bathygobius* larvae from the Hol Chan collection were compared to illustrations of larval *Glossogobius olivaceus* (Okiyama (ed.), 1988; Suzuki et al., 1988), another *Bathygobius* group species, there was a striking resemblance in the dorsal and ventral pattern of large, heavy stellate melanophores that blended into one another. Also, as in *B. soporator*, the ventral melanophores in *G. olivaceus* extended up over the gut, and melanin was present on the mouth. However, some inconsistency exists between descriptions of *B. soporator* and *B. fuscus* which, at 6.4 mm TL, did not possess the heavy dorsal pigmentation seen in *B. soporator* (Okiyama (ed.), 1988).

Within the five morphological categories of larval gobies from the Hol Chan survey material belonging to the *Gobiosoma* group of Birdsong et al. (1988) (which contains 17 genera), an interesting scenario occurred that may be a function of at least three of the categories belonging to the genus *Gobiosoma* and, presumably, representing at least three different species within *Gobiosoma*. Although each of these categories had pigment patterns distinct enough to be defined separately, they shared a character of at least one, large stellate melanophore on the ventral surface in the region of the anal fin. Categories 8 and 10 had three to four, large stellate melanophores in the region of the anal fin, and categories 9 and 11-12 had one, large (and, in categories 11-12, also one small) stellate melanophore in the same area. In the Gobiosoma group specimens from the survey material, a pigmentational theme emerged that may support a common phylogeny for the genus Gobiosoma, but the possible significance of additional pigments on these larvae should not be disregarded. This theme was not duplicated in the temperate Gobiosoma larvae, G. bosc and G. ginsburgi, which have in common a series of melanophores along the anal fin and a single, non-stellate post-anal melanophore extending vertically in G. bosc and horizontally in G. ginsburgi (Massman et al., 1963) (see Introduction). Gobiosoma bosc and G. ginsburgi are in the subgenus Gobiosoma, and the Gobiosoma species from the survey material are likely in the subgenera Elacatinus or Tigrigobius (Bohlke and Robins, 1968) (see Results). The pigmentational differences observed in Gobiosoma larvae, after further study, may help corroborate these subgeneric classifications or provide reason to consider elevation of the subgenera to generic status. Larvae of Ophiogobius from the Gobiosoma group did not contribute to a group-wide pigmentational theme. Ophiogobius jenynsi larvae (from illustrations in Herrera, 1984) exhibited elongate, post-anal pigment patches that blended together along the ventral margin.

Evidence supporting like pigmentational themes on goby larvae of genera grouped together by Birdsong et al. (1988) was produced in the four generic groups represented by specimens in the Hol Chan survey material. This evidence suggested that there is some validity to the hypothesis that similar patterns of melanophores on goby larvae indicate a common phylogeny. However, discrepancies abounded in patterns of melanophores among the larvae of these taxa proposed to be related, and although possibly attributable to misclassifications, these discrepancies are significant. The degree of consistency or discrepancy in patterns of melanophores on larvae of grouped gobiid taxa was undeterminable because most of the genera within these groups do not have a described larva or the larvae are described at sizes too different to allow comparison (see Table 20). Nonetheless, data from this study supported pigment patterns on larval gobies as a character worthy of attention in future analyses of gobiid relationships. Since the phylogeny of the Gobiidae is unknown, the adults are difficult to identify and the larvae exhibit little precocial development, patterns of melanophores on larvae, which unlike adult coloration, persist relatively well in preservative, may provide valuable insights into gobiid relationships.

Suggestions for future research:

Although certain pigmentational themes arose within the generic groupings of Birdsong et al. (1988), contradictions to the themes were numerous, and further studies are necessary before groupings are supported or questioned. To make conclusive statements about recurring pigment patterns, larval specimens should be reared under standardized conditions to eliminate the biases of environmental variability in production of melanophores and age differences at comparison. Reliance on published illustrations to discern pigment patterns should be minimized due to the above stated biases as well as the obvious subjectivity of comparing illustrations of varying quality and detail.

In addition, since patterns of melanophores have, thus far, shown relevance to larval goby taxonomy and, perhaps, systematics, the relevance of patterns of carotenoids and other chromatophores should be addressed. To date, these pigments have largely been omitted in taxonomic descriptions because they are quick to fade in commonly used preservatives (Leis and Trnski, 1989). Although its long-term effectiveness is not known, butylated hydroxytoluene (BHT) has been used to successfully preserve color in larval fishes in excess of two years (W.A. Laroche, personal communication).

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Appendix I. Putative groups and genera of Gobiidae from the western Atlantic Ocean (from Birdsong et al., 1988). *Elacatinus* and *Ioglossus*, recognized by Richards (1990) as western Atlantic goby genera, were not treated by Birdsong et al. (1988).

Bathygobius group	*Bathygobius*
Gobioides group	*Gobioides*
Gobionellus group	*Ctenogobius* *Gnatholepis* *Gobionellus* *Oxyurichthys*
Gobiosoma group	*Barbulifer* *Chriolepis* *Evermannichthys* *Ginsburgellus* *Gobiosoma* *Gobulus* *Nes* *Pariah* *Psilotris* *Pycnomma* *Risor* *Varicus*
Microgobius group	*Bollmania* *Microgobius* *Palatogobius* *Parrella*
Priolepis group	*Coryphopterus* *Lophogobius* *Lythrypnus* *Priolepis*
Sicydium group	*Awaous* *Evorthodus* *Sicydium*
Unassigned genera	*Vomerogobius*

Appendix II. Species list of the Gobiidae from Belize and Honduras. An asterisk marks the name of species collected at Ambergris Cay. This list was compiled by David W. Greenfield and Robert K. Johnson (personal communication) (except Bathygobius curacao from USNM 276129).

