Anguillid Leptocephali in the Southwest Pacific

By P. H. J. Castle,

Zoology Publications from Victoria University of Wellington.
No. 33, issued July 12, 1963.

Abstract

Of twelve leptocephali from the New Caledonia area, myotome counts, etc., firmly identify two as *Anguilla megastoma,* three as *A. australis,* one as *A. obscura,* but six, recognisable as long-finned larvae and associated with *A. marmorata* and *A. reinhardti* cannot be assigned definitely to either of these species. Two glass-eels from near Sydney are referred to *A. australis ?australis* on geographic grounds. Including the four *Dana* leptocephali of 1928-29 from the Southwest Pacific, the relative sizes suggest a breeding area east of New Caledonia.

Introduction

In the course of a study of New Zealand eels, a small collection of eel larvae, about 20 specimens in number, was assembled from various sources in this country. During the early stages of identification and description of these specimens several large collections of leptocephali were made available to the author for study purposes from institutions outside New Zealand—namely, (a) the Centre d'Océanographie de l'Institut Française d'Océanie, Nouméa, New Caledonia, (b) the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, New South Wales, (c) the Australian Museum, Sydney, and (d) the Western Australian Museum, Perth. At the time of writing the total number of leptocephali assembled by the author is about 1100 specimens. The present paper, however, deals with only a small fraction of this number, some 14 specimens, belonging to the genus *Anguilla* Shaw and referable to four or five of the six known Australasian species. This group of larvae was chosen for study before others because *Anguilla,* more than any other genus of eels, is the most completely known. Eel larvae are often difficult to identify, mainly due to insufficient knowledge of the adults. The species of *Anguilla,* however, have been so well described (Ege, 1939) from their adults and are so well characterised that the identification of their larvae is a relatively easy matter. Further, Jespersen's (1942) account of the larvae of the Indo-Pacific anguillid eels in the massive *Dana* collection (1500 specimens) serves as a most valuable reference in this present work.

The author would here like to express his warmest thanks to the authorities of the above institutions who kindly placed their collections on loan; to Mr M. Legand (I.F.O., Nouméa), Mr I. S. R. Munro (Div. Fish. Oceanogr., Cronulla), Mr G. P. Whitley (Australian Museum, Sydney) and Dr R. W. George (Western Australian Museum, Perth) without whose individual interest this study would not have been possible; finally, Prof. L. R. Richardson, of the Department of Zoology, Victoria University of Wellington, for his welcome criticisms.

Study Material

The present collections from the Australian region include about 550 leptocephali, but only one of these leptocephali is referable to the genus *Anguilla*; two others are glass-eels or virtually unpigmented elvers. These three specimens were collected on the east coast of Australia. Eleven other *Anguilla* leptocephali were taken in the New Caledonia-Solomons-New Hebrides area as part of a collection of about 550 specimens.

Publication of this paper has been assisted by a grant from the Victoria University of Wellington Publications Fund. Material described here was in part assembled with the aid of a grant, enabling travel to Australia, from the Victoria University of Wellington.

PRESERVATION AND METHODS OF MEASUREMENT

Where possible, preserved leptocephali were transferred to and held in a mixture to the formula given in Lea (1913, p. 5): alcohol (96%), 3 pts., formalin (3%), 3 pts. and glycerine, 2 pts. in which they remained soft and pliable; those that were already hardened by previous preservation softened noticeably. The glycerine included in this preservative raised the refractive index and offered an admirable medium for examination. Specimens which had become swollen on previous preservation in formalin were often restored by this mixture. Its chief disadvantage was that the glycerine attracted dust particles and scrupulously clean working methods were therefore required. Other specimens were stored in alcohol or 5% formalin.

Specimens were examined under a low-power binocular microscope with both transmitted and reflected light, the latter being particularly useful in observing teeth and in counting myomeres. Drawings were made with the aid of a camera lucida. Some specimens were stained in acetic acid-alum-carmine and cleared in glycerine for examination of structures in the alimentary, renal and vascular systems.

Total lengths were measured to the nearest 0.1mm by placing the specimen on a piece of white, waxed card and using pins to indicate the extremities; total length was measured from the tip of the upper jaw to the tip of the caudal fin. Contraction in length on preservation has been observed in *Anguilla* leptocephali by Jespersen (1942, p. 9) amounting to about 1–2mm in specimens of about 60mm total length. Other measurements in each specimen are as used by other authors, but a few which may be uncertain are taken as follows: Head—tip of snout to anterior extremity of pectoral base (the branchial aperture is often hard to distinguish in leptocephali); upper jaw—tip of snout to end of exposed surface of maxilla (this is a more satisfactory measurement than that of the gape or cleft of mouth since the exact corner of the mouth when open is also hard to distinguish); postorbital—posterior margin of eye to anterior extremity of pectoral base (or branchial aperture where the pectoral fin is absent). Caudal rays are counted on each hypural, from the upper to the lower, and expressed as $h_1 + h_2 + h_3$ etc., where h_1 is the upper. Teeth are counted on the left side in both upper and lower jaws in the manner of Jespersen (1942, p. 12); the sizes and separation of the various groups of teeth are distinguished by Arabic and Roman numerals, thus: $\frac{1 + \text{VI} + 8}{1 + \text{V} + 11}$ indicates that in the upper jaw there is a "grasping tooth" (usually a large recurved tooth) projecting forwards at the anterior tip of the upper jaw followed by six larger blade-like teeth and finally by a series of eight smaller teeth; the size of the teeth and the formula are much the same in the lower jaw. This type of dentition is found in leptocephali of *Anguilla* but occurs very similarly throughout the larvae of many different eels.

Identification of leptocephali to the species level is often a difficult task. The relatively few characters which are associated with a certain form of leptocephalus—e.g., disposition of melanophores and vertical intestinal blood-vessels, dentition, shape of caudal fin, always fail to survive the metamorphosis from the larva to the juvenile eel. In only a few species have a series of transitional stages been collected and the complete metamorphosis worked out. Transitional forms are in many cases active, bottom-dwelling and more easily escape trawls than do the leptocephali.

Fortunately, however, there is one major, accessible character which continues on from the larva, through the metamorphosis, to the juvenile and the adult. This is the number of myomeres (actually postcranial segments). Other characters such as fin-rays and branchiostegal rays also appear unchanged in number at least from the fully-developed leptocephalus, but are less useful for identification since they do not always appear in the larva in early stages of development.

In counting segments the first full segment is taken as the most anterior myomere extending at least to the level of the notochord and the last taken as that indicated by the last spinal ganglion. Spinal ganglia are indeed often easier to count than the myomeres. In eels the number of vertebrae is usually one less than the number of myomeres in the larvae, and this has been taken into account when referring the leptocephali to their adult species. Preanal myomeres are counted to a vertical through the vent; usually the vertical falls on the middle of a myomere at the lateral midline, and in these cases this myomere is included in the preanal number. All segments posterior to this are regarded as postanal. The distance between the dorsal and anal origins, or a–d, is expressed as the number of segments counted between the verticals through these origins.

In all leptocephali the viscera are supplied by a number of median blood-vessels from the aorta; these are referred to in this study as the "vertical blood-vessels". The positions of these vessels—there may be few to many—provide a valuable specific character. Usually the first vessel (to the anterior margin of the liver) and the last (to the posterior margin of the opisthonephros) are the most conspicuous and more readily observed. The position of each vessel is indicated by the myomere level at which it lies—e.g., 17, 25, 41, being the junction of the vessel with the aorta. In the case where a vessel is situated level with a myoseptum the level is indicated by the two nearest myomeres—e.g., 41-42.

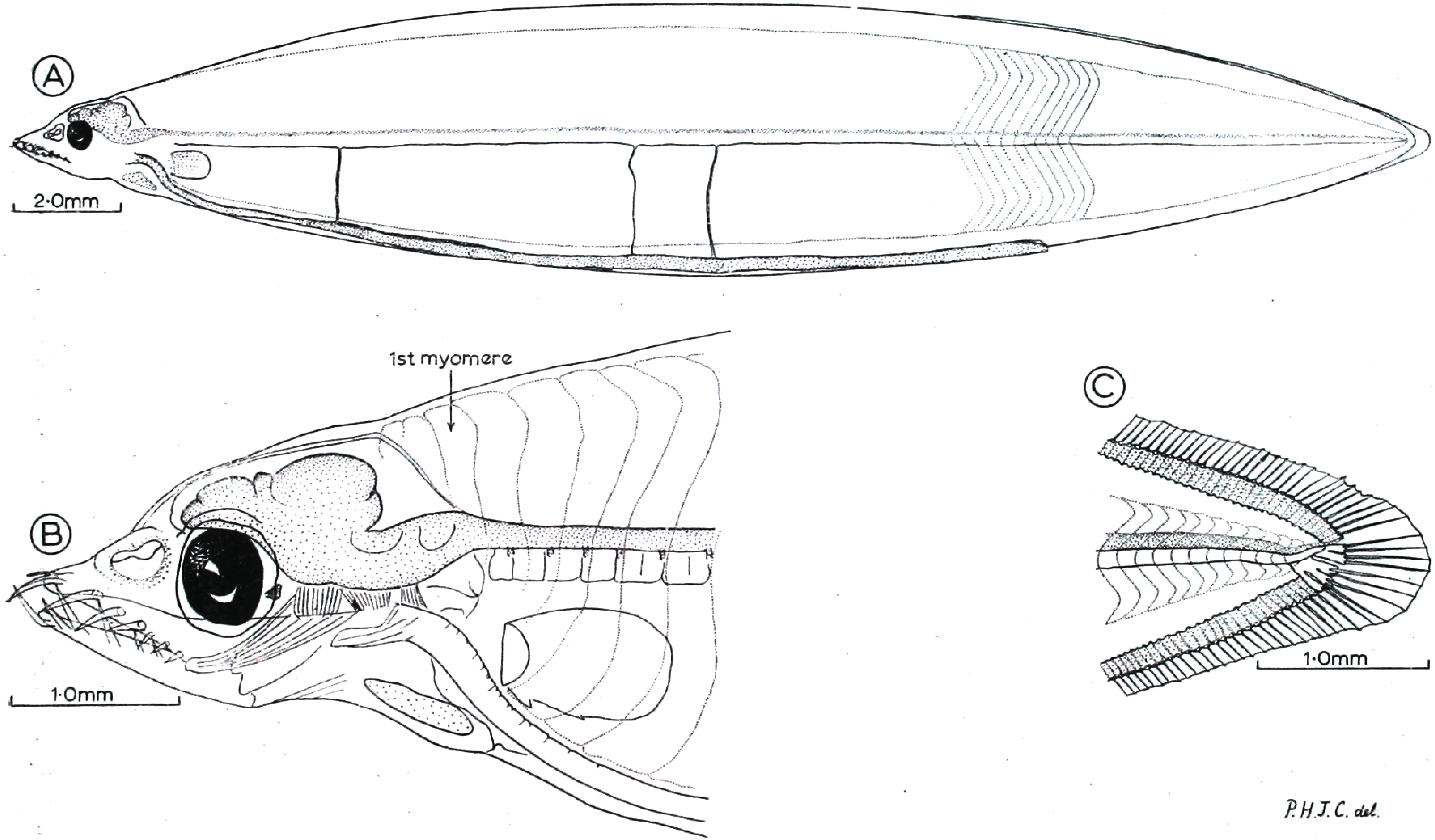
NOMENCLATURE

Opinion 44 (1912) of the International Rules of Zoological Nomenclature recognised *Leptocephalus* Gronovius, 1763, as the genus for conger eels since the larval specimen described by this author as *L. morrisii* was indeed a young conger. This action was reversed by Opinion 93 (1926) when *Conger* Cuvier, 1817 (deleted in 1958, and *Conger* Oken, 1817, replaced) was designated as the official name for conger eels and *Leptocephalus* reserved for the larval form. While a number of attempts have been made to group larval eels into various genera and subgenera, the present author follows the simple course of referring all species to the genus *Leptocephalus*. In naming leptocephali it has often been the practice to use the clumsy genitive form for leptocephali whose adults are known—e.g., *Leptocephalus Anguillae marmoratae*. The author proposes to follow Bruun (1937, p. 1) indicating a given form by the nominative—e.g., *Leptocephalus Anguilla marmorata* or more simply *L. Anguilla marmorata*.

SYSTEMATIC ACCOUNT

The genus *Anguilla* Shaw, the sole representative of the Family Anguillidae, has become, with the exhaustive researches of Danish scientists, the most intimately-known genus of eels. The two Atlantic species *A. anguilla* (L.) and *A. rostrata* (Le Sueur) were studied thoroughly by Johannes Schmidt over a long period of years, initiating a great deal of further work. His collections formed the basis of a definitive study of the systematics of the genus by Ege (1939), and Jespersen (1942) followed with a detailed account of the leptocephali of many of the Indo-Pacific species of the genus. A considerable amount is nevertheless still to be added, especially concerning the biology of the Southwest Pacific species which, because of limited material, was treated rather briefly by Jespersen.

Ege (1939) has established that there are six *Anguilla* species present in the Southwest Pacific. Four of these are long-finned species—that is, with the origin of the dorsal fin conspicuously in advance of the level of the anal origin. These



TEXT-FIG. 1.—*L. Anguilla megastoma*, 26.4mm total length, IFO St. 56-4-3. Fig. A—Lateral view, to show distribution of major vertical blood-vessels, intestine and myomeres at level of vent. Fig. B—Lateral view of head. Fig. C—Lateral view of caudal region.

are: *A. megastoma* Kaup with an average of 112 vertebrae and known from the Solomons to Pitcairn; *A. marmorata* Quoy & Gaimard with about 106 vertebrae and distributed widely throughout the Indo-Pacific from Africa to the Marquesas but not reaching south of New Caledonia or New Guinea in the Southwest Pacific; *A. reinhardti* Steindachner with about 108 vertebrae, confined to New Caledonia and eastern Australia from Cape York to Victoria; and *A. dieffenbachi* Gray with about 113 vertebrae, restricted to New Zealand. The remaining two species are short-finned eels with the dorsal origin only a little in advance of the level of the anal origin. These are: *A. australis* Richardson with about 112 vertebrae and present in Fiji, New Caledonia, Southeast Australia and possibly Tahiti: and *A. obscura* Günther with about 104 vertebrae, occurring from Tahiti through Fiji, New Caledonia, North Queensland and New Guinea.

Despite this widespread occurrence of so many species of *Anguilla* in the South Pacific only four anguillid leptocephali have ever been recorded from this area; these were from the *Dana* collection (see Jespersen, 1942, pp. 13–15). By contrast, nearly 1500 specimens of *Anguilla* larvae were taken by the *Dana* in the whole of the Indo-Pacific. The South Pacific area was widely explored by this vessel during the months of October, 1928, to March, 1929, and Jespersen assumes that the scarcity of *Anguilla* larvae in this area may have been due to the time of year when the trawling took place. The larvae described here, 12 in number, therefore make a significant addition to knowledge of the South Pacific species of *Anguilla*. These larvae were collected in similar depths to those of the *Dana* larvae and in various months of the year, so that Jespersen's assumption is not supported by the present collection.

L. Anguilla megastoma (Text-fig. 1, A, B, C)

MATERIAL EXAMINED. Two specimens, 23.7mm and 26.4mm total lengths; Institut Français d'Océanie Station 56–4–3; 12° 55′ S., 170° 04′ E.; 27/9/56 (2324 hours); horizontal tow in 70m; 0.5m net, No. 2 mesh.

DESCRIPTION. Measurements in mm: total length 26.4 (23.7), head 2.7 (2.7), snout 0.9 (0.9), eye 0.5 (0.6), upper jaw 1.0 (1.0), postorbital 1.3 (1.2), pectoral 0.9 (0.8), preanal 18.8 (17.4), predorsal 16.8 (16.2), depth just before eye 1.2 (1.0), depth at pectoral origin 2.2 (3.1), depth at midpoint between pectoral and vent 4.6 (4.2), depth at anal origin 4.4 (3.2). Branchiostegal and pectoral rays not obvious, dorsal and anal elements visible only near tip of caudal region, caudal rays 2 + 2 + 2 + 2 + 1. Teeth $\frac{1 + 1 + \text{III} + 3}{1 + \text{III} + 2}$. Myomeres 72 + 39 = 111 (114). a–d = 7 (7). 1st vertical blood-vessel at 17th myomere, 2nd at 42nd and 3rd at 48th. Anterior margin of gall-bladder at level of 29th myomere.

Body elongate but not excessively so, much compressed, not very deep and tapering a little more gradually in front of midpoint of body. Head short, about one-ninth of total length, its lower profile indented at the throat to make the head region clearly differentiated from the trunk; snout short, equal to one-third of head length, acutely pointed with its dorsal profile conspicuously concave and anterior and posterior nares almost separated; eye moderate, oval, with its greatest diameter vertical and a little less than length of snout; gape oblique, extending to level of anterior margin of eye; teeth relatively large, very acute, eight in the upper jaw, projecting outside the six of the lower jaw and distributed as follows: a large, forwardly-projecting grasping tooth is preceded by a tiny, needle-like tooth placed almost on the dorsal surface of the snout and is followed by three large teeth which become progressively smaller; this series is followed by three noticeably smaller teeth, the most posterior of which is placed almost directly under the anterior rim of the orbit; the teeth of the lower jaw are similar in size and grouping to those of the upper with the most posterior tooth placed a little in advance of the level of the last upper tooth. Pectoral fin relatively large, equal to length of snout and elongate-oval in shape; base of fin thick and fleshy, web of fin thin, supported by delicate fin-rays which are poorly developed. Dorsal fin low, with only the radials visible at the end of the caudal region. Anal fin similar. Caudal fin conspicuously separated from the tips of the dorsal and anal fins.

Colour in preservative translucent, with black pigment confined to the chorioid of the eye.

REMARKS. The two specimens described here belong unquestionably to the genus *Anguilla*. They agree very well with Group I (Anguillidae) of Ancona (1928, p. 102) in which the body is relatively short, high, in the form of an olive leaf, the intestine is straight and not festooned or swollen; the vent is about two-thirds of the length along the body; the dorsal fin originates a little in advance of the level of the vent; there is no pigmentation in the body except in very small specimens (5.0mm to 10.0mm). Both are long-finned larvae having seven myomeres between the dorsal and anal origins. They have a relatively high number of myomeres for *Anguilla* larvae, 111 and 114, suggesting that they are the young of either *A. dieffenbachi* (109–116 vertebrae) or *A. megastoma* (108–116 vertebrae). They were both collected at the same station, north-east of the New Hebrides, which is well outside the known distribution of *A. dieffenbachi* (a species restricted to New Zealand). Although the position of capture does not entirely rule out the possibility that they are the young of the latter species, since its breeding area is possibly as far north as New Caledonia, I am satisfied mainly for geographical reasons that the two larvae are the young of the other long-finned species with a high number of vertebrae—i.e., *A. megastoma.*

The two specimens of *A. megastoma* described above are evidently about half-grown, possessing only a few teeth (8–9) compared with the average full complement of about 18–20 in *Anguilla* larvae about to undergo metamorphosis. In both specimens the olfactory organ is not well developed, but in the larger the anterior and posterior nares are near to separation; the vertebral column is well chondrified; the vent is not greatly posterior; the heart is well developed, and the cranium well ossified.

L. Anguilla marmorata and L. Anguilla reinhardti

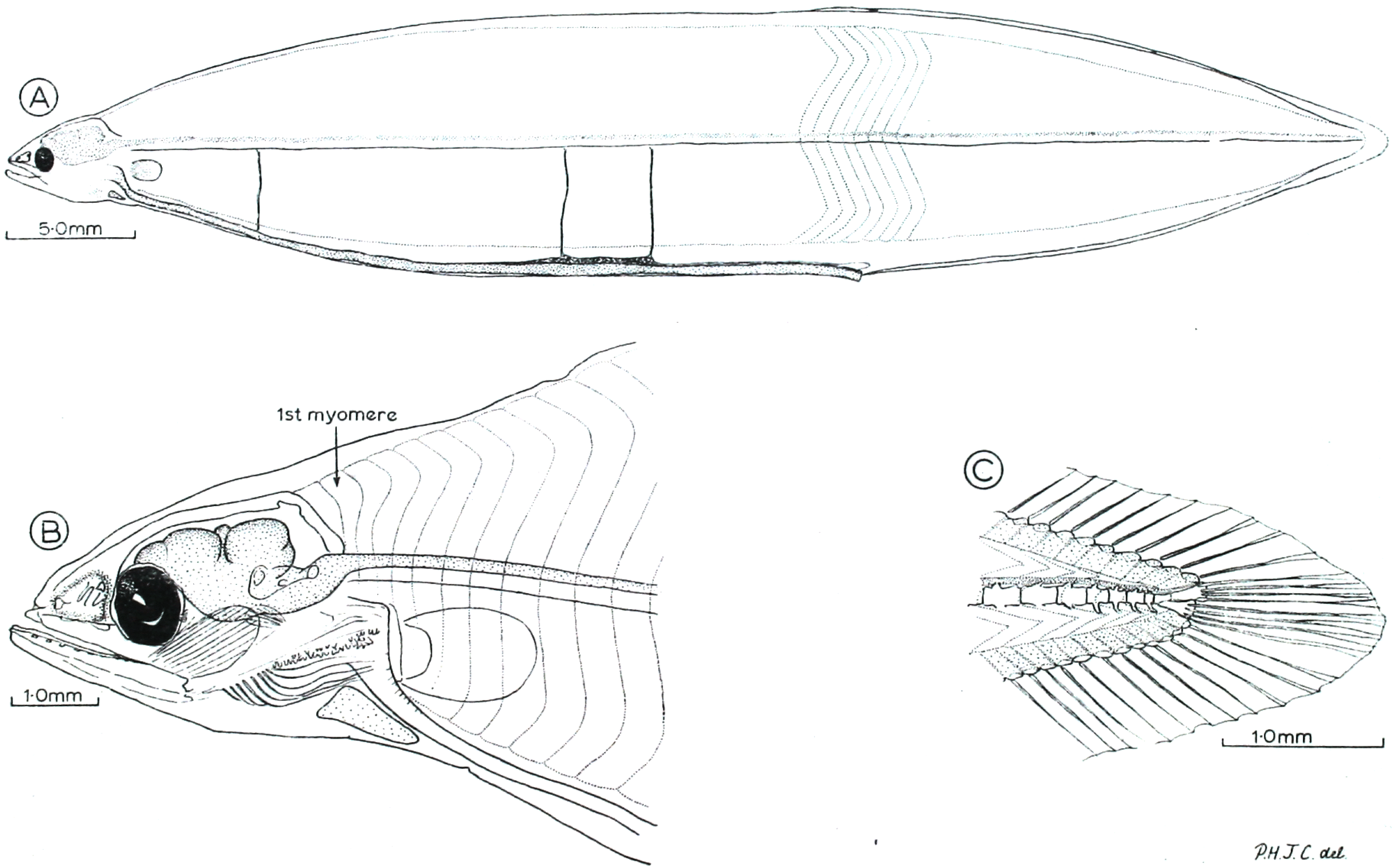
MATERIAL EXAMINED. One specimen, 27.3mm total length; IFO St. Ep 27b(1); 17° 13′ S., 162° 30′ E.; 28/9/60 (0205 hrs); 2 oblique tows in 0–300m; 0.5m net, No. 2 mesh. One specimen, 27.6mm t.1.; IFO St. Ep 9b(1); 17° 40′ S., 157° 40′ E.; 17/9/60 (0206 hrs); 2 obl. tows in 0–300m. One specimen, 37.3mm t.1.; IFO St. S 6; 11° 51′ S., 159° 13′ E.; 11/6/62; 5ft midwater trawl (Isaacs-Kidd); ca. 95m. One specimen, 39.2mm t.1.; IFO St. P Bs 16; 12° 59′ S., 165° 42′ E; 13/11/58 (0311 hrs); 2 obl. tows in 0–300 m; 0.5m net, No. 2 mesh. One specimen, 41.4mm t.1.; IFO St. D 10; 14° 50′ S., 157° 52.5′ E.; 16/5/60 (2003 hrs); 2 obl. tows in 0–300m; 0.5m net, No. 2 mesh. One specimen, 43.6mm t.l.; IFO St. Ep 19b(1); 10° 24′ S., 160° 30′ E.; 24/9/60 (0204 hrs); 2 obl. tows in 0–300m; 0.5m net, No. 2 mesh.

DESCRIPTION. Measurements in mm: total length 39.2 (27.3–43.6), head 3.8 (3.1–4.0), snout 1.2 (1.1–1.7), eye 0.8 (0.9–1.0), upper jaw 1.9 (1.4–2.1), postorbital 1.9 (1.3–2.0), pectoral 0.9 (0.6–1.2), preanal 30.9 (21.3–33.6), predorsal 25.8 (19.6–31.1), depth just before eye 1.7 (1.5–2.1), depth at pectoral origin 3.4 (2.4–4.0), depth at midpoint between pectoral and vent 8.6 (5.0–8.8), depth at anal origin 6.8 (4.1–8.4). Branchiostegal and pectoral rays not obvious, dorsal rays before level of vent 89 (91 and 82 in the two largest specimens), total rays 256 (256 and 253), first dorsal ray at level of segment 62 (61 in the two largest specimens), anal rays 200 (183–225), caudal rays 3 + 2 + 2 + 2 (variable, usually 2 + 2 + 2 + 2). Teeth $\frac{1 + 1 + VI + 10}{1 + XII + 3}$. Myomeres 73 + 34 = 107 (106–110). a–d = 9 (8–9). 1st vertical blood-vessel at 16 (15–17), 2nd at 37 (37–39), 3rd at 43 (43–44). Anterior margin of gall-bladder at level of 25th or 31st myomere.

Body elongate, but not excessively so, much compressed but relatively deep, its maximum depth contained a little more than four times in the total length, tapering equally in front of and behind midpoint of body. Head short, about one-tenth of total length, indented at the throat, pointed, with the dorsal profile slightly convex; anterior and posterior nostrils clearly separated; eye contained one and a-half times in snout, oval, with the greatest diameter vertical; cleft of mouth oblique, extending to level of middle of pupil; teeth conspicuous, very acute, 18 in upper jaw projecting outside those of lower jaw, distributed as follows: first tooth minute, needle-like, directed immediately forwards and placed on the anterodorsal surface of the snout above the second tooth, which is a much larger anteriorly-directed grasping tooth; these two are followed by a second series of large, needle-like fangs and a third of much smaller teeth to a point below the middle of the pupil; the teeth of the lower jaw are similar in grouping and size to those of the upper jaw. Branchiostegal rays not obvious. Pectoral fin large, about equal to vertical diameter of eye, rounded, base of fin fleshy but with the rays not obvious. Dorsal fin low with the rays well developed only in the larger specimens but the radials always countable. Anal fin a little higher than the dorsal. Caudal fin in the larger specimens well marked off from the dorsal and anal fins and with well developed hypurals and fin-rays.

Colour in preservative translucent with pigment restricted to the chorioid of the eye.

REMARKS. These six specimens are long-finned larvae, having 8–9 myomeres between the origins of the dorsal and anal fins compared with about 5 in short-finned species. They have 106–110 myomeres. These two characters, taken together with the location of capture of the six larvae, restrict the identification to either *A. reinhardti* or *A. marmorata*. However, it is difficult to refer these larvae further to either one or other of these two species or both since the definitive adult characters are relatively insignificant and are not exhibited in the larvae. There is evidence, nevertheless, to show that these larvae represent two species. I have examined a large number of leptocephali of the Genus *Gnathophis* (Congridae) including a wide range of sizes for two species. In this case, the segmental level of the gall-bladder is the same in both species and does not change with growth. In the present six specimens, the two smallest larvae (27.3mm and 27.6mm) have the gall-bladder at the level of the 31st myomere, but in the other four specimens the gall-bladder is level with myomeres 24 and 25. From this I consider that there are two species in this particular group of six larvae. The two smallest larvae with a more posterior gall-bladder were collected in the northerly region of the area known for the adult *A. reinhardti*. The four larger were taken in the southern part of the known distribution of *A. marmorata*. Since the areas occupied by the adults overlap only in New Caledonia, and since two larval species are indicated, further work may confirm my proposed identifications.



TEXT-FIG. 2.—*L. Anguilla australis ?schmidti*, 47.6mm total length, IFO St. 56–4–2. Fig. A—Lateral view, to show distribution of major vertical blood-vessels, intestine and myomeres at level of vent. Fig. B—Lateral view of head. Fig. C—Lateral view of caudal region.

L. Anguilla australis ?schmidti (Text-fig. 2, A, B, C)

MATERIAL EXAMINED. One specimen, 24.6mm total length; IFO St. 56–4–2; 14° 37′ S., 170° 03′ E.; 26/9/56 (2122 hrs); horizontal tow in 10m; 0.5m net, No. 2 mesh. One specimen, 47.6mm t.l.; IFO St. P 60–2–1; 22° 38′ S., 168° 20′ E; 11/4/60 (1953 hrs); hor. tow in 50m; 0.5m net, No. 2 mesh.

DESCRIPTION. Measurements in mm: total length 47.6 (24.6), head 4.3 (2.8), snout 1.0 (1.2), eye 0.7 (0.6), upper jaw 1.6 (1.2), postorbital 2.4 (1.2), pectoral 1.1 (0.5), preanal 29.6 (19.2), predorsal 27.0 (18.2), depth just before eye 1.8 (1.2), depth at pectoral origin 3.4 (2.0), depth at midpoint between pectoral and vent 8.5 (4.2), depth at anal origin 9.4 (4.1). Branchiostegal rays 12 (–), pectoral rays 17 (–), dorsal rays before level of vent 26 (–), total rays 194 (–), 1st dorsal ray at level of myomere 58; anal rays 187 (–), caudal rays 2 + 2 + 2 + 2. Teeth none and $\frac{1 + V + 3}{1 + 1 + II + 3}$. Myomeres 62 + 54 = 116 (112). a–d = 3 (2). Vertical blood-vessels at myomeres 17, 41, 48 (17, ? 48). Anterior margin of gall-bladder at myomere 27 in one specimen, obscured in the larger specimen.

Body not excessively elongate, much compressed except along the head but relatively deep with the maximum depth contained about five times in total length; tapering about equally in front of and behind the midpoint of the body. Head short, about one-tenth of total, slightly indented at the throat: snout about one-fourth of head, rounded, with a slightly convex dorsal profile and both nostrils well separated; eye contained 1.3 times in snout, oval, with the greatest diameter vertical; cleft of mouth oblique, extending to level of middle of pupil; teeth absent in the larger specimen, but eight small cavities remain in the lower jaw. Branchiostegal rays well developed and curving across the space in front of pectoral. Pectoral fin just less than snout and eye combined, rounded, base of fin fleshy. Dorsal fin low, with the radials visible throughout as well as most of the rays. Anal fin conspicuously higher than the dorsal. Caudal fin not greatly differentiated from the dorsal and anal.

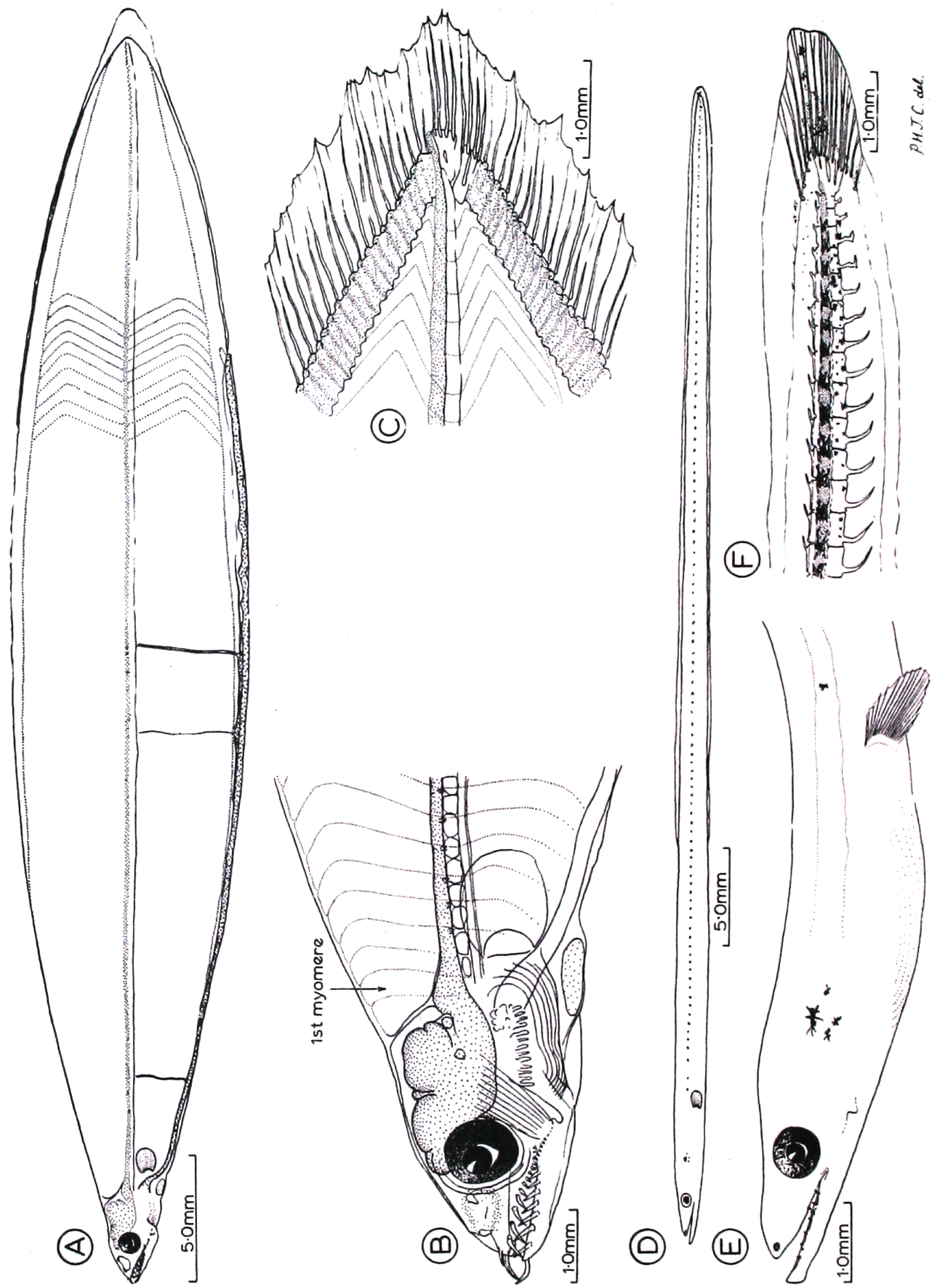
Colour translucent with pigment restricted to the chorioid of the eye.

REMARKS. These two leptocephali are short-finned, having the difference between the dorsal and anal origins equal to three myomeres. The two species of short-finned eels present in the south-west Pacific are *A. australis* with 108–116 vertebrae and *A. obscura* with 101–107 vertebrae. The two larvae have 112 and 116 myomeres and are therefore referred to *A. australis.* Two subspecies of *A. australis* have been recognised: *A. australis australis* Richardson in New South Wales, Victoria, Tasmania and Lord Howe Island and *A. australis schmidti* Phillipps from New Zealand and outlying islands, Norfolk Island, New Caledonia, Fiji, and possibly Tahiti. The larger specimen of these two larvae, almost at metamorphosis, was taken very close to New Caledonia and is probably *A. australis schmidti.* The smaller specimen was taken far from the area known for the adult of the Australian subspecies and is also tentatively referred to *A. australis schmidti.*

L. Anguilla australis ?australis

MATERIAL EXAMINED. One specimen, 75.7mm total length; Aust. Mus. regd. no. IA.2363; McCulloch Reef, Great Barrier Reef, Queensland, between 17° S. and 19° S.; transitional larva.

DESCRIPTION. Measurements in mm: standard length 74.9, head 5.8, snout 1.0, eye 1.1, interorbital 1.0, upper jaw 2.3, postorbital 4.0, pectoral 1.3, preanal 41.8, predorsal 40.3, depth just before eye 2.0, depth at pectoral origin 3.2, depth at anal origin 5.2. Myomeres 52 + 60 = 112. a–d = 1.



TEXT-FIG. 3.—Figs. A-C—*L. Anguilla obscura,* 49.6mm total length, IFO St. G 16. Fig. A—Lateral view to show distribution of major vertical blood-vessels, intestine and myomeres at level of vent. Fig. B—Lateral view of head. Fig. C—Lateral view of caudal region. Figs. D-F—*Anguilla australis australis,* glass-eel, 57.9mm total length, Aust. Mus. regd. no. I.B.5289. Fig. D—Lateral view, to show distribution of deep pigment on spinal cord. Fig. E—Lateral view of head. Fig. F—Lateral view of caudal region to show deep pigment on spinal cord and scattered lateral pigment.

Body moderately elongate, compressed, tapering appreciably only at head and along posterior half of caudal region. Head short, about one-thirteenth of total length, not greatly differentiated from trunk; snout acute, one-sixth of head, projecting in front of lower jaw and turned noticeably downwards; nostrils well separated with the anterior one almost at tip of snout, the other just in advance of eye; eye round, about equal to length of snout; gape considerably oblique, extending to a point just in advance of pupil. Teeth difficult to distinguish. Pectoral a little longer than snout; dorsal low, originating only slightly in advance of level of vent; anal also low; caudal fin distinct from tips of dorsal and anal. Colour creamy brown with black pigment restricted to the chorioid of the eye.

REMARKS. This specimen is a late leptocephalus which has taken on the elongate form of the elver. It has not yet become rounded in cross-section but is losing its transparency. The preanal myomeres number 52, compared with 39 in the elver. With a total of 112 myomeres and a short dorsal fin there is little doubt that the specimen belongs to *A. australis* and, considering its point of capture close in to the Queensland coast, to the Australian subspecies, *A. australis australis*. The specimen is not in the best condition and shows no distinctions from the larvae assigned to *A. australis schmidti* enabling certainty of subspecific identification.

Anguilla australis ?australis (Text-fig. 3, D, E, F), glass-eel.

MATERIAL EXAMINED. Two specimens, 52.5mm and 57.9mm total lengths, Aust. Mus. regd. no. IB.5289; rock-pool, Forty Baskets Beach, Sydney; 12/6/61.

DESCRIPTION. Measurements in mm: total length 57.9 (52.5), head 6.0 (6.0), snout 1.4 (1.1), eye 0.6 (0.7), interorbital 0.3 (0.3), upper jaw 1.4 (1.7), postorbital 4.3 (4.1), pectoral 1.1 (1.2), preanal 20.0 (–), predorsal 19.8 (–), depth just before eye 1.0 (0.8), depth at pectoral origin 1.8 (1.8), depth at midpoint between pectoral and vent 1.5 (1.5), depth at anal origin 1.4 (1.7). Branchiostegal rays 12 (12), pectoral rays 19 (18), dorsal rays before level of vent 9 (8), total rays ca. 193 (211), anal rays ca. 186 (203), caudal rays 2 + 2 + 2 + 2 (2 + 2 + 3 + 2). Teeth $\frac{5+2}{10+2}$ and $\frac{(5)}{(7)}$. Myomeres 39 + 74 = 113 (110). a–d = 2 (2).

Body greatly elongate, cylindrical, compressed only near tip of caudal region, tapering only at snout and at tip of caudal. Head long, about one-tenth of total length, slightly swollen in front of pectoral but otherwise little differentiated from trunk; snout rounded, less than one-quarter of head length with anterior nostril far forward on tip of snout, posterior nostril a little in advance of eye; eye less than twice in snout or about seven times in postorbital, circular; gape oblique, extending to just behind forward margin of eye, lower jaw projecting for a distance equal to length of pupil. Teeth bluntly conical, short, sparse, uniserial, unlike those of the leptocephali; distributed as follows: on the maxilla five small teeth are followed by two larger ones posteriorly, while on the dentary there are ten small teeth anteriorly and two larger ones posteriorly. Pectoral fin about equal to snout, oval. Dorsal fin low, originating only a short distance in advance of the anal; anal fin also low, caudal fin well differentiated from the tips of the dorsal and anal fins.

Colour in preservative restricted to a few large melanophores on the lateral surface of the head, a continuous series of deeply-placed, expanded melanophores on the spinal cord beginning at the level of the pectoral fin through to the tip of the caudal region, a scattering of pigment laterally on the tip of the caudal region and on the caudal fin as well as a pigmented chorioid.

REMARKS. The specimens described here are transitional elvers between Stage V and Stage VI of Strubberg (1913, p. 4); that is, they have surface pigment on the caudal, deep pigment on the caudal region of the spinal cord and neck, but the body is cylindrical. The two specimens, having two myomeres between the levels of dorsal and anal origins are short-finned and with a high number of myomeres, 110 and 113, can be referred to *A. australis*. They were collected at Sydney, New South Wales, and therefore fall well within the geographical range known for the Australian subspecies, *A. australis australis*.

L. Anguilla obscura (Text-fig. 3, A, B, C)

MATERIAL EXAMINED. One specimen, 49.6mm total length; IFO St. G 16; 16° 52′ S., 166° 26′ E; 27/2/62; horizontal tow in 16m; 1m plankton net.

DESCRIPTION. Measurements in mm: head 4.0, snout 1.1, eye 0.9, upper jaw 1.8, postorbital 2.4, pectoral 1.0, preanal 36.1, predorsal 33.3, depth just before eye 1.4, depth at pectoral origin 3.0, depth at midpoint between pectoral and vent 8.8, depth at anal origin 7.6. Branchiostegal rays 8; pectoral rays not obvious; dorsal rays before level of vent 59, total rays 216, 1st dorsal ray at myomere 63; anal rays 204; caudal rays 2 + 2 + 2 + 2. Teeth $\frac{1 + 1 + \text{IV} + 12}{1 + \text{VIII} + 5}$. Myomeres 70 + 33 = 103. a–d = 5. Vertical blood-vessels at 17, 37, 43.

Body moderately elongate, much compressed, deep, with the greatest depth contained five times in total length. Head short, about one-eleventh of total length, rather depressed so that it is well differentiated from trunk; snout short, about one-fourth of head length, its dorsal profile convex; anterior and posterior nostrils well separated; eye about equal to length of snout, oval; cleft of mouth oblique, extending almost to level of posterior margin of eye; teeth conspicuous, very acute, 18 in upper jaw projecting outside those of lower jaw which number about 13, distributed as follows: first tooth of upper jaw small, needle-like, directed anteriorly and placed immediately above the second, much larger, anteriorly-directed grasping tooth; these two are followed by a series of four large teeth and a final series of 12 noticeably smaller teeth; lower teeth similar to those of upper jaw with the absence of the needle-like anterior tooth. Branchiostegal rays delicate and curving up around the operculum. Pectoral fin about 1.5 times diameter of eye, rounded, fleshy. Median fins well developed with fin rays and radials clearly visible.

Colour in preservative translucent with black pigment restricted to the chorioid of the eye.

REMARKS. The specimen belongs to a short-finned species, having five myomeres between the levels of the dorsal and anal origins. The myomeres number 103, and this character fully identifies the specimen with *A. obscura* which has 101–107 vertebrae. The specimen is well advanced in development having very nearly a full complement of teeth, well developed fin-rays, etc., and the vent placed half way between the midpoint of the body and the tip of the caudal region.

DISCUSSION

The twelve leptocephali dealt with above plus the four specimens from the *Dana* collection giving a total of 16 known specimens of anguillid larvae from the Southwest Pacific contrasts strongly with the richness of collections of this family in other ocean areas. This is the more interesting because the area contains six known species, all of which are common in the freshwaters of the area. There is no uncertainty in sorting these few larvae into long-finned and short-finned categories. Within these groups, four larvae can be identified as the short-finned *A. obscura* (one specimen) and *A. australis* (three specimens) since the number of myomeres is distinctive between the adults of these species, but so far no distinction other than zoogeographic in the sense of the localities at which specimens were taken can be made at the subspecific level for *A. australis*.

Of the eight long-finned larvae two are here identified with *A. megastoma,* since these two specimens were taken much further to the north of the observed geographic range of *A. dieffenbachi* with which the larvae of *A. megastoma* could be confused. The six remaining specimens belong either to *A. marmorata* or *A. reinhardti* although certain differences in morphology and geographical reasons suggest that four of these are *A. marmorata* and two *A. reinhardti.*

Although there are no very early larvae in this collection, the smallest being 23.7mm (*A. megastoma*), it may be significant in determining the location of the breeding areas of the various species that all the smaller larvae were collected to the east of the larger larvae (with the exception of the *Dana* specimen of *A. obscura,* 43mm). Taking into consideration the general east-west trend of the prevailing current system in this area it seems likely that the breeding area for these species is well to the east of New Caledonia—that is, between Fiji and Tahiti. All of these *Anguilla* larvae were collected in depths of about 100m–200m where the temperature is at least 20° C. and the salinity is about 35.5‰. Conditions such as these are known to occur in the breeding areas of the Atlantic species of *Anguilla.*

In 11 early elvers of *A. australis australis* from the New South Wales region Ege (1939, p. 209) records the total length to be 47mm–64mm although the average was about 53mm. Both of the glass-eels described above fall within this range (52.5mm and 57.9mm). Elvers of *A. australis schmidti* from New Caledonia reach an average maximum of about 50mm, while those of this species from New Zealand reach a much greater average length, about 61mm. As Ege (1939, p. 211) notes, there appears to be no systematic significance in the difference in maximum size between elvers from New Caledonia and New Zealand, but that this is rather " an expression of biological-geographical conditions ". A similar condition in which the elvers are relatively large nevertheless also occurs in the other two temperate species of *Anguilla* in the Pacific. *A. japonica* Temminck & Schlegel from Japan has elvers which reach about 57mm (Ege, 1939, p. 142) while those of *A. dieffenbachi* from New Zealand reach about 64mm–70mm. It is possible that the temperate elvers are more distant from the breeding grounds of the adults than are their tropical counterparts, and this may account for their larger average size.

KEY TO THE LEPTOCEPHALI OF SOUTHWEST PACIFIC SPECIES OF THE GENUS *Anguilla*

This key has been prepared from the 16 known *Anguilla* larvae from this area; the number of myomeres in each species (one more than the number of vertebrae) has been taken from the observed range of variation in the vertebral count of the adult. The key is simple to use. Where there is agreement at one number, proceed to the consecutive number; where there is no agreement, proceed to the alternative indicated in parentheses.

Body elongate to elongate-oval, not filamentous, reaching about 50mm just before metamorphosis begins, depth about one-fifth of total length. Pectoral fin present; upper jaw reaching to below middle of pupil; gut straight, not swollen or festooned; major vertical intestinal vessels usually lying at segments 17, 40, 45; vent never closer to tip of tail than by about 30 segments, before metamorphosis the myomeres numbering about 70 + 40 with a total in all species between 100 and 120. Pigment restricted to the chorioid of the eye but very young specimens have a few small black spots on the caudal tip .... *Anguilla* Shaw.

1 (4) Number of complete myomeres between verticals through the dorsal and anal origins less than six (short-finned species)

2 (3) Myomeres 102–108, anterior margin of gall-bladder at the level of the 27th myomere, a–d = 5–6, major vertical blood-vessels at 15–17, 35–37, 42–44 .... *A. obscura* Günther, known from Tahiti, south of Fiji and New Hebrides.

3 (2) Myomeres 109–117, anterior margin of gall-bladder at the level of the 27th myomere, a–d = 1–4 .... *A. australis* Richardson.

Major vessels at 16–17, 39, 45–46 ...... *A. australis ? australis* Richardson, known from south-east of New Caledonia and North Queensland.

Major vessels at 17, 41, 48 .... *A. australis ? schmidti* Phillipps, known from east of New Caledonia and north-east of New Hebrides.

4 (1) Number of complete myomeres between verticals through the dorsal and anal origins more than six (long-finned species).

5 (8) Myomeres 101–111, a–d = 8–10.

6 (7) Anterior margin of gall-bladder at level of 25th myomere, major vessels at 15–17, 36–37, 42–43 .... *A. marmorata* Quoy & Gaimard, known in the south-west Pacific from near Samoa and between Solomon Is. and New Caledonia.

7 (6) Anterior margin of gall-bladder at level of 31st myomere, major vessels at 16–17, 38–39, 44 .... *A. reinhardti* Steindachner, known from north-west of New Caledonia.

8 (7) Myomeres 109–117, a–d = 7, major vessels at 17–19, 41–42, 47–48, anterior margin of gall-bladder at 29–31 .... *A. megastoma* Kaup, known from north-east of New Hebrides. *A. dieffenbachi* Gray is unknown as a leptocephalus but would probably fall close to *A. megastoma* in its larval characters.

LITERATURE CITED

ANCONA, U, d', 1928. Muraenoidi (Apodes) del Mar Rosso e del Golfo di Aden. Materiali raccolti dal Prof. L. Sanzo nella campagna della R.N. "Ammiraglio Magnaghii" 1923-24. *Mem. R. Com. talassogr. ital.*, 146: 1–146, 5 pls.

BRUUN, A. F., 1937. Contributions to the life histories of the deep sea eels: Synaphobranchidae. *Dana Rep.*, 9: 1–31, 1 p., 17 text-figs.

EGE, V., 1939. A revision of the genus *Anguilla* Shaw. A systematic, phylogenetic and geographical study. *Dana Rep.*, 16: 1–256, 6 pls., 53 text-figs., 208 tabs.

JESPERSEN, P., 1942. Indo-Pacific leptocephalids of the genus *Anguilla*. Systematic and biological studies. *Dana Rep.*, 22: 1–127, 4 pls., 83 figs.

LEA, E., 1913. Muraenoid larvae from the "Michael Sars" North Atlantic Deep-Sea Expedition, 1910. *Rep. Sci. Res. Sars Exped.*, 3 (1): 1–48, 6 pls., 38 figs.

STRUBBERG, A. C., 1913. The metamorphosis of elvers as influenced by outward conditions. *Medd. Komm. Havunders., Fiskeri,* 4 (3).

P. H. J. CASTLE, M.Sc.,
Department of Zoology,
Victoria University of Wellington,
P.O. Box 196, Wellington, N.Z.

The Systematics, Development and Distribution of Two Eels of the Genus *Gnathophis* (Congridae) in Australasian Waters

By P. H. J. Castle,

Zoology Publications from Victoria University of Wellington.
No. 34, issued July 12, 1963.

Abstract

Gnathophis habenatus habenatus (Richardson, 1848) of shallow New Zealand coastal waters has the preanal region long, never less than 40% of total length, while *Gnathophis h. longicaudatus* (Ramsay & Ogilby, 1888) from Southeast Australia resembles the Japanese *G. heterognathus* and *G. nystromi* and the Californian *G. catalinensis* in a short preanal region, less than 40% of total length. Both subspecies have 120–129 vertebrae, scroll-like anterior nostrils and an inconspicuous, triangular premaxillary-ethmoid patch of teeth, distinct from *G. incognitus* n. sp., the adult as yet known only from New Zealand waters, which has 139–147 vertebrae, anterior nostril with a simple, free flap, externally obvious premaxillary-ethmoid patch of teeth, minute, scattered epidermal papillae and preanal region usually less than 40% of total length.

Size-range of leptocephali indicate spawning off New South Wales and Western Australia, metamorphosis at about 80mm and characteristically a posterior vent, somatic pigment as a ventral, regular series at the level of the simple intestine, small pigment crescent below iris and in the largest larvae, a pigment spot at the base of most anal rays.

Introduction

Among the fishes collected by the vessels H.M.S. *Erebus* and H.M.S. *Terror* while they were in New Zealand waters during the years 1840–41 was a small congrid eel which Sir John Richardson (1848, p. 109, pl. 50, figs. 1–5) described and figured under the name *Congrus habenatus*. The type specimen was taken in "Cook's Strait", but no more precise locality was given. Since the time of Richardson's account the "little conger" or "silver conger", as the species has come to be known by fishermen and others, has occasionally appeared in seine nets, trawls and fish stomachs from other parts of the New Zealand coast as well as from the Cook Strait area. The silver conger is also well-known in south-east Australia. Such an eel cannot easily be confused with other eels of these regions in view of its remarkably bright silver colouration over the anterior part of the body and particularly the iris making this a most attractive and easily-remembered fish.

Although Richardson's *Congrus habenatus* is thus well-recognised from Australasian coastal waters there has always been considerable systematic confusion, involving some nine generic names, in the correct name of this animal and related species elsewhere. This paper finally resolves this confusion; but further, early in the examination of numerous specimens of the silver conger from the New Zealand region, it was found that a second, unrecognised species was also present in the area and this is described and figured here.

In the preparation of this paper I have been able to examine 33 juveniles and adults of the two species, most of which were taken in seine nets in Wellington

Publication of this paper has been assisted by a grant from the Victoria University of Wellington Publications Fund. Material described here was in part assembled with the aid of a grant, enabling travel to Australia, from the Victoria University of Wellington.

Harbour while the others were collected mainly by commercial trawls from various localities around the New Zealand coast and from as far north as the Kermadec Islands. I have also been able to examine two glass-eels, still possessing their larval pigment, from Western Australia. These provided a conclusive link between the larval stages and the young elvers of these eels. A great number of larvae of the two species, about 250 in all, representing an almost complete series up to late metamorphosis, were also available. The development and distribution of the larvae are thus now established and have been included in the account to complete the knowledge of the two species of silver conger in the Australasian area.

Proportional measurements were made to the nearest 0.1mm with accurate calipers in the manner I have already described (Castle, 1961, p. 2). Small structures were drawn with the aid of a camera lucida. One adult specimen of each of the two species was stained in alizarin and cleared in glycerine for the purpose of osteological study. Two skulls were examined as hand specimens. In the examination of the leptocephali the first myomere is taken as the one which extends ventrally to the level of the notochord. Myomeres are counted along the midlateral level. Preanal myomeres are those which lie in front of the vertical through the vent and where this cuts across a myomere this is included in the preanal count.

I am greatly indebted to the following institutions and persons who have helped in many ways in the preparation of this account. Firstly, to those institutions which have so generously allowed me to examine leptocephali or adults in their collections (a) the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, New South Wales, (b) the Centre d'Océanographie de l'Institut Français d'Océanie, Nouméa, New Caledonia, (c) the Australian Museum, Sydney, (d) the Western Australian Museum, Perth, (e) the Dominion Museum, Canterbury Museum and Otago Museum, New Zealand; secondly, to Mr R. H. Kanazawa, Division of Fishes, U.S. National Museum, Washington, for valuable comments on the distinctions of various genera of eels and for literature; Dr J. C. Yaldwyn, Australian Museum, for examining the type of *Congromuraena longicauda*; finally, to Prof. L. R. Richardson, Department of Zoology, for his valuable criticisms.

SYSTEMATIC ACCOUNT

Günther's Catalogue of the Fishes of the British Museum (1870) provides the first clue to the correct generic name of the Australasian silver conger. Because of certain similarities in dentition, Günther (1870, pp. 42–43) included as a possible synonym of Richardson's *Congrus habenatus* a species which had been described as *Myrophis heterognathos* by Bleeker (1859, p. 9) from Nagasaki, Japan. Kaup (1859, p. 7) based his new genus *Gnathophis* on Bleeker's species, clearly distinguishing *Gnathophis* from *Myrophis* Lütken, 1851, in having three prong-like preorbital bones in the upper lip, the dorsal originating over the middle of the pectoral fin and the head length equal to the length of the abdomen. Mr R. H. Kanazawa, U.S. National Museum, has kindly provided me with both Bleeker's and Kaup's original descriptions and also informs me that *Myrophis* indeed does not have the prong-like bones in the upper lip. Bleeker (1864, p. 29) later admitted his error in referring the Nagasaki specimen to *Myrophis* (although Schultz et al. (1953, p. 70) perpetuate the mistake) and stated that his specimen was a second species of *Uroconger* Kaup, 1856. Asano (1962, p. 114) supports Bleeker's view in part and places *Myrophis heterognathos* as a synonym of *Uroconger lepturus* (Richardson, 1844). But a comparison of Bleeker's illustration of *Myrophis heterognathos* with Asano's description of *Uroconger lepturus* shows conclusively that the Nagasaki specimen cannot be a *Uroconger*.

In his useful and detailed account of the Japanese congrid eels Asano recognises on morphological grounds two divisions of the Congridae (a) the *Anago-*

stem, including *Anago, Ariosoma, Alloconger, Chiloconger* and *Thyreoconger* (which is a synonym of *Ariosoma*; see Rosenblatt, 1958, p. 54) all of which, among other characters, lack the supraoccipital bone and (b) the *Conger*-stem, including the other congrid genera examined, which all have the supraoccipital bone except *Congriscus.* Reference may be made to Asano's account for the numerous other characters which serve to distinguish the genera of the two groups. Bleeker's illustration of *Myrophis heterognathos* shows an eel with the dorsal fin originating over the middle of the pectoral, a character possessed only by *Congriscus megastomus, Conger cinereus, Rhynchocymba nystromi, R. xenica* and *Congrina retrotincta* of the Japanese eels; the tail is relatively short, referring it to *Congriscus, Conger* or *Rhynchocymba*; the vomerine teeth are molariform and in several rows, while the maxillary teeth are conical, both characters which are indicative of all genera except *Uroconger* and *Congrina*; the prong-like preorbital bones are directed forwards and outwards. *Uroconger* has a dorsal origin over the branchial aperture, a very long tail and preorbital prongs which are directed backwards and outwards; *Congriscus* and *Conger* have no preorbital prongs. *Myrophis heterognathos* can therefore be referred only to *Rhynchocymba* under Asano's system and clearly not to *Uroconger.* Since *Myrophis heterognathos* is the type of Kaup's genus *Gnathophis* then *Rhynchocymba* (Jordan & Hubbs, 1925) is a synonym of this genus.

Returning to Günther's suggestion that *Gnathophis heterognathus* is very closely similar to the Australasian silver conger, an examination of various osteological characters of the two shows them to be congeneric. The silver conger is immediately referable to Asano's *Conger*-stem in having a supraoccipital present, a reduced ethmoid process, four suborbital bones and lateral line ossicles of the *Conger* type. Further, there are three prong-like bony projections into the upper lip from the ventral aspect of the preorbital bone and the upturned labial flange of the upper lip is present but reduced. By Asano's account these characters restrict Richardson's *Congrus habenatus* to "*Rhynchocymba*"—i.e., *Gnathophis.* Phillipps (1927, p. 17) has already listed the silver conger as *Gnathophis habenata* but *Gnathophis* is masculine gender and the specific name therefore becomes *G. habenatus* (Richardson, 1848). The type species of *Gnathophis* is *G. heterognathus* (Bleeker, 1859) from Nagasaki, Japan (type specimen 140mm total length held in the British Museum as BMNH 1867–11–28–305) and not *G. habenatus* as I had already noted in error (1960, p. 464).

Wade (1946, p. 194) describes a species of *Gnathophis* from the coast of California and thus the distribution of the genus is further extended from the Japanese and New Zealand regions, but the range is probably not confined to the Pacific. It is my opinion that *Muraena mystax* Delaroche, 1809, from the Mediterranean (*in lit.* variously *Congermuraena, Bathycongrus,* etc.) is also a *Gnathophis* but lacking specimens I am unable to confirm this. Lozano Rey (1947, pp. 531–534, pl. 7, fig. 3) describes and figures this species. His illustration shows an eel with essentially ventrally directed anterior nostrils, a labial flange not especially well developed, a relatively short tail and from the description, a silver iris. All of these features are characteristic of *Gnathophis.* Further, the larvae of Delaroche's species, as described and figured by Lea (1913, pp. 18–21, figs. 12–15, pl. 3, nos. 1–2) are strikingly similar to those of *Gnathophis habenatus* as described later in this account. They have the vent placed relatively far back (in fully developed larvae), there is a crescentic patch of black pigment below the posteroventral corner of the iris, there is a series of regularly-spaced pigment spots at the level of the intestine along the ventral body-wall and a series of spots on the bases of most anal rays. Although it would be unwise at this stage of knowledge to speculate too much on the relationships of adult eels as shown by their larvae, in view of the fact that leptocephali show fairly clearly defined generic categories it seems likely that Delaroche's "*Muraena*" *mystax* is a species of *Gnathophis*.

Gnathophis habenatus has been known under a variety of generic names, the first of which is *Congermuraena* Kaup, 1856. Kaup (1856, p. 105) first applied *Congermuraena* (or *Congromuraena* as emended by Günther, 1870, p. 40) to *Congrus habenatus* but in doing so referred two other species, *Muraena balearica* Delaroche, 1809, and *Muraena mystax* Delaroche, 1809, to this genus. Kaup gave a long description of *Congermuraena habenata* (copied from Richardson) in comparison with only brief mention of the other two species and Bleeker later selected *Muraena balearica* as the genotype. However, Swainson (1838, p. 220) had already diagnosed a new genus *Ariosoma* from a species well-known from Sicilian shores which was "richly coloured with silver reflections, very different from the lurid hues of the true eels". As Ogilby (1898, p. 287) points out Swainson was probably referring to Delaroche's *Muraena balearica* when he established *Ariosoma*. It is unlikely that he had *Muraena mystax* in mind since this species has only a silver iris compared with the broad silver colouration in *Ariosoma balearica* (Lozano Rey, 1947, pp. 530 & 533). Swainson's "nostrils not tubular" in his description of *Ariosoma* was probably meant to distinguish this genus from *Muraena* which has conspicuously tubular posterior nostrils.

As Griffin (1936, 16–17) indicates, Bleeker's action in selecting *Muraena balearica* as the genotype of *Congermuraena* makes the latter a synonym of *Ariosoma*. Griffin recognised the generic distinction of Richardson's *Congrus habenatus* from *Ariosoma balearica* and that the former was apparently left without a valid generic name. He therefore proposed *Poutawa* for this species and thus *Poutawa* is a synonym of *Gnathophis*.

GNATHOPHIS Kaup, 1859

1848. *Congrus* Richardson (partim), *Voy. Ereb. Terr., Fish.*, p. 109.
1856. *Congermuraena* Kaup (partim), *Cat. Apod. Fish.*, p. 105.
1859. *Gnathophis* Kaup, *Abh. Naturw. Hamburg*, 4 (2): 7.
1925. *Rhynchocymba* Jordan & Hubbs, *Mem. Carneg. Mus.*, 10 (2): 194.
1936. *Poutawa* Griffin, *Trans. roy. Soc. N.Z.*, 66: 16.

Six species are here referred to the genus *Gnathophis* Kaup, of which two have been each further subdivided into two subspecies. Three of these species are known from the shallow waters of Japan and China: the type species *G. heterognathus* (Bleeker, 1859), *G. nystromi* (Jordan & Snyder, 1901) and *G. xenicus* (Matsubara & Ochiai, 1951). As indicated earlier in this account, the dorsal fin originating over the middle of the pectoral, the reduced upper labial flange, the three prong-like bones in the upper lip, the relatively short, robust tail, the molariform vomerine teeth and the scroll-like or flap-like anterior nostril are easily recognisable features of these gnathophid eels. Schultz et al. (1953, p. 70) give measurements taken from Bleeker's description of the type specimen of *G. heterognathus* and these are as follows (in per cent total length): head 17.0, snout 4.3, eye 2.9, cleft of mouth 5.3, pectoral 4.7, predorsal 20.7, preanal 37.3. Jordan & Snyder (1901, p. 853) give similar proportions for the type specimen of *G. nystromi*: head 16.1, snout 4.6, eye 3.1, cleft of mouth 5.3, pectoral 5.3, predorsal ca. 18.5, preanal 37.5. The number of vertebrae in the latter species is 114–132 (Matsubara & Ochiai, 1951, p. 6) but unfortunately no vertebral count is available for *G. heterognathus*. Nevertheless, considering the relative abundance of *G. nystromi* in Japanese waters and that *G. heterognathus* is still only known from the one specimen, the very close similarity of the two species in proportional measurements indicates that *G. nystromi* is very probably a synonym of

G. heterognathus. A complete re-examination of Bleeker's type is necessary to confirm or refute this suggestion.

G. nystromi has been divided into two subspecies, *G. nystromi nystromi* (Jordan & Snyder, 1901) and *G. nystromi ginanago* (Asano, 1958). The former has fewer lateral line pores before the vent, fewer vertebrae, shorter trunk, smaller eye, sharper snout, longer vomerine band and dark pigmented alimentary canal. The third Japanese species, *G. xenicus*, which Matsubara & Ochiai (1951, p. 8) originally described as a subspecies of *G. nystromi* is distinguished from *G. heterognathus–G. nystromi* in having a shorter head and a much greater number of vertebrae, 152–154.

One other species has been described from the North Pacific; this is *G. catalinensis* (Wade, 1946) known from one individual collected off Santa Catalina Island, California. *G. catalinensis* has the many features characteristic of gnathophid eels, but Wade's illustrations (pl. 26, figs. 1–3, p. 209) show a simple tubular anterior nostril, an inconsistent feature which should be checked in view of the close similarity of this species in other characters to Japanese species. Wade gives the following proportions for the type of *G. catalinensis*: head 16.8, snout 4.6, eye 3.2, cleft of mouth 5.3, pectoral 6.0, predorsal ca. 18.0, preanal 37.0, vertebrae 132. Wade distinguishes his species from *G. nystromi* in having " a longer, more pointed vomerine band of teeth, smaller mouth, shorter eye, less projecting snout and a more anteriorly inserted dorsal " but these figures, compared with those given from Jordan & Snyder's account of *G. nystromi* do not support the distinction. In addition, the vomerine band of teeth in *G. nystromi* is subject to such variation (Matsubara & Ochiai, 1951, fig. 1, A-E) as to include the condition shown for *G. catalinensis*. The relationships of *G. heterognathus–G. nystromi–G. catalinensis* are clearly in need of further clarification.

Two species of *Gnathophis* are present in the Australasian region of which the only one known previous to this account is *G. habenatus* (Richardson, 1848) having 120–129 vertebrae, scroll-like anterior nostrils, and a small, triangular premaxillary-ethmoid patch of teeth which does not extend conspicuously in front of the maxillary patches. *G. habenatus* inhabits the shallow waters of harbours and river mouths from New Zealand to Lord Howe Island, New South Wales, Victoria, Tasmania, West Australia and possibly St. Paul's Island, South Indian Ocean, and is redescribed in this paper.

Ramsay & Ogilby (1888, p. 1022) described a small eel taken from the Parramatta River, Sydney, as *Congromuraena longicauda* which has been accepted of recent years to be a subspecies of *G. habenatus.* Dr J. C. Yaldwyn, of the Australian Museum, Sydney, has kindly re-examined the type specimen of *G. habenatus longicaudatus* (Aust. Mus. regd. no. I.1618) and informs me that, although the specimen is in poor condition with the caudal tip detached, a total of not more than 123 vertebrae are present. Two more specimens, Aust. Mus. regd. nos. IA.4984 (Karuah River Mouth, N.S.W., 14/6/1913) and IA.3630 (Lord Howe Island) have vertebrae numbering 128 and ca. 129 respectively. These numbers agree well with the 120-127 of New Zealand specimens. The single character which has been used to separate the Australian subspecies is the greater length of the tail, so that the preanal length is about 38.5% of total length in the type specimen compared with an average of 42.9% in 23 specimens of *G. habenatus* from New Zealand. The Australian subspecies thus appears to be valid, although there is some little evidence to support the belief that differing conditions or duration of larval development in *G. habenatus* may affect the ultimate length of the tail in the adult. This matter will be discussed in greater detail below.

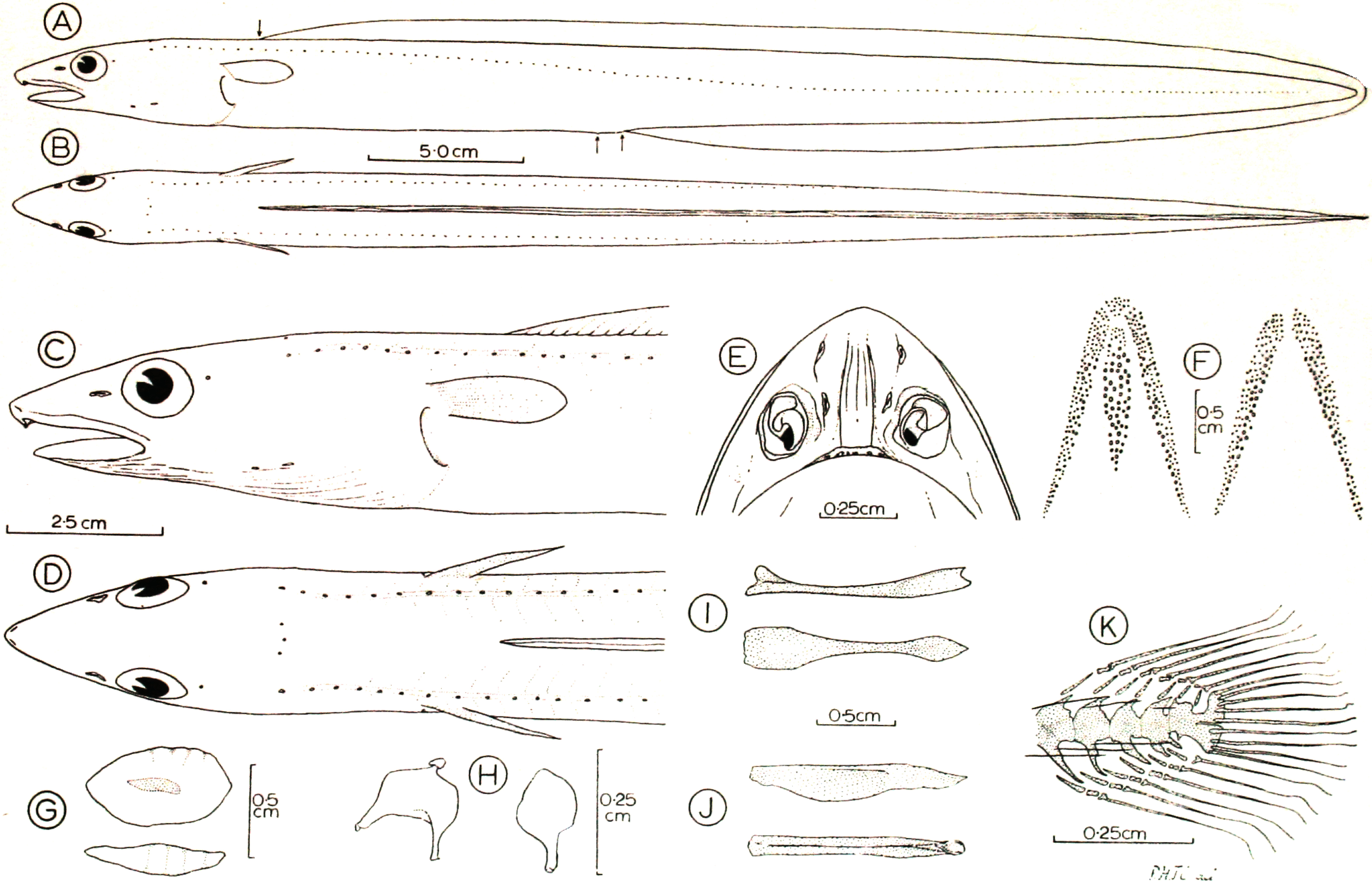
During the preliminary sorting of over 200 gnathophid leptocephali described elsewhere in this paper two groups of larvae emerged from the sorting, one having 116-131 myomeres, the other with 134–150 myomeres, both of which were otherwise closely similar. The group with the lower number of segments were readily identified with *Gnathophis habenatus* (120–129 vertebrae), but the second group was referable to no known adult. The abundance of larvae in this group suggested that the adult had been previously confused with *G. habenatus*. This subsequently proved to be the case as a close examination of the available New Zealand specimens of *G. habenatus* revealed the second species with vertebrae numbering 139–147, a longer tail, minute epidermal papillae, anterior nostril with a simple free flap and a round premaxillary-ethmoid patch of teeth extending conspicuously in advance of the maxillary patches. This species is known from rather deeper water than is *G. habenatus*, from New Zealand as far north as the Kermadec Islands.

The number of myomeres in leptocephali identified with *Congermuraena mystax* from the Atlantic (132-147) is almost identical with the known range for the second species in New Zealand waters (134-150). Having regard only to this and to the proposal that *C. mystax* is a *Gnathophis* would suggest that *C. mystax* may prove to be a species of the widest distribution, including New Zealand. Until the generic relationships of the Atlantic species are clarified, the present author feels justified in separating the second New Zealand species of *Gnathophis* from *Congermuraena mystax*.

Gnathophis habenatus habenatus (Richardson, 1848). Text-fig. 1, A-K.

1848. *Congrus habenatus* Richardson, *Voy. Ereb. Terr., Fish.*, p. 109, pl. 50, figs. 1–5.
1856. *Congermuraena habenata* (Richardson). Kaup, *Cat. Apod. Fish.*, p. 105.
1870. *Congromuraena habenata* (Richardson). Gunther, *Cat. Fish. Brit. Mus.*, 8: 42.
1872. *Congromuraena habentata* (Richardson). Hutton, *Cat. Fish. N.Z.*, p. 66.
1898. *Congermuraena habenata* (Richardson). Ogilby, *Proc. Linn. Soc. N.S.W.*, 23: 285.
1901. *Congermuraena habenata* (Richardson). Jordan & Snyder, *Proc. U.S. nat. Mus.*, 23: 851.
1911. *Congermuraena habenata* (Richardson). Waite, *Rec. Canterbury (N.Z.) Mus.*, 1 (3): 163–164.
1927. *Gnathophis habenata* (Richardson). Phillipps, *N.Z. Mar. Dept. Fish. Bull.*, 1: 17.
1936. *Poutawa habenata* (Richardson). Griffin, *Trans. roy. Soc. N.Z.*, 66: 16, pl. 7, fig. 2, text-figs. 3–4.
1956. *Poutawa habenata* (Richardson). Whitley, in Graham, *Treas. N.Z. Fish.*, app., p. 401.
1961. *Gnathophis habenata* (Richardson). Moreland, in Doogue & Moreland, *N.Z. Sea Anglers' Guide*, p. 199, fig.

MATERIAL EXAMINED. One specimen: gravid female, 275.5mm total length; Shelly Bay, Wellington Harbour; beach seine; 12/10/52; Dominion Museum No. 1160. Three specimens: 329.9mm, 333.0mm and 338.0mm (female); York Bay, Wellington Harbour; beach seine; 5/3/53; Dom. Mus. No. 1241. One specimen: 396.0mm; Lowry Bay, Wellington Harbour; beach seine; 5/4/53; Dom. Mus. No. 1262. Three specimens: 429.5mm (gravid female), 403.7mm (gravid female) and 382.8mm (mature male); York Bay, Wellington Harbour; beach seine; 16/4/53; Dom. Mus. Nos. 1270(a), 1270(b) and 1270(c) respectively. One specimen: 184.0mm; Shelly Bay, Wellington Harbour; beach seine; 28/6/53; Dom. Mus. No. 1335. One specimen: gravid female, 361.2mm; York Bay, Wellington Harbour; beach seine; 2/3/54; Dom. Mus. No. 1484. One specimen: female, 278.5mm; power house intake, Evans Bay, Wellington Harbour; 12/8/54; Dom. Mus. No. 1561. One specimen: 389.0mm; Shelly Bay, Wellington Harbour; 7/1/56; Dom. Mus. No. 1860. One specimen; 142.7mm; off Wanganui



TEXT-FIG. 1.—*Gnathophis habenatus habenatus* (Richardson, 1848), 429.5mm total length, female, Dom. Mus. No. 1270 (a), York Bay, Wellington Harbour, 16/4/53. Fig. A—Lateral view, arrows indicate origin of dorsal, anterior margin of vent and origin of anal. Fig. B—Dorsal view. Fig. C—Lateral view of head to indicate throat folds and prominent myomeres. Fig. D—Dorsal view of head. Fig. E—Ventral view of snout to show anterior nostrils and pores. Fig. F—Pattern of upper (left) and lower (right) teeth. Fig. G—Otolith, internal surface (upper) and dorsal surface (lower). Fig. H—Left preorbital bones, lateral view. Fig. I—Urohyal bone, left lateral view (upper) and ventral view (lower). Fig. J—Glossohyal bone, left lateral view (upper) and ventral view (lower). Fig. K—Caudal skeleton (184.0mm, t.l., Dom. Mus. No. 1335).

in 40 fathoms by trawler *Admiral*; May, 1957; Dom. Mus. No. 2327. One specimen: gravid female, 269.0mm; off Oamaru by trawler *Orion*; 1960; VUW Zoo. Dept. Coll. One specimen: gravid female, 268.5mm; Shelly Bay, Wellington Harbour; beach seine; April, 1961; VUW Zoo. Dept. Coll. Eight specimens: five gravid females and three mature males, 289.8mm–373.9mm; Shelly Bay, Wellington Harbour; beach seine; 26/6/62; VUW Zoo. