

LARVAL MORPHOLOGY OF THE EELS *BASCANICHTHYS*
BASCANIUM, *B. SCUTICARIS*, *OPHICHTHUS*
MELANOPORUS AND *O. OPHIS* (OPHICHTHIDAE),
WITH A DISCUSSION OF LARVAL
IDENTIFICATION METHODS

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ABSTRACT

Larvae of *Bascanichthys bascanium*, *B. scuticaris*, *Ophichthus melanoporus* and *O. ophis* are described. The larvae of *B. bascanium* and *B. scuticaris* had been described in the literature as *O. melanoporus* and *O. ophis*. Developmental osteology of *Bascanichthys* (based mainly on *B. bascanium*) and of *O. melanoporus* are presented. The osteology of one metamorphic *O. ophis* is described. Osteological development of *Bascanichthys* and *Ophichthus* larvae differs from that of *Myrophis punctatus* larvae in the more pronounced division between symplectic and hyomandibula, in the more rapid development of their branchial arches, in the sequence of ossification of the suspensoria and in development of their caudal and axial skeletons.

The look-alike method of identifying ophichthid leptocephali is rejected. The larval genus *Ophichthus* determined using this method contained species of *Ophichthus*, *Bascanichthys* and *Apterichtus*.

Tribes and genera of ophichthid larvae are determined using the structure of gill arches, opercular apparatus and cephalic lateralis system, median fin position and number of branchiostegal rays. Species are then determined using total and nephric myomere counts.

Larval evidence indicates that *Verma* is a synonym of *Apterichtus*.

Most larvae of the eel family Ophichthidae are undescribed. Castle (1965) tentatively assigned 18 forms from Australasian waters to genera, but was unable to provide reliable generic definitions. Until Blache's (1977) large work, the only identified ophichthid leptocephali in the Atlantic were *Myrophis punctatus* by Eldred (1966), *Echelus myrus* and *Myrophis plumbeus* by Blache (1968) and *Pisodonophis cruentifer* by Richardson (1974). Subsequently, Fahay and Obenchain (1978) published a study of western Atlantic ophichthid leptocephali offering names for 12 nominal species in 6 genera.

Castle (1965) separated his specimens into nine groups using the amount and distribution of pigment. He felt that dorsal fin position or condition in ophichthid larvae was not useful in identifying ophichthid larvae. Failure to consider dorsal fin position and other larval morphology results in erroneous identifications.

Fahay and Obenchain (1978) grouped look-alike larvae based on "structure of the gut (relative length and degree of looping), structure of the opisthonephros, position of the liver, and extent and character of midline pigment." These groups were considered genera. Each of their genera was subdivided into look-alike subgroups which were considered species. The number of subgroups per group was compared to the number of adult species per genus in order to identify their genera. Finally they compared total myomere numbers of each subgroup with the total vertebral counts of adult species to identify their larvae to species. This technique may result in groups which contain two or more genera. Like Castle (1965) they did not consider dorsal fin position in forming their groups.

Blache (1977) compared the total myomeres and nephric myomeres (sensu Leiby, 1979a; b) of his specimens, with the total and precaudal vertebrae of adult

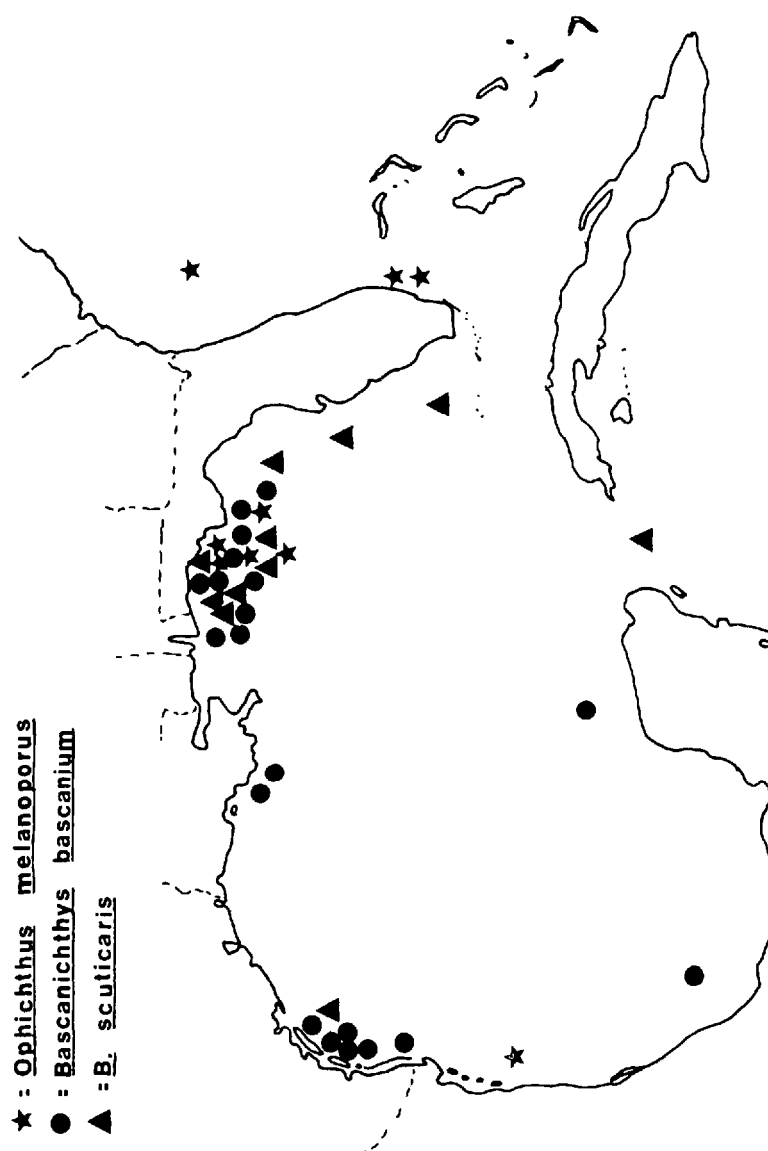


Figure 1. Distribution of larval *Bascanichthys bascanium*, *B. scuticaris* and *Ophichthus melanoporus*.

ophichthids. In doing so, he relied less heavily on look-alikes than either Castle (1965) or Fahay and Obenchain (1978); however, he too ignored dorsal fin position as a usable character.

Leiby (1979a; b) demonstrated that the gill arches, branchiostegal rays, opercular apparatus, pectoral girdle, cephalic lateralis system and median fins are sufficiently developed in late euryodontic and early metamorphic larvae to be useful in assigning leptocephali to tribe (McCosker, 1977) and usually to genus. After tribes and genera have been determined, the number of total and nephric myomeres can be used to assign the larvae to species. Branchiostegal ray number and condition of the cephalic lateralis system can often be used to support these identifications.

In this paper I describe the morphological development of *Bascanichthys bascanium*, *B. scuticaris* and *Ophichthus melanoporus*; describe one metamorphic *O. ophis*; and discuss methods for identifying ophichthid larvae and the elucidation of adult systematics using larval morphology.

MATERIALS AND METHODS

The specimens described in this study are from: Florida Department of Natural Resources, Marine Research Laboratory, St. Petersburg, Florida (MRL); Gulf Coast Marine Research Laboratory, Ocean Springs, Mississippi (GCMRL); Marine Biomedical Institute, Galveston, Texas (MBI); National Marine Fisheries Service, Miami, Florida (TABL); National Marine Fisheries Service, Panama City, Florida (BLM); and, Rosenstiel School of Marine and Atmospheric Science, Miami, Florida (UMML). Collection locations for *B. bascanium*, *B. scuticaris*, and *O. melanoporus* are shown in Figure 1. The single specimen of *O. ophis* was collected near 15°18'N, 56°5'W.

Measurements were made to the nearest 0.1 mm using an optical micrometer. Proportional measurements given in reverse order indicate the relative size of that structure decreases during development (e.g., Preanal Length 86.7–82.6% TL). All counts, measurements and growth stages are as defined in Leiby (1979a; b).

Specimens of each species described were stained for bone and cartilage. They were then dissected for osteological study. The osteological description of *Bascanichthys* is based primarily on *B. bascanium* since more specimens of that species were available.

Data on adult *B. bascanium* and *B. scuticaris* were obtained primarily from Leiby and Yerger (1980). Branchiostegal ray counts of *O. melanoporus* and *O. ophis* were made with a dissecting microscope after slitting and teasing back the skin covering the branchial basket. Vertebral and fin ray counts of *O. melanoporus* and *O. ophis* were taken from X-rays provided by Dr. J. E. Böhlke, Academy of Natural Sciences, Philadelphia.

Drawings were made using a camera lucida on a Wild dissecting microscope.

LARVAL IDENTIFICATION

Since many ophichthid genera are widely distributed, I compared my material to ophichthine genera known to occur in the eastern Pacific or eastern Atlantic as well as to those in the western Atlantic. Based on the gill arches, branchiostegal rays, opercular apparatus, cephalic lateralis system and median fin condition the four larval forms examined in this study were determined to belong in the genera *Bascanichthys* and *Ophichthus*.

Böhlke (pers. comm.) currently recognizes seven species of *Bascanichthys* and nine species of *Ophichthus* from the western Atlantic. Total and precaudal vertebral counts of these 16 species were obtained from the literature, from X-rays of available specimens or from X-rays made available by Böhlke. The vertebral counts were compared to the total and nephric myomere counts of the four larval forms. Based on these comparisons, the *Bascanichthys* species were identified as *B. bascanium* and *B. scuticaris*, and the *Ophichthus* species were identified as *O. melanoporus* and *O. ophis*.

In the general morphology section of each species description, adult meristics

follow larval meristics for comparison (e.g., total myomeres 179–194, total vertebrae in adults 178–191).

Bascanichthys bascanium (Jordan)

Leptocephali of this species were identified as *Ophichthus melanoporus* by Fahay and Obenchain (1978).

General Morphology.—One hundred thirty-nine larvae examined. Body relatively elongate, much compressed, clear. Total myomeres 179–194 (\bar{x} = 185; n = 124), total vertebrae in adults 178–191 (\bar{x} = 182.9; n = 67); nephric myomeres 100–112 (\bar{x} = 105.6; n = 135), precaudal vertebrae in adults 99–108 (\bar{x} = 103.3; n = 10); preanal myomeres 102–114 (\bar{x} = 107.2; n = 137), anus migrates anteriorly late in metamorphosis, adult preanal vertebrae 94–102 (\bar{x} = 98.1; n = 67); predorsal myomeres 11–17 (\bar{x} = 13.7; n = 78), adult predorsal vertebrae 0–2 (n = 10). Branchiostegal rays 29–33 (n = 6), 31–33 in adults (n = 4). Dorsal fin rays 557–621 (\bar{x} = 583.0; n = 6), 568–604 in adults (n = 2); anal fin rays 216–268 (\bar{x} = 241.8; n = 21), 231–277 in adults (n = 4). Pectoral fin rays develop after metamorphosis, 4–5 weak rays in adults. Pectoral fin base at myomeres 3–5 before metamorphosis, at vertebrae 6–7 in adults.

Two to nine much reduced gut loops or swellings. First two often discernible only by association with lobes of liver; last seven often indiscernible. First loop at anterior end of liver under myomeres 13–22 (most commonly 15–17), second at posterior end of liver under myomeres 22–30 (most commonly 25–28); gut expands posterior to gall bladder and liver; gut loops three to nine, when present, under myomeres 32–40 (36–38), 46–53 (48–50), 56–61 (57–59), 64–71 (66–68), 75–83 (79–81), 90–95 (91–93), 101–111 (103–105). Distance between renal arteries relatively great (10–15 myomeres). Nephros generally terminates one to two myomeres before anus.

Pigmentation in Formalin preserved specimens inconspicuous, chromatophore patches small and usually amorphous. Chromatophore patch occasionally present on anterior portion of upper lip. Occasionally one to five chromatophore patches in body wall ventro-lateral to heart. Chromatophores usually on each myoseptum below mid-lateral line starting above anterior portion of esophagus. Irregular pigment patches along gut beneath nephric duct mark gut loops, when present, and occur randomly between gut loops. Irregular pigment patches in body wall ventral to liver and gut. One to six faint, irregular subcutaneous chromatophore patches occasionally present on tail below aorta. A single, weak chromatophore patch on ventral surface of each anal fin pterygiophore.

Engyodontic Stage (Figs. 2A, B).—Size range of seven specimens examined, 10.1–23.6 mm Total Length (TL). Greatest body depth midway between head and anus. Preanal length (PAL) 86.7–82.6% TL. Head length (HL) 12.7–8.5% TL; 13.5–10.3% PAL. Eye diameter 27.3–24.0% HL. Snout length 2.8–4.7% TL, 30.2–33.0% HL. Reduction in relative PAL and HL due to differential growth in tail region. Preanal myomere number remains stable.

Euryodontic Stage (Figs. 3A–D).—Size range of 121 specimens examined, 24.1–85.8 mm TL. Greatest body depth shifts posteriorly to anus. PAL 84.4–60.3% TL; midway through euryodontic stage PAL 71.2–65.4% TL. Predorsal length 17.5–7.8% TL; 23.0–12.1% PAL. Predorsal and preanal myomere numbers remain constant. HL 7.9–3.8% TL; 3.8–4.9% TL by end of euryodontic stage; 9.9–6.3% PAL. Reduction in relative preanal, predorsal and head length due to differential growth in tail region. Eye diameter 16.7–23.8% HL. Snout length 2.7–

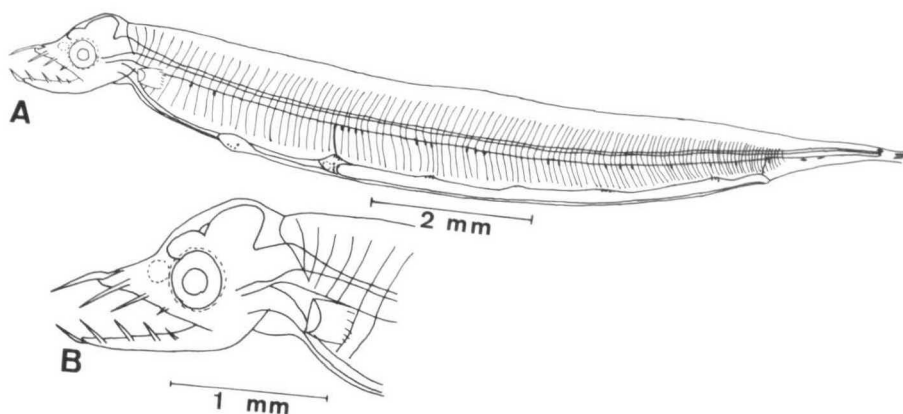


Figure 2. *Bascanichthys bascanium*, engyodontic stage: A, Leptocephalus 10.4 mm TL; B, Head of same specimen.

1.0% TL; 33.0–22.4% HL. Decrease in relative snout length due to differential growth in tail region, beginning resorption of ethmoid cartilage and slight posterior migration (about one myomere) of pectoral fin.

Metamorphic Stage.—Size range of 11 specimens examined, 88.3–66.5 mm TL. PAL 58.7–60.4% TL. All available specimens early metamorphic; forward migration of anus not begun. Predorsal length 8.0–9.7% TL; 13.3–16.0% PAL, forward migration of dorsal fin not begun. HL 4.9–5.8% TL; 8.6–9.6% PAL. Slight increase in relative HL due to posterior migration of pectoral fin to myomeres six or seven. Eye diameter 15.8–17.5% HL. Snout length 1.0–1.2% TL; 22.0–17.7% HL. Decrease in relative snout length due to posterior migration of pectoral fin, resorption of ethmoidal cartilage.

Bascanichthys scuticaris (Goode and Bean)

Leptocephali of this species were identified as *Ophichthus ophis* by Fahay and Obenchain (1978).

General Morphology.—Thirty larvae examined. Body relative elongate, much compressed, clear. Total myomeres 161–169 (\bar{x} = 164.3; n = 20), total vertebrae in adults 155–171 (\bar{x} = 162.5; n = 374); nephric myomeres 85–96 (\bar{x} = 91.3; n = 26), precaudal vertebrae in adults 86–92 (\bar{x} = 90.1; n = 11); preanal myomeres 87–99 (\bar{x} = 93.2; n = 25), anus migrates anteriorly late in metamorphosis, adult preanal vertebrae 79–89 (\bar{x} = 84.3; n = 384), predorsal myomeres 12–16 (\bar{x} = 13.5; n = 12), adult predorsal vertebrae 0–2 (n = 11). Branchiostegal rays 29 (n = 2), 26–29 in adults (n = 4). Dorsal fin rays not countable in larvae, 526 in 1 adult; anal fin rays 184–221 (\bar{x} = 194.5; n = 6), 211 in 1 adult. Pectoral fin rays develop after metamorphosis, 4–5 weak rays in adults. Pectoral fin base at myomeres 3–5 before metamorphosis, at vertebrae 6–7 in adults.

Generally seven much reduced gut loops or swellings, often differentiable from preservation artifacts only by chromatophore patch beneath nephric duct on swelling; two usually distinct loops along esophagus, first at anterior end of liver under myomeres 12–17 (most commonly 13–15), second at posterior end of liver under myomeres 20–28 (most commonly 24–26); gut expands posterior to gall bladder and liver; gut loops three to seven, when present, under myomeres 33–40 (36–37), 44–53 (48–50), 60–69 (62–64), 75–83 (78–80), 83–95 (91–92). Distance

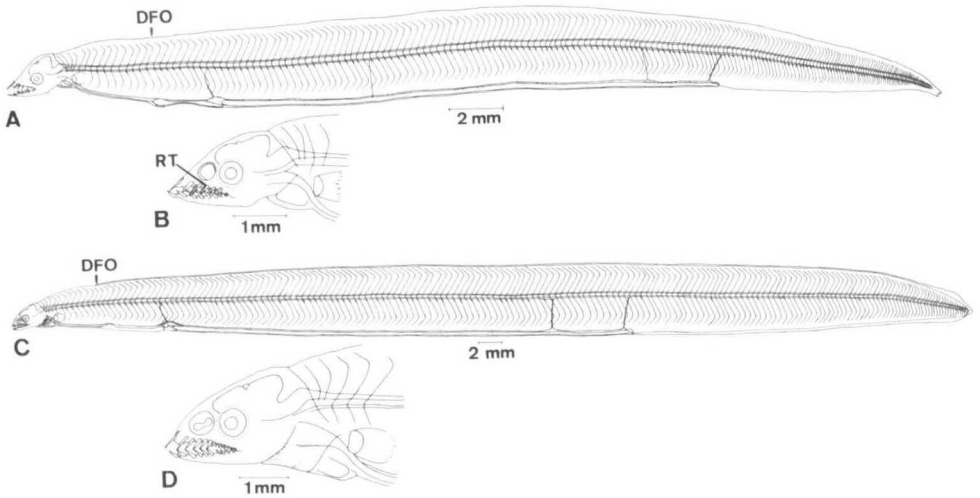


Figure 3. *Bascanichthys bascanium*, euryodontic stage: A, Leptocephalus 34.2 mm TL; B, Head of specimen 44.1 mm TL; C, Leptocephalus 79.5 mm TL; D, Head of same specimen (Abbreviations: DFO, dorsal fin origin; RT, replacement tooth).

between renal arteries relatively short (1–4 myomeres). Nephros generally terminates one to two myomeres before anus.

Pigmentation in Formalin preserved specimens same as in *B. bascanium* except three to five faint, irregular subcutaneous pigment patches on tail below aorta near postanal myomeres 11–15, 20–22, 30–37, 44–49, 52–60.

Engyodontic Stage (Figs. 4A, B).—Size range of 11 specimens examined, 12.9–19.5 mm TL. Greatest body depth midway between head and anus. PAL 86.0–81.6% TL. HL 12.2–9.8% TL; 14.9–10.5% PAL. Eye diameter 26.0–23.4% HL. Snout length 3.6–4.5% TL; 33.0–37.2% HL. Reduction in relative PAL and HL due to differential growth in tail region. Preanal myomere number remains stable.

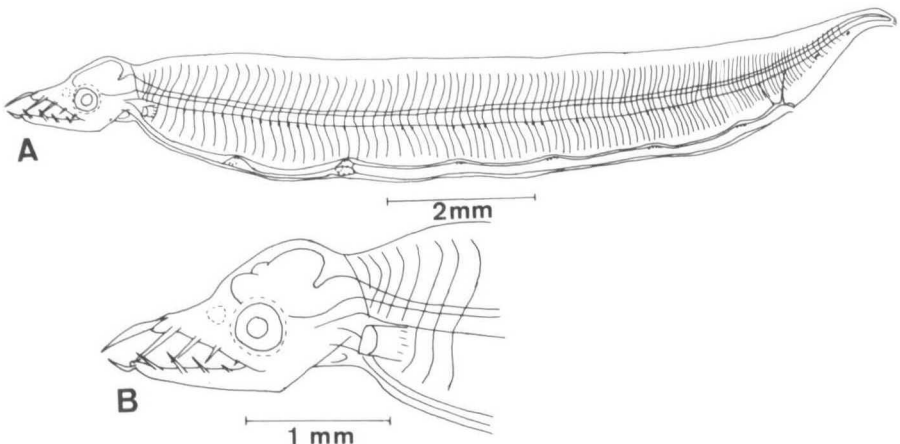


Figure 4. *Bascanichthys scuticaris*, engyodontic stage: A, Leptocephalus 12.9 mm TL; B, Head of same specimen.

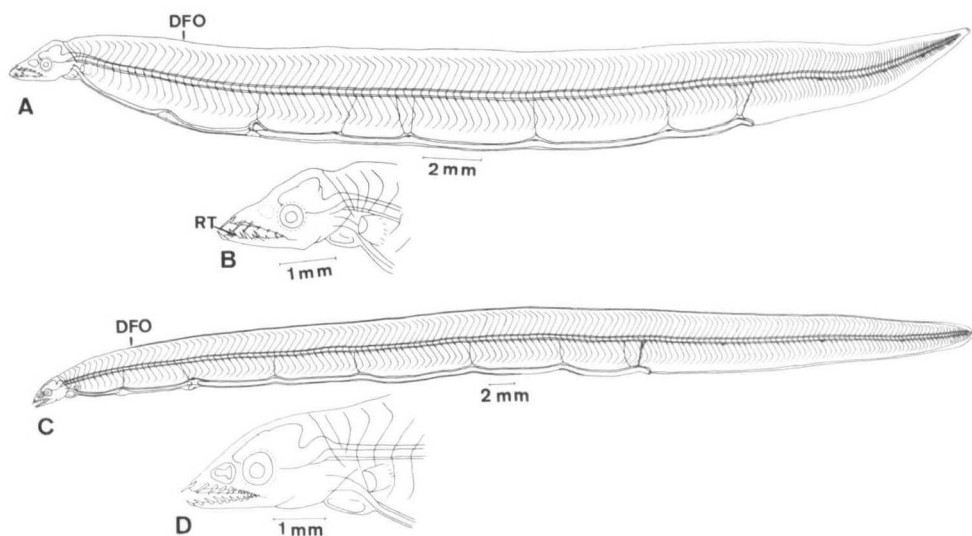


Figure 5. *Bascanichthys scuticaris*, euryodontic stage: A, Leptocephalus 33.6 mm TL; B, Head of same specimen; C, Leptocephalus 73.2 mm TL; D, Head of same specimen (Abbreviation: same as Fig. 2).

Euryodontic Stage (Figs. 5A–D).—Size range of 19 specimens examined, 27.2–78.1 mm TL. Greatest body depth shifts posteriorly to anus. PAL 80.5–65.0% TL. Predorsal length 17.3–8.5% TL; 22.7–12.8% PAL. Predorsal and preanal myomere numbers remain constant. HL 7.5–3.8% TL; 9.5–5.9% PAL. Reduction in relative preanal, predorsal and head length due to differential growth in tail region. Eye diameter 20.0–25.0% HL. Snout length 3.8–1.2% TL; 40.0–28.0% HL. Decrease in relative snout length due to differential growth in tail region and slight posterior migration (about one myomere) of pectoral fin.

Ophichthus melanoporus (Kanazawa)

General Morphology.—Twenty-two larvae examined. Body elongate, much compressed, clear. Total myomeres 176–193 (\bar{x} = 185.6; n = 19), total vertebrae in adults 178–186 (n = 6); nephric myomeres 63–70 (\bar{x} = 66.4; n = 21), precaudal vertebrae 64 in 1 adult; preanal myomeres 69–76 (\bar{x} = 73.0; n = 21), anus migrates anteriorly late in metamorphosis, adult preanal vertebrae 50–53 (n = 6); predorsal myomeres 42–53 (\bar{x} = 47.7; n = 11), adult predorsal vertebrae 10–13 (n = 6). Branchiostegal rays 17–18 (n = 4), 17 in adults (n = 2). Dorsal fin rays 386 in 1 larva, 384 in 1 adult; anal fin rays 228–294 (\bar{x} = 260.0; n = 7), not determined for adults. Pectoral fin rays 14 in 1 larva, 15 in adults (n = 2). Pectoral fin base at myomeres 4–6 before metamorphosis, at vertebra 9 in adults.

Nine pronounced gut loops. First at anterior end of liver under myomeres 9–14 (most commonly 10–12), second at posterior end of liver under myomeres 16–22 (most commonly 17–19); gut expands posterior to gall bladder and liver; gut loops three to nine under myomeres 23–29 (25–26), 30–36 (32–33), 37–43 (39–41), 46–52 (47–49), 54–60 (55–56), 61–67 (63–65), 68–76 (69–72). Nephros terminates on loop 8 or between loops 8 and 9, 6 to 10 myomeres anterior to anus.

Pigmentation in Formalin-preserved specimens conspicuous. One or two large, stellate chromatophores on cheek posterior to hyomandibula. Large patch of

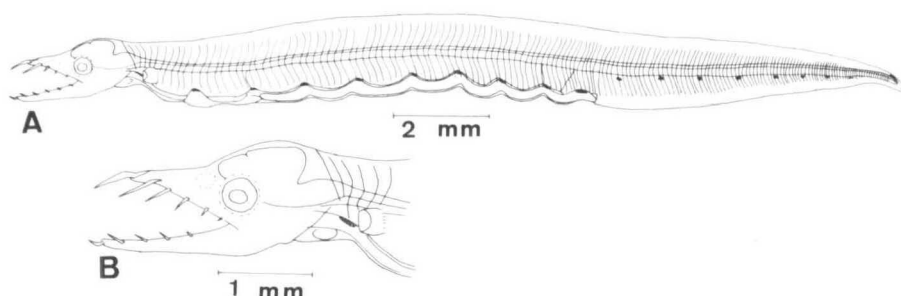


Figure 6. *Ophichthus melanoporos*, engyodontic stage: A, Leptocephalus 18.0 mm TL; B, Head of same specimen.

pigment on dorsal surface of esophagus near pectoral fin base. Well-developed chromatophore patches ventral to nephros on each gut loop. Occasional small chromatophore patches below midline on myosepta, no pattern of distribution discernible. Nine to 11 pronounced subcutaneous pigment patches on tail below aorta near postanal myomeres 4–7, 22–28, 32–39, 41–49, 50–60, 59–70, 69–79, 89–98, 100–106; generally 9 postanal patches in smaller larvae becoming 10 or 11 in larger larvae.

Pigment on anal pterygiophores in patches. Groups of five to ten pterygiophores with pigment separated by groups of five to ten unpigmented pterygiophores.

Engyodontic Stage (Figs. 6A, B).—Size range of four specimens examined, 17.0–21.7 mm TL. Greatest body depth midway between head and anus. PAL 65.0–61.6% TL. HL 13.3–11.1% TL; 20.5–18.0% PAL. Eye diameter 17.5–18.2% HL. Snout length 5.0% TL; 37.5–45.4% HL. Reduction in relative PAL and HL due to differential growth in tail region. Preanal myomere number remains stable.

Euryodontic Stage (Figs. 7A–C).—Size range of 18 specimens examined 22.6–105.8 mm TL. Greatest body depth shifts posteriorly to anus. PAL 57.3–44.0% TL. Predorsal length 37.3–30.0% TL. Predorsal and preanal myomere numbers remain stable. HL 11.5–5.3% TL; 18.2–11.9% PAL. Reduction in relative preanal, predorsal and head length due to differential growth in tail region. Eye diameter 13.5–18.0% HL. Snout length 4.2–2.0% TL; 42.4–33.9% HL. Decrease in relative snout length due to differential growth in tail region and slight posterior migration (one to two myomeres) of pectoral fin.

Ophichthus ophis (Linnaeus)

Leptocephali of this species were correctly identified by Blache (1977). Additional meristic data are given in this description.

General Morphology.—One larva examined. Body elongate, much compressed, clear. Total myomeres 163, total vertebrae in adults 163–167 ($n = 7$); nephric myomeres 80, precaudal vertebrae in adults 75–80 ($n = 8$); preanal myomeres 88, anus migrates anteriorly late in metamorphosis, adult preanal vertebrae 57–60 ($n = 5$); predorsal myomeres 81, adult predorsal vertebrae 12–16 ($n = 7$). Branchiostegal rays 21, 19–21 in adults ($n = 6$). Dorsal fin rays 294, not determined in adults; anal fin rays 209, not determined in adults, pectoral fin rays 13, not determined in adults.

Eight moderate gut loops. First at anterior end of liver under myomeres 12–13,

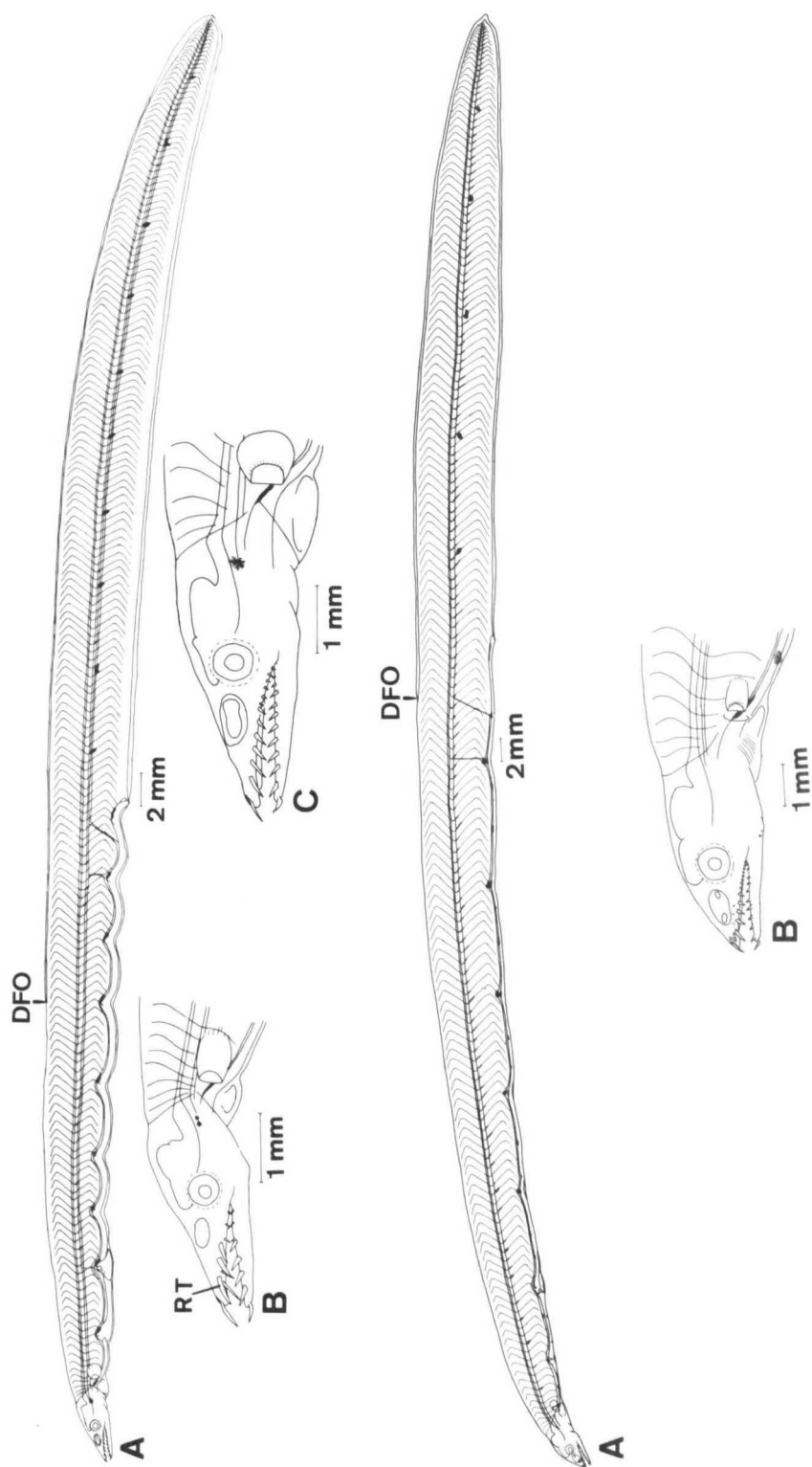


Figure 7. (Upper) *Ophichthus melanoporos*, euryodontic stage: A, *Leptocephalus* 86.1 mm TL; B, Head of specimen 37.1 mm TL; C, Head of specimen 86.1 mm TL (Abbreviations: same as Fig. 2).

Figure 8. (Lower) *Ophichthus ophis*, early metamorphic stage: A, *Leptocephalus* 120.0 mm TL; B, Head of same specimen (Abbreviations: DFO, dorsal fin origin).

second at posterior end of liver under myomeres 21–22; gut expands posterior to gall bladder and liver, gut loops 3 to 8 under myomeres 31–33, 42–43, 52–53, 63–64, 75–76, 86–88. Nephros terminates between loops 8 and 9, 8 myomeres anterior to anus.

Pigmentation in Formalin preserved specimen conspicuous. One nondescript chromatophore on upper jaw from snout tip to below middle of nasal capsule. One or two nondescript chromatophores on postero-ventral surface of lower jaw. Dense patch of pigment on esophagus near pectoral fin. Well-developed chromatophore patches ventral to nephros on each gut loop. One to two chromatophore patches ventral to nephros between gut loops. Randomly distributed, usually amorphous pigment patches on liver. Pronounced pigment patches below midline on most myosepta starting above esophagus. Four subcutaneous pigment patches on tail below aorta at postanal myomeres 8, 20, 33–34, 47. Pigment on anal pterygiophores as in *O. melanopus*. Pigment patch in body wall lateral to esophagus, midway between heart and first liver lobe. Pigment patches in body wall lateral to gut loops three to seven.

Metamorphic Stage (Figs. 8A, B).—One 120.0 mm TL specimen examined. PAL 57.2% TL. Predorsal length 52.3% TL. HL 4.5% TL; 7.9% PAL. Eye diameter 19.3% HL. Snout length 1.2% TL; 27.8% HL.

DEVELOPMENTAL OSTEOLOGY

Bascanichthys bascanium, *B. scuticaris*

Leiby and Yerger (1980) found the only differences in adult osteology between *B. bascanium* and *B. scuticaris* to be number of branchiostegal rays on the epihyal and the number of vertebrae. To verify that there are no differences in larval osteology, I cleared, stained and dissected 8 *B. scuticaris* larvae to compare with 50 *B. bascanium* larvae at similar stages of development. The description of glass eel osteology is based on a single specimen of *B. scuticaris*.

Head Skeleton.—Sequence of development of the head skeleton is shown in Table 1.

Engyodontic Stage (Figs. 9A–D).—The chondrocranium of engyodontic *Bascanichthys* (Fig. 8A) closely resembles that of engyodontic *M. punctatus* (Leiby, 1979b). In the splanchnocranium (Figs. 9C, D) however, there are differences. In *M. punctatus* there is only a slight separation between the symplectic process and quadrate, while in *Bascanichthys* there is a pronounced separation which extends to the large foramen in the middle of the hyomandibula. Leiby (1979b) found only the first basibranchial in engyodontic *M. punctatus*. The smallest *B. bascanium* examined (10.1 mm TL) already had some elements of all 5 gill arches (Fig. 9B). Basibranchials one and two were present and clearly separated; they do not appear to develop from one cartilaginous bar as they do in congrid (Hulet, 1977). Hypobranchial one and ceratobranchial one are distinct although closely joined. No suture lines were visible between hypobranchials and ceratobranchials in gill arches two and three even after staining with eosin to bring out greater detail. The fourth and fifth ceratobranchials are present.

The maxillaries, dentaries and rostral teeth ossify shortly after hatching. The maxillary, a thin sheet of dermal bone, is positioned along the inner surface of the lip. It lies in a broad, loosely organized sheet of tissue which connects weakly with the outer surface of the quadrate and Meckel's cartilage. The posterior margin of the bone is weakly ossified and grades imperceptibly into soft connec-

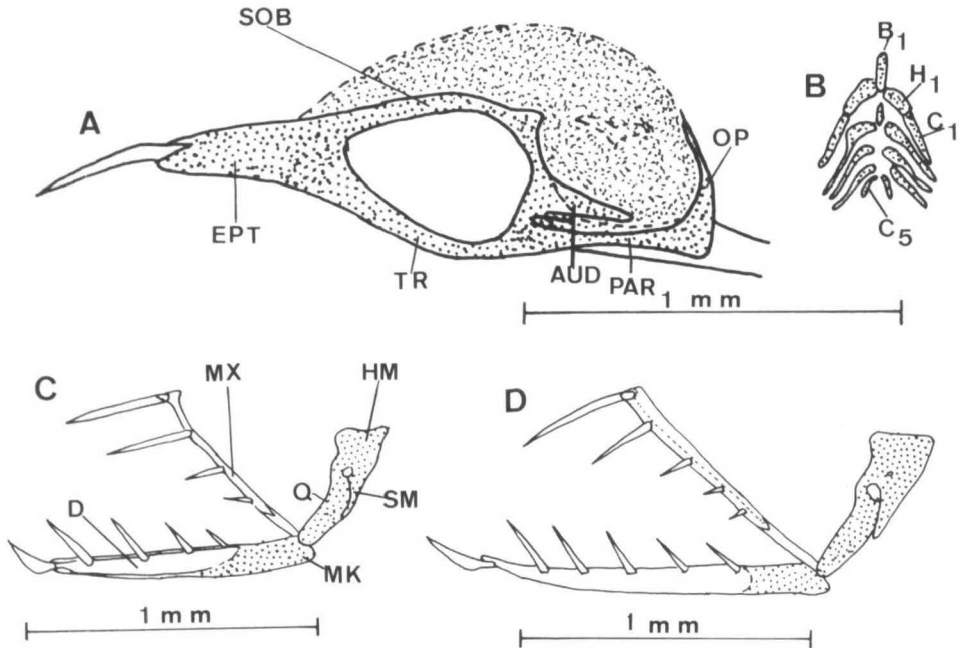


Figure 9. Head skeleton, engyodontic stage *Bascanichthys bascanium*: A, Neurocranium of specimen 10.1 mm TL; B, Gill arches of same specimen; C, Suspensorium and jaws of specimen 10.4 mm TL; D, Suspensorium and jaws of specimen 18.5 mm TL (Abbreviations: AUD, auditory capsule; B₁, basibranchial 1; C₁₋₅, ceratobranchials 1-5; D, dentary; EPT, ethmoid plate; H₁, hypobranchial 1; HM, hyomandibula; MK, Meckel's cartilage; MX, maxilla; OP, occipital process; PAR, parachordal; Q, quadrate; SM, symplectic; SOB, supraorbital bar; TR, trabecula).

tive tissue. The maxillary develops as an extremely thin, shallow bone (Fig. 9C), barely wider than the attached engyodontic teeth. Late in the engyodontic stage, the maxillary expands dorsally (Fig. 9D). The euryodontic teeth ultimately attach to this dorsal expansion (Fig. 10B). The dentary, also a thin sheet of bone, is positioned along the outer face of Meckel's cartilage (Figs. 9C, D). Ossification of the dentary appears to end just posterior to the last tooth; however, when teased away from Meckel's cartilage, it can be seen to extend nearly to the quadrate/Meckel's cartilage juncture. At the tip of the rostrum are two spike-like teeth, attached to small, teardrop shaped bones which adhere closely to the dorsal surface of the ethmoid cartilage.

The blade of the opercle develops late in the engyodontic stage, even before the opercular cartilage can be seen. It is first detected in stained specimens as a slight red blush in the cheek. This development is significantly different from opercular development in *M. punctatus* (Leiby, 1979b) in which the blade of the opercle apparently forms as a collagenous matrix prior to ossification.

Euryodontic Stage (Figs. 10A-D).—The onset of the euryodontic stage is marked by a change in jaw dentition (Leiby, 1979a; b). The few, narrow, spike-like teeth of the engyodontic stage are lost. The euryodontic teeth are formed in the mesenchyme just below the epidermis and overlay, but do not touch, the maxillary and dentary (Fig. 10A). How the engyodontic teeth are lost is uncertain. They do not fuse with the euryodontic teeth, therefore they must be resorbed or shed. Leiby (1979b) describes the sequence of development of the euryodontic teeth.

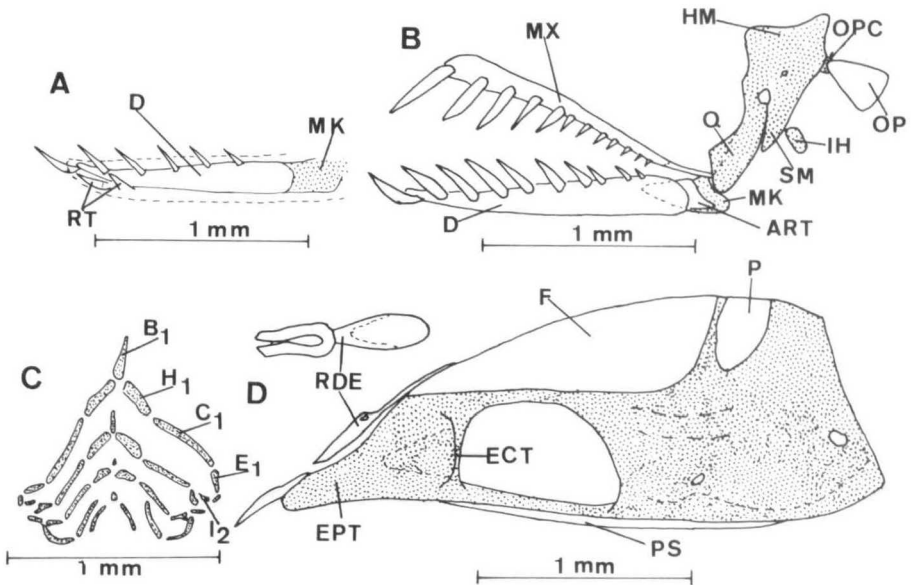


Figure 10. Head skeleton, euryodontic stage *Bascanichthys bascanium*: A, Lower jaw of specimen 24.1 mm TL; B, Suspensorium and jaws of specimen 59.7 mm TL; C, Gill arches of specimen 64.2 mm TL; D, Neurocranium of specimen 79.5 mm TL (Abbreviations: same as Fig. 8 except; ART, angulo-retroarticular; E₁, epibranchial 1; ECT, ectehmoid bar; F, frontal; I₂, infra-pharyngobranchial 2; IH, interhyal; OPC, opercular cartilage; P, parietal; PS, parasphenoid; RDE, rostrodermethmoid; RT, replacement tooth).

Early in the euryodontic stage an opercular cartilage develops independently of the hyomandibula (Fig. 10B). It is first seen as a dense aggregation of cells near the posterior edge of the already chondrified hyomandibula. No late engyodontic or early euryodontic specimens examined had a hyomandibular process which could pinch off to form this structure.

Late in the euryodontic stage, the quadrate starts to ossify, but does not separate from the hyomandibula. Soon thereafter, the hyomandibula starts ossifying on its medial face. Shortly before metamorphosis a small, apparently dermal, bone forms at the anteromedial edge of the hyomandibula. This bone, possibly a fusion of the endopterygoid and metapterygoid, ultimately fuses with the ossifying hyomandibula. In *M. punctatus* (Leiby, 1979b) none of these three bones start to ossify until metamorphosis is well underway, and the sequence of ossification is endo-metapterygoid, hyomandibula, quadrate.

Branchial arch development is faster in *Bascanichthys* than in *M. punctatus*. Early in the euryodontic stage of *Bascanichthys*, sutures separate all hypobranchials and ceratobranchials. These sutures are not seen in *M. punctatus* until midway through the euryodontic stage (Leiby, 1979b). All gill arch elements, including the rudimentary third basibranchial which is lost prior to metamorphosis, are present in a 64.2 mm TL *Bascanichthys* (Fig. 10C). The branchial arches of *M. punctatus* are not completely formed until early in metamorphosis (Leiby, 1979b).

Development of the neurocranium in *Bascanichthys* (Fig. 10D) is generally the same as described for *M. punctatus* by Leiby (1979b), except that the frontals and parietals in *Bascanichthys* are not preformed prior to ossification.

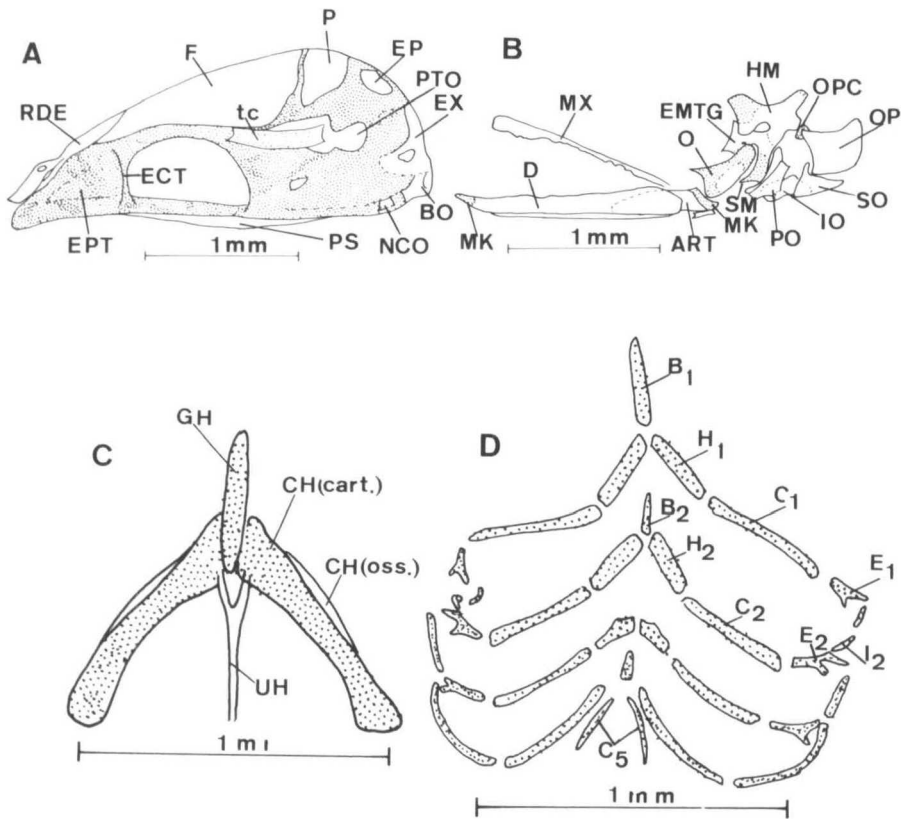


Figure 11. Head skeleton, early metamorphic *Bascanichthys bascanium*: A, Neurocranium of specimen 66.5 mm TL; B, Suspensorium and jaws of same specimen; C, Hyoid arch of same specimen; D, Gill arches of same specimen (Abbreviations: same as Fig. 9 except; BO, basioccipital; CH, ceratohyal; EMTG, endometapterygoid; EP, epiotic; EX, exoccipital; GH, glossohyal; IO, interopercle; NCO, ossification in notochord remnant between parachordals; PO, preopercle; PTO, pterotic; SO, subopercle; TC, temporal canal; UH, urohyal).

Metamorphic Stage (Figs. 11A–D).—Resorption of the cartilaginous ethmoid plate begins in the metamorphic stage (Fig. 11A). As resorption takes place, the rostral teeth and teardrop shaped bones on which they articulate are lost. No metamorphic specimens examined have yet formed the vomer. It seems likely that it develops at the end of metamorphosis.

During metamorphosis the jaws and suspensorium undergo marked change. The anterior end of the dentary and all larval teeth are lost (Fig. 11B). The angulo-retroarticular extends posterior to the articulation of the quadrate and Meckel's cartilage, but is not part of the articular surface. No metamorphic specimens examined had a coronomeckelian.

The maxillary appears to be partially resorbed along with the larval teeth but has not moved to its adult position in any of the specimens examined. As noted for *M. punctatus* (Leiby, 1979b) this movement, and attendant change in shape, occurs late in metamorphosis.

The quadrate separates from the nearly ossified hyomandibula early in metamorphosis. There is no sign of the narrow, apparently dermal, bone on the lateral

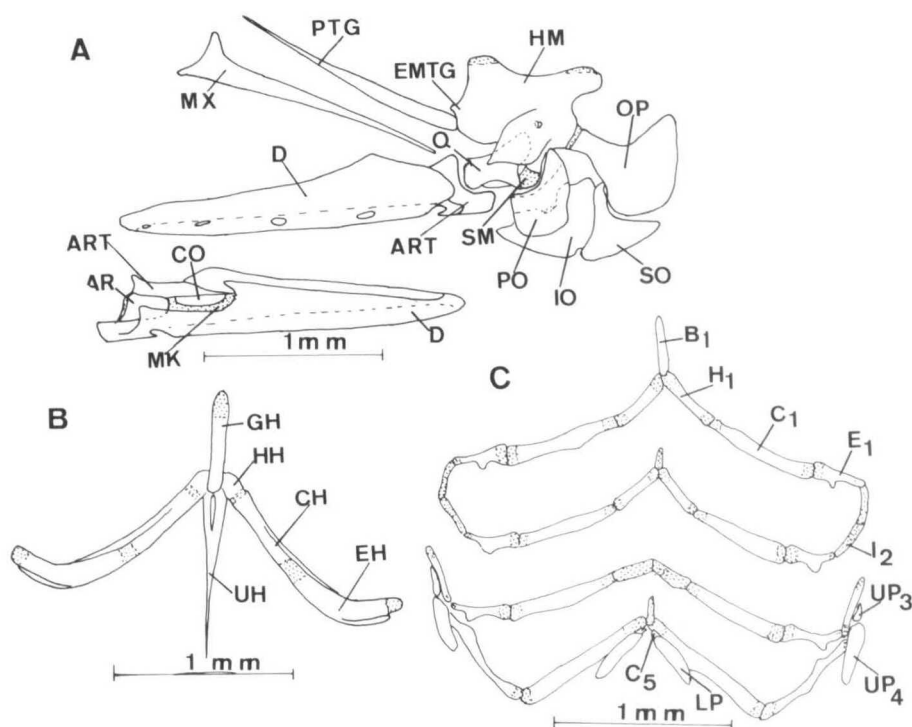


Figure 12. Splanchnocranium of glass eel stage *Bascanichthys scuticaris*: A, Suspensorium and jaws of specimen 67.4 mm TL; B, Hyoid arch of same specimen; C, Gill arches of same specimen (Abbreviations: Same as Fig. 10 except; AR, articular; CO, coronomeckelian; EH, epihyal; HH, hypohyal; LP, lower pharyngeal tooth plate; PTG, ectopterygoid; UP₃₋₄, upper pharyngeal tooth plates 3-4).

face of the hyomandibula observed in *M. punctatus* by Leiby (1979b). The symplectic has not started to ossify.

The opercular cartilage has begun to ossify. It appears that, as in *M. punctatus*, it will fuse with the blade of the opercle and become its articular facet.

Early in metamorphosis the lateral edge of the ceratohyal has started to ossify (Fig. 11C) and an apparently preformed urohyal develops. Shortly after its appearance, the urohyal starts to ossify. The full complement of branchiostegal rays is ossified.

All cartilaginous elements of the branchial arches are well developed (Fig. 11D). The rudimentary third basibranchial is gone. The future double articulation of ceratobranchials four and five with basibranchial four, mentioned by Nelson (1966) for *Bascanichthys*, is indicated by the position of the ceratobranchials. Upper pharyngeal tooth plates three and four are just visible as single, weakly ossifying teeth on very small bases. This development in early metamorphosis is in contrast to their development in *M. punctatus* (Leiby, 1979b). There is no sign of lower pharyngeal tooth plates.

All elements of the cephalic lateralis system are formed and ossifying. As described for *Bascanichthys* by McCosker (1977) there are three supraorbital pores associated with the developing nasal bone and only two preoperculomandibular pores.

Glass Eel Stage (Figs. 12A–C).—This description is based on one 67.4 mm TL specimen of *B. scuticaris*.

Development of the neurocranium seems to be as described for *M. punctatus* (Leiby, 1979b).

The dentary encases most of the receding Meckel's cartilage, is fused with the mentomeckelian and has teeth. A coronomeckelian is present. The angulo-retroarticular extends around the ventral and medial surface of Meckel's cartilage, but does not articulate with the quadrate. The articular is a separate ossification at the posterior end of Meckel's cartilage. It alone articulates with the quadrate (Fig. 12A). Later in development, the angulo-retroarticular and articular fuse with no visible sutures.

The hyomandibula is completely ossified except for its cartilaginous articular surfaces. The symplectic has ossified, separated from the hyomandibula and fused with the quadrate. A projection from the lateral face of the hyomandibula overlaps and supports the quadrate. This is probably the unnamed bone on the lateral face of the hyomandibula described by Leiby (1979b) in *M. punctatus*.

The interhyals are no longer present. The glossohyal, urohyal, ceratohyals and epihyals are all nearly ossified. The anterior end of the ceratohyals are pinching off to form hypophyals (Fig. 12B).

All branchial arch elements which are ossified in adult *Bascanichthys* have begun to ossify (Fig. 12C). The lower pharyngeal tooth plates are present. The anterior end of the fifth ceratobranchials are cartilaginous. I could not determine whether the posterior portion of the fifth ceratobranchials have been incorporated into the lower pharyngeal tooth plates (Nelson, 1966) or resorbed (Leiby, 1979b).

Fins and Axial Skeleton (Figs. 13A–F).—A median fin-fold persists until the euryodontic stage. The first noticeable fin rays form concurrently in dorsal, anal and caudal fins. Ray development in dorsal and anal fins is from posterior to anterior. The full complement of anal rays is developed and countable in alcian blue stained specimens as small as 38.0 mm TL. The full complement of dorsal rays is not developed and countable until metamorphosis.

The pectoral fin initially is a large, fleshy tab with no apparent skeletal support until a weak, cartilaginous support develops early in the euryodontic stage (Fig. 13A). The pectoral fin is reduced in size during metamorphosis. Its cartilaginous support is well developed (Fig. 13B), but does not ossify until the glass eel stage. The cleithrum appears late in the euryodontic stage. It appears to be preformed, taking up alcian blue during its initial development. The supracleithrum appears early in metamorphosis taking up alizarin red throughout development. The scapula, coracoid and pectoral fin rays are beginning to ossify in the 67.4 mm TL glass eel. Actinosts are not visible in either larvae or adults.

Formation of the caudal skeleton starts in the euryodontic stage (approx. 37.0 mm TL). The notochord flexes (Figs. 13C, D) and a dense aggregation of cells which become the hypurals, forms beneath it. At approximately 39.0 mm TL the hypurals start to chondrify. There are three hypurals which are united at the base; the lower two hypurals are also united posteriorly but are separated by a foramen (Fig. 13D). No further caudal skeleton development takes place until approximately 64.0 mm TL when the notochord starts constricting from posterior to anterior, and a parhypural is formed. Soon after the parhypural appears, hemal arches, neural arches and an ossifying uroneural develop. The upper hypural is on the terminal half centrum. The lower two hypurals are on ural centrum one. Neural arch formation is posterior to anterior for 50–60 centra, but then starts on the anterior-most centra and proceeds from both ends. Hemal arch formation

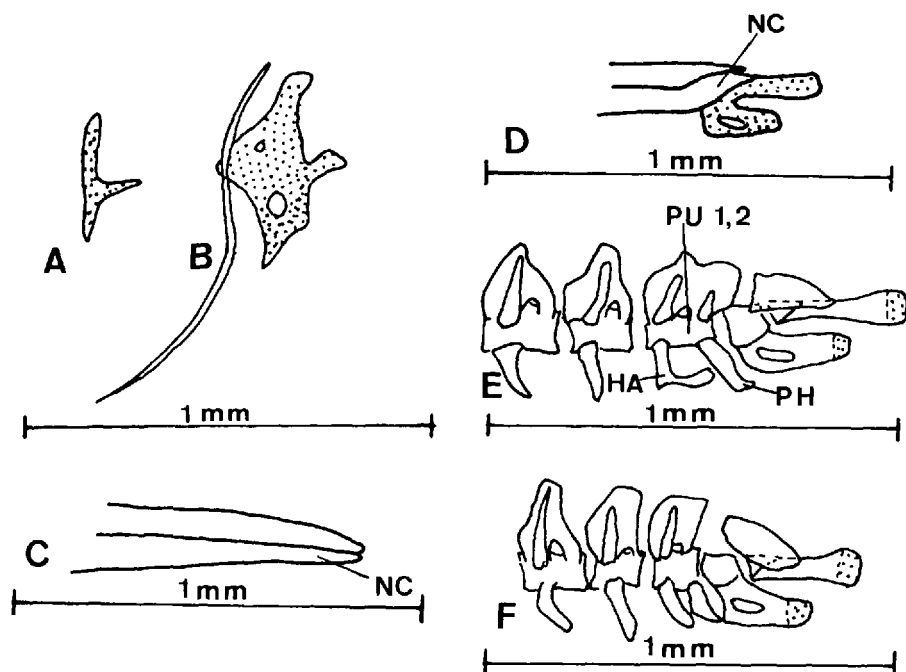


Figure 13. Pectoral girdle and axial skeleton of *Bascanichthys bascanium*: A, Pectoral fin support of specimen 42.0 mm TL; B, Pectoral fin support and cleithrum of specimen 79.6 mm TL; C, Caudal skeleton of specimen 29.2 mm TL; D, Caudal skeleton of specimen 49.4 mm TL; E, Caudal skeleton of specimen 79.6 mm TL; F, Caudal skeleton of specimen 76.3 mm TL (Abbreviations: HA, hemal arch; NC, notochord; PH, parhypural; PU_{1,2}, preural centrum 1, 2).

occurs more slowly than neural arch formation. The most advanced metamorphic specimen available (66.5 mm TL) had hemal arches on only the last 24 centra. Preural centra one and two appear to be united from the beginning. In all specimens examined, the parhypural and a hemal arch are on the same centrum. In most cases there are two neural arches on this centrum, although occasionally there is only one (Figs. 13E, F). Leiby (1979a) described a similar condition in *O. gomesi*. In *M. punctatus*, however, the parhypural is on the terminal half centrum with the hypurals and there is only one hemal arch and one neural arch on the last full centrum (Leiby, 1979b). Ossification of the caudal skeleton starts shortly before the onset of metamorphosis.

Ophichthus melanoporos

Head Skeleton.—Sequence of development of the head skeleton is shown in Table 2.

Engyodontic Stage (Figs. 14A, B).—The chondrocranium of engyodontic *O. melanoporos* (Fig. 14A) seems to differ from that of engyodontic *Bascanichthys* only in its greater length. The splanchnocranium of engyodontic *O. melanoporos* differs from that of engyodontic *Bascanichthys* primarily in size, although there are some differences in rate of development.

The maxilla and dentary are more strongly developed in an 18.0 mm TL *O. melanoporos* (Fig. 14B) than in an 18.5 mm TL *Bascanichthys* (Fig. 9A). The

Table 2. Development of the Neurocranium, Suspensorium and Jaws in 16 *Ophichthus melanopus* Larvae (-, absent; +, present but not ossifying; o, present and ossifying)

| Bones | Engyodontic | | Specimens TL (mm) Euryodontic | | | | | | | | | | | | | |
|---------------------------|-------------|------|----------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| | 18.0 | 19.8 | 21.7 | 22.6 | 27.2 | 31.3 | 36.7 | 42.1 | 49.1 | 52.5 | 69.2 | 74.3 | 76.1 | 86.1 | 89.2 | 105.8 |
| Maxillary | o | o | o | o | o | o | o | o | o | o | o | o | o | o | o | o |
| Dentary | o | o | o | o | o | o | o | o | o | o | o | o | o | o | o | o |
| Mentomeckelian | - | - | - | - | o | o | o | o | o | o | o | o | o | o | o | o |
| Coronomeckelian | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Anguloretroarticular | - | - | - | - | - | - | - | - | - | - | o | o | o | o | o | o |
| Articular | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hyomandibula | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Quadrate | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | o |
| Symplectic | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Endometapterygoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ectopterygoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Interhyal | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Ceratohyal | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Glossohyal | ? | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Urohyal | - | - | - | - | - | - | - | - | - | - | - | ? | + | + | + | + |
| Epihyal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hypohyal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Branchiostegal Rays | - | - | - | - | - | - | - | - | + | + | + | + | + | + | + | o |
| Opercular Cartilage | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Opercle | - | o | o | o | o | o | o | o | o | o | o | o | o | o | o | o |
| Subopercle | - | - | - | - | - | - | - | - | - | - | o | o | o | o | o | o |
| Preopercle | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | o |
| Interopercle | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | o |
| Parasphenoid | - | - | - | - | ? | o | o | o | o | o | o | o | o | o | o | o |
| Frontal | - | - | - | - | - | - | - | o | o | o | o | o | o | o | o | o |
| Parietal | - | - | - | - | - | - | - | - | - | - | o | - | o | o | o | o |
| Rostrodermethmoid | - | - | - | - | - | - | ? | ? | + | + | + | + | + | + | + | + |
| Basioccipital | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| Exoccipital | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Epitotic | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pterotic | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Prootic | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nasal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Supraoccipital | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sphenotic | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pterosphenoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vomer | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ethmoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Basisphenoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cleithrum | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | o |
| Supracleithrum | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | o |
| Scapula | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Coracoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cephalic Lateralis System | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

opercular cartilage is distinct in the 18.0 mm TL *O. melanopus*. The same degree of development is not seen in *Bascanichthys* until approximately 24.0 mm TL. The branchial arches develop more slowly in *O. melanopus* than in *Bascanichthys*. In an 18.0 mm TL specimen only elements of the first two arches are definitely present, while elements of all five arches are present in a 10.1 mm TL *Bascanichthys*.

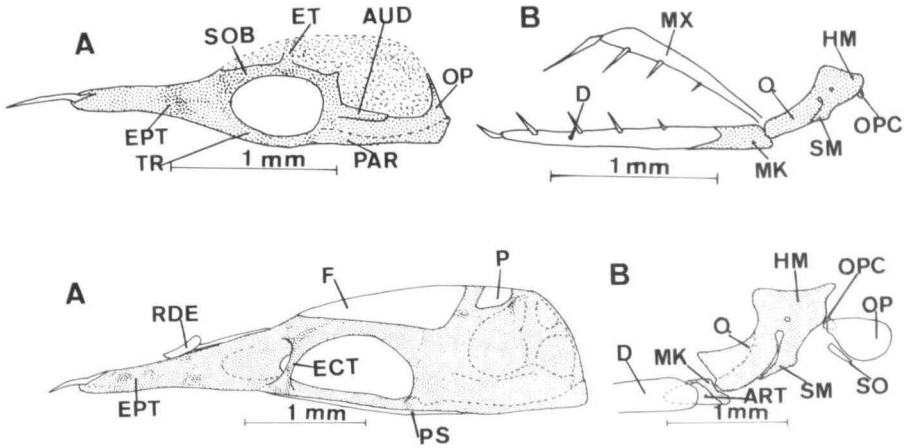


Figure 14. (Upper) Head skeleton, engyodontic stage *Ophichthus melanopus*: A, Neurocranium of specimen 18.0 mm TL; B, Suspensorium and jaws of same specimen (Abbreviations: same as Fig. 8 except; ET, epiphysial tectum).

Figure 15. (Lower) Head skeleton, euryodontic stage *Ophichthus melanopus*: A, Neurocranium of specimen 105.8 mm TL; B, Suspensorium of specimen 86.1 mm TL (Abbreviations: same as Fig. 10).

Euryodontic Stage (Figs. 15A, B; 16A, B).—The onset of the euryodontic stage is marked by a change in jaw dentition. The process does not appear to differ from that already described for *Bascanichthys*.

The chondrocranium (Fig. 15A) seems to develop in much the same way as in *Bascanichthys*, although the rostrodermethmoid is relatively farther from the snout tip than it is in *Bascanichthys*. The reason for the elongate ethmoid cartilage, which is resorbed during metamorphosis, is unclear. The incomplete state of chondrocranium development in a 105.8 mm TL euryodontic specimen suggests that metamorphosis commences at approximately 110.0–130.0 mm TL.

The development of the suspensorium (Fig. 15B) does not appear to differ from that of *Bascanichthys*. The quadrate starts to ossify first, but sufficient specimens were not available to follow the sequence of ossification to completion.

All lower elements of the branchial arches are developed early in the euryodontic stage (approx. 42.0 mm TL). By 89.2 mm TL (Fig. 16A) the epibranchials and infrapharyngobranchials are developing but are too rudimentary to illustrate. Development is slower than in *Bascanichthys* but faster than in *M. punctatus*. Prior to the onset of metamorphosis, all cartilaginous elements of the gill arches are well-developed (Fig. 16B). Upper pharyngeal tooth plates three and four are weakly developed. There is no sign of lower pharyngeal tooth plates. The condition of basibranchial three indicates that it is present, but probably reduced, in the adult. The fifth ceratobranchial is almost as strongly developed as the fourth. The position of ceratobranchials four and five relative to basibranchial four agrees with that in *O. zophochir* as illustrated by McCosker (1977).

The ceratohyal is unossified; a preformed urohyal is present. There are 18 ossified branchiostegal rays in the 105.8 mm TL specimen.

The cephalic lateralis system is weakly developed; however, the condition of the supraorbital branch indicates that there are four pores between the ethmoidal pore and the frontal commissure. This condition agrees with that found in adults

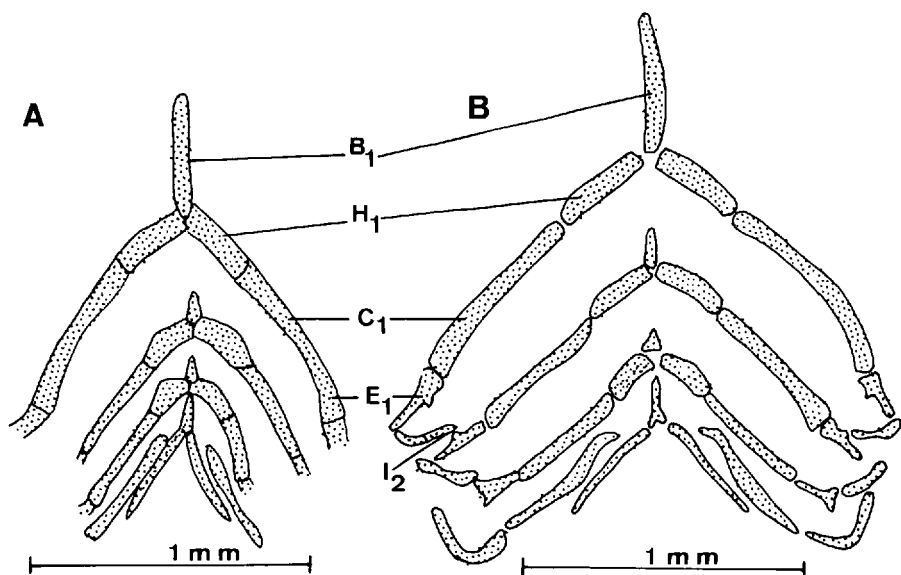


Figure 16. Gill arches of *Ophichthus melanoporus*: A, Specimen 89.2 mm TL; B, Specimen 105.8 mm TL (Abbreviations: same as Fig. 10).

(pers. obs.). The preoperculomandibular branch was not sufficiently developed to determine the number of pores associated with the preopercle.

Fins and Axial Skeleton (Figs. 17A–C).—Sequence of median fin-ray development is as in *B. bascanium*. The full complement of anal rays is developed and countable in alcian blue stained specimens as small as 49.1 mm TL. The full complement of dorsal rays is not developed and countable until late euryodontic stage.

The pectoral fin is large and strongly developed. A cartilaginous pectoral fin support is developing in the 36.7 mm TL specimen. Prior to metamorphosis the pectoral fin support (Fig. 17A) is well developed, and 14 rays are ossifying. The cleithrum and supracleithrum are present and ossified but there are no actinosts.

Formation of the caudal fin starts in the euryodontic stage (approx. 31.0 mm TL). At approximately 69.0 mm TL, the notochord starts constricting from posterior to anterior and the parhypural is formed. Soon after the parhypural appears, hemal arches and neural arches start developing from posterior to anterior. The most completely developed specimen has only nine neural arches and five hemal arches forming, therefore sequence of development cannot be elucidated. It seems likely, however, that they develop as in *Bascanichthys* and *O. gomesi*.

There are three hypurals (Fig. 17B) on the terminal half centrum. In the 105.8 mm TL specimen, preural centrum one has only one neural arch, but it supports both the parhypural and the last hemal arch (Fig. 17C). No other specimens which had developing neural arches were available, but it seems likely that its development is similar to that of *Bascanichthys* and *O. gomesi*.

Ophichthus ophis

One early metamorphic (120.0 mm TL) specimen was examined.

Head Skeleton (Figs. 18A, B; 19A, B).—Resorption of the rostral teeth is underway. The parasphenoid, rostrodermethmoid, frontals and parietals are well

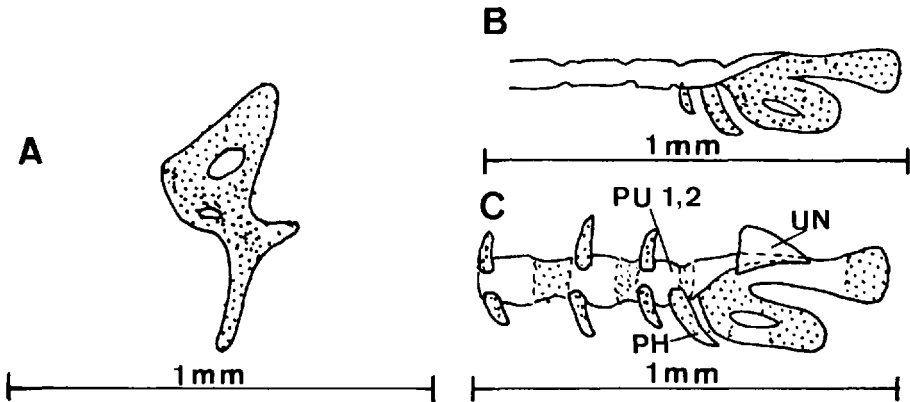


Figure 17. Pectoral support and axial skeleton of *Ophichthus melanoporos*: A, Pectoral fin support of specimen 89.2 mm TL; B, Caudal skeleton of specimen 69.2 mm TL; C, Caudal skeleton of specimen 105.8 mm TL (Abbreviations: same as Fig. 12).

ossified. The temporal ossicle of the cephalic lateralis system and the pterosphe-noid are ossifying (Fig. 18A). The ethmoid cartilage is long, but shorter than in *O. melanoporos*.

Development of the suspensorium (Fig. 18B) is similar to that in *Bascanichthys*. There is a small center of ossification in the quadrate and hyomandibula, but as yet there is no indication of the endo-metapterygoid. All four elements of the opercular apparatus are present; the opercular cartilage is not yet ossifying. The angulo-retroarticular extends past, but does not participate in, the quadrate/Meckel's cartilage articulation. Presumably the articular develops late in meta-morphosis as it does in *Bascanichthys* and *M. punctatus*.

There is no ossification in the hyoid arch and there is no sign of a urohyal (Fig. 19A). There are 21 ossifying branchiostegal rays on the left ceratohyal, 22 on the right.

The branchial arches (Fig. 19B) are well developed. The condition of the ba-sibranchials indicates that all four are probably well-developed in the adults. Ceratobranchial five is nearly as large as ceratobranchial four. The position of ceratobranchials four and five relative to basibranchial four agrees well with McCosker's (1977) illustration of *O. zophochir*. Upper pharyngeal tooth plates three and four are just developing. There is no other ossification in the branchial arches.

The cephalic lateralis system is fairly well developed although there is little ossification of the ossicles. There are four supraorbital pores between the eth-moidal pore and the frontal commissure. Preopercular pores one through three are present as in adults.

Fins and Axial Skeleton (Figs. 20A, B).—A well developed cartilaginous pectoral fin support (Fig. 19A) is present. The cleithrum is present but unossified; the supracleithrum is not present. The well developed pectoral fin has 13 rays ossi-fying.

Three hypurals articulate with the terminal half centrum (Fig. 20B). The par-hypural, one hemal arch and two neural arches are on the fused preural centra one and two. An ossified uroneural is present.

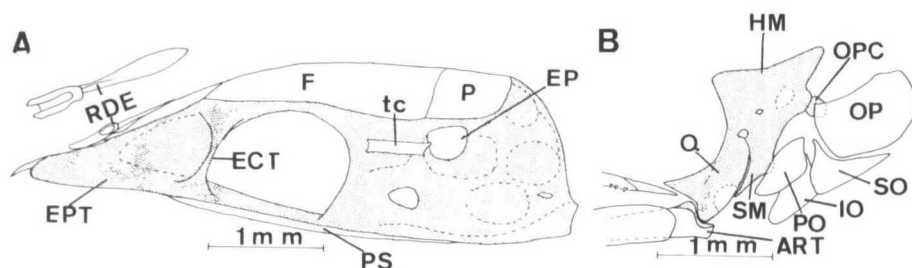


Figure 18. Neurocranium and suspensorium of *Ophichthus ophis*: A, Neurocranium of specimen 120.0 mm TL; B, Suspensorium of same specimen (Abbreviations: same as Fig. 10).

DISCUSSION

Since Schmidt (1913), it has been considered axiomatic that ophichthid leptocephali are distinguished from all other families by their three or more gut loops or swellings; by their chromatophore patches under the spinal cord in the postanal region; and, in metamorphic specimens of the subfamily Ophichthinae, by their abbreviated caudal fin (Castle, 1965; Richardson, 1974; Fahay and Obenchain, 1978). Once placed in the family Ophichthidae, the pro forma technique for identifying the larvae to genus and species has been to lump together look-alikes based on the nature of gut development and overall pigmentation (Castle, 1965; Fahay and Obenchain, 1978).

Contrary to Castle (1965), dorsal fin position is useful in identifying ophichthid leptocephali. Adult ophichthines can be placed in three groups based on dorsal fin origin. The first group, which contains all genera of the tribe Callechelyini, most genera of the tribe Bascanichthyini and a few genera in the tribe Ophichthini (not *Ophichthus*) has a dorsal fin origin above or before the gill opening. The second group, which contains many genera in the tribe Sphagebranchini, a few genera in the tribe Bascanichthyini and most genera of the tribe Ophichthini (including *Ophichthus*), has its dorsal fin origin above or behind the gill opening. The third group, limited to several genera in the tribe Spagebranchini, has no

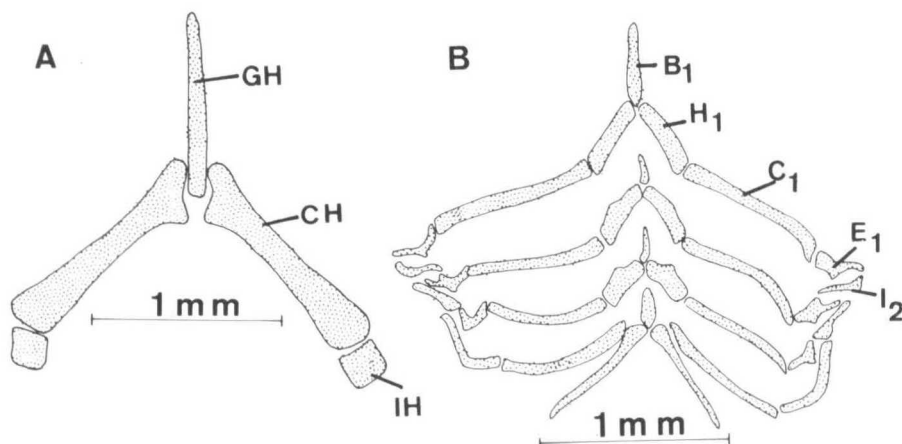


Figure 19. Hyoid arch and gill arches of *Ophichthus ophis*: A, Hyoid arch of specimen 120.0 mm TL; B, Gill arches of same specimen (Abbreviations: same as Fig. 10).

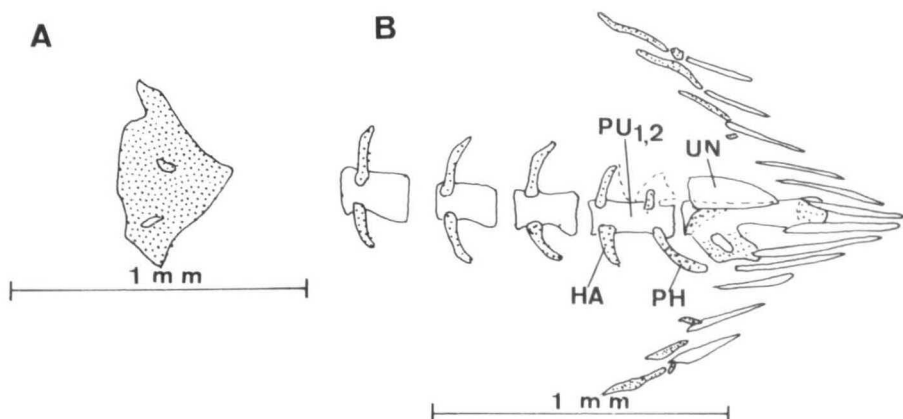


Figure 20. Pectoral support and axial skeleton of *Ophichthus ophis*: A, Pectoral support of specimen 120.0 mm TL; B, Caudal skeleton of same specimen (Abbreviations: same as Fig. 12).

dorsal fin. Dorsal fin origin in all larval, western Atlantic Ophichthinae is posterior to its adult position; however, there is a correlation between larval and adult dorsal fin position. Larvae of the first group have a dorsal fin arising between myomeres 5 and 23; larvae of the second group have a dorsal fin arising between myomeres 42 and 81; larvae of the third group have a dorsal fin origin between myomeres 117 and 135 (pers. obs.).

A series of larvae can be assigned to tribe, and usually to genus, using the above correlation between adult and larval dorsal fin position and the characters used by Leiby (1979a; b) (i.e., gill arches, branchiostegal rays, opercular apparatus, pectoral girdle, cephalic lateralis system, median fin-ray number). When a series has been identified to genus, its species can usually be determined by comparing the total and nephric myomere counts to the total and precaudal vertebral counts of adults. Additional evidence for species identification can often be obtained from the number of branchiostegal rays and the number of pores in the cephalic lateralis system. When the identity of several species in a genus has been reliably established, the diagnostic characters of the genus can be summarized. Only then can the look-alike system be used for identifying larvae to genus.

Castle (1965: 101–104) described and illustrated a specimen he called *Ophichthus* sp. Since its dorsal fin origin is at myomere 17, it cannot be an *Ophichthus*. It probably belongs in the tribe Bascanichthyini.

Using their look-alike technique, Fahay and Obenchain (1978) distinguished what they felt to be four species in one group using gut and pigmentation characters. Citing Castle's (1965) erroneous identification as partial justification, they assigned the group to *Ophichthus* arguing that "Most ophichthid genera in the western Atlantic are represented by 1 to 3 species while *Ophichthus* is known to include at least 4 and as many as 11 species." They identified their species as *O. melanoporus*, *O. ophis*, *O. gomesi* and *O. ocellatus*. Comparison of larval characters (meristics, hyo-branchial apparatus, cephalic lateralis system) with those of adults indicates the species they described as *O. melanoporus* is actually *B. bascanium*. The species they described as *O. ophis* is actually *B. scuticaris*.

Fahay and Obenchain's descriptions of *O. gomesi* and *O. ocellatus* were also erroneous. Leiby (1979a) in his description of *O. gomesi* pointed out that there was a discrepancy between his description (56–63 nephric myomeres) and Fahay

and Obenchain's description (61–75 nephric myomeres) of the same species. Michael Fahay has kindly made some of the specimens they described as *O. gomesi* and *O. ocellatus* available to me. Examination of these specimens revealed the reason for this discrepancy. Fahay and Obenchain's series of *O. gomesi* actually contains two species, *O. gomesi* and a few *Apterichtus kendalli*. The series of 164 specimens they described as *O. ocellatus* also contains two species, *O. ocellatus* and a few *Apterichtus ansp*. *A. kendalli* has low gut loops, sparse pigmentation and a range of total myomeres (137–148) similar to *O. gomesi* (138–150), but can be distinguished from *O. gomesi* by, in part, number of predorsal myomeres (121–135 for *A. kendalli* vs. 60–69 for *O. gomesi*), number of nephric myomeres (68–75 for *A. kendalli* vs. 56–63 for *O. gomesi*) and terminal point of the nephros (1–3 myomeres anterior to the anus for *A. kendalli* vs. 8–12 for *O. gomesi*). *A. ansp* has low gut loops, sparse pigmentation and a range of total myomeres (126–136) similar to *O. ocellatus* (128–138), but can be distinguished from *O. ocellatus* by, in part, number of predorsal myomeres (117–125 in *A. ansp* vs. 50–61 in *O. ocellatus*) and the terminal point of the nephros (1–3 myomeres anterior to the anus in *A. ansp* vs. 7–12 in *O. ocellatus*).

Dorsal fin origin can be difficult to determine in some leptocephali. Leiby (1979a) was able to determine predorsal origin in only 107 of 250 *O. gomesi* he examined. Fahay and Obenchain (1978) were able to determine predorsal origin in only 67 of 150 specimens they identified as *O. gomesi* and only 52 of 164 specimens they identified as *O. ocellatus*. Predorsal origin for *A. kendalli* and *A. ansp* is even more difficult to determine than in *Ophichthus* spp. I was able to determine predorsal origin in only 7 of 28 *A. ansp* and 7 of 27 *A. kendalli*. Predorsal origin in several specimens of these two species could only be determined by staining with alcian blue. It is not surprising therefore, that Fahay and Obenchain did not detect the specimens in their series which had a dorsal fin origin as far posterior as myomere 117. Nevertheless, the termination of the nephros (1–3 myomeres anterior to the anus in *A. kendalli* and *A. ansp* vs. 7–12 in *O. gomesi* and *O. ocellatus*) clearly demonstrates that Fahay and Obenchain's series identified as *O. gomesi* and *O. ocellatus* each contain two taxa rather than one. Fahay and Obenchain's (1978: 461) illustration of *O. ocellatus* is based on a specimen of *A. ansp*. It shows the nephros terminating near the anus. To be *O. ocellatus*, the illustration should have the nephros terminating more anteriorly.

Since Fahay and Obenchain (1978) inadvertently included *A. kendalli* and *A. ansp* with *O. gomesi* and *O. ocellatus*, it follows that the specimens they described as *A. kendalli* and *A. ansp*, are misidentified. Their *A. kendalli* is probably *Callochelys muraena* and their *A. ansp* is probably an undescribed member of the tribe Callechelyini (pers. obs.).

Fahay and Obenchain (1978) concluded that "The leptocephali in the genus *Ophichthus* form a cohesive group which share most characters." They felt that the well-developed gut loops and pronounced pigmentation pattern in larval *Ophichthus cruentifer* precluded placing the species in *Ophichthus* (sensu McCosker, 1977). However, since *O. cruentifer* has a larval morphology similar to that described here for *O. melanoporus*, the larval evidence does not support excluding *O. cruentifer* from the genus *Ophichthus*.

Fahay and Obenchain (1978) felt that the degree of gut looping and pigmentation in ophichthid larvae were "related to certain external features in adults. Larvae with mildly swollen guts and scattered pigment patterns are the young stages of eels with well-developed fins and relatively thick bodies. Larvae with strongly looped guts and bold, consolidated pigment patterns are the young stages of eels with reduced (or no) fins and relatively elongate bodies." Based on this assump-

tion, Fahay and Obenchain predicted that *Bascanichthys* larvae would have well-developed gut loops and pronounced pigmentation, and that *Pseudomyrophis* larvae would have a mildly swollen gut and scattered pigmentation. *Bascanichthys* larvae, as demonstrated here (Figs. 1–4), rather than having well-developed gut loops and pronounced pigmentation, have poorly developed gut loops and pigmentation. *Pseudomyrophis* larvae have well developed gut loops and distinct pigmentation (Blache, 1977; pers. obs.). Clearly, degree of gut looping and pigmentation patterns alone are not reliable indices for identifying ophichthid larvae.

After examining characters of the sphagebranchin species *Verma kendalli*, *V. ansp*, *V. monodi* and *Apterichtus caecus* McCosker (1977) concluded, contrary to Blache and Bauchot (1972), that the genus *Verma* is not distinct from *Apterichtus*. Blache (1977) continued to separate the two nominal genera and supported his conclusion using differences in morphology between larvae he described as *A. caecus* and larvae he described as *V. kendalli*, *V. monodi* and *Verma* sp. Like Fahay and Obenchain (1978), Blache (1977) ignored dorsal fin position when making his identifications. Without Blache's material, or specimens which match their description, I am unable to comment with assurance on all four identifications. However, some tentative conclusions may be drawn. First, there is nothing in Blache's (1977) description of *A. caecus* which would separate it at the generic level from *A. kendalli* or *A. ansp* as I have referred to them in this paper. Second, the species he calls *V. kendalli* is not in the tribe Sphagebranchini (sensu McCosker, 1977) but is probably *Callechelys muraena*. Third, based on dorsal fin position and other morphological characters given in the description and illustration, the species he describes as *V. monodi* is also not in the tribe Sphagebranchini but is probably in the tribe Ophichthini. Finally, based on dorsal fin position, the specimen he calls *Verma* sp. is probably one of the finless sphagebranchins, but it is not sufficiently described to assign it to genus.

In all, Blache (1977) used misidentified and inadequately described species to distinguish between *Verma* and *Apterichtus*. Since larvae of *A. caecus* do not differ at the generic level from larvae of *A. kendalli* and *A. ansp* as I have referred to them, I concur with McCosker (1977) that *Verma* is a synonym of *Apterichtus*.

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