Awaous tajasica
Barbulifer ceuthoecus
Bathygobius curacao
Bathygobius soporator
*Chriolepis fisheri
Coryphopterus alloides
*Coryphopterus dicrus
*Coryphopterus eidolon
*Coryphopterus glaucofraenum
*Coryphopterus hyalinus
Coryphopterus lipernes
*Coryphopterus personatus
*Coryphopterus thrix
Evermannichthys metzelaari
Evorthodus lyricus
Gnatholepis thompsoni
Gobionellus boleosoma (Ctenogobius in Birdsong et al., 1988)
Gobionellus pseudofasciatus (Ctenogobius)
Gobionellus saepapallens (Ctenogobius)
Gobionellus smaragdus (Ctenogobius)
Gobionellus stigmalophius (Oxyurichthys in Birdsong et al., 1988)
Gobionellus stigmaticus (Ctenogobius)
Gobioides broussoneti
*Gobiosoma dilepis
Gobiosoma evelynae
Gobiosoma gemmatum
Gobiosoma grosvenori
Gobiosoma horsti
Gobiosoma louisae
Gobiosoma multifasciatum
*Gobiosoma pallens
Gobiosoma prochilos
Gobiosoma saucrum
Gobiosoma xanthiprora
Gobiosoma yucatanum/spes?
Lophogobius cyprinoides
*Lythrypnus crocodilus
Lythrypnus elasson
*Lythrypnus heterochroma
*Lythrypnus nesiotes
*Lythrypnus okapia
Lythrypnus spilus

Appendix II. (continued).

Microgobius microlepis
Nes longus
*Priolepis hipoliti
Psilotris batrachodes
Psilotris kaufmani
Pycnomus roosevelti
Risor ruber
Varicus imswe
Vomerogobius flavus

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Appendix IV. Adult material examined (from radiographs except where otherwise indicated).

Gobionellus group:

Ctenogobius boleosoma SU 1675, TCWC 3266.1 (cleared and stained), UMML 13613, UMMZ 184680, USNM 287153 (cleared and stained); C. fasciatus UMMZ 147536, UMMZ 180655, UMMZ 199685, USNM 293437, C. pseudofasciatus ANSP 109179, UMMZ 199544, USNM 293464, C.saepepallens ANSP 109180, ANSP 86135, USNM 167676; C. smaragdus UMML 733, UMMZ 189754; C. stigmaticus UMMZ 201445; C. stigmaturus UMMZ 189866.

Gnatholepis thompsoni CAS 31752, USNM 144046, USNM 178879, USNM 218840, USNM 276130, USNM 276135, USNM 276216, USNM acc. no. 294338, USNM Beebe collection uncatalogued.

Gobionellus oceanicus RMNH 4679, UMML 2446, UMMZ 173099, UMMZ 209794, USNM 123228, USNM 205203, USNM 265066, USNM 49365.

Oxyurichthys stigmalophius ANSP 144295, ANSP 81233, ANSP 81855, UMML 3992 (cleared and stained).

Priolepis group:

Coryphopterus dicrus USNM acc. no. 249592; C. glaucofraenum USNM 73255, USNM 82516, USNM acc. no. 249592; C. hyalinus USNM 267835, USNM 267844; C. personatus USNM 088631; C. thrix USNM acc. no. 249592.

Appendix IV. (continued).

Lophogobius cyprinoides USNM 122649, USNM 122650, USNM 123545, USNM 123648, USNM 133744, USNM 134679, USNM 144048, USNM 147632, USNM 178728, USNM 178729, USNM 178876, USNM 178877, USNM 178890, USNM 192080, USNM 192235, USNM 226370, USNM 37509, USNM 74087, USNM 9767.

Lythrypnus crocodilus USNM 122614.

Bathygobius group:

Bathygobius curacao USNM 119322, USNM 119324, USNM 219094, USNM 276129, USNM 81810; *B. soporator* TCWC 3275.1 (cleared and stained), USNM 121544, USNM 192066, USNM 192068, USNM 192320, USNM 22853, USNM 287163 (cleared and stained), USNM 648, USNM 81801, USNM 81815.

Gobiosoma group:

Gobiosoma bosci USNM 167048, USNM 306262 (cleared and stained); *G. dilepis* USNM 219137; *G. gemmatum* USNM 194003, *G. horsti* USNM 178884, USNM 178885, USNM 178886, USNM 178887, USNM 267834, USNM 203834; *G. robustum* USNM 030854, USNM 184205, USNM 287147 (cleared and stained); *G. spilotum* USNM 274857.

Gobulus myersi UMML 4927.

Nes longus USNM 116362.

Risor ruber USNM 134289, USNM 170233, USNM 267830, USNM 267836, USNM 274925.

VITA

Elizabeth D. Maddox

Elizabeth was born in Jacksonville, Florida in 1962. She was graduated from Kickapoo High School in Springfield, Missouri in 1980 and received her B.S. in Biological Sciences (marine biology option) from the Florida Institute of Technology in Melbourne, Florida in 1984. Elizabeth entered the master's program in Biological Oceanography at the College of William and Mary, School of Marine Science in 1985. She has been employed with the Caribbean Marine Research Center on Lee Stocking Island, Exuma Cays, Bahamas since 1990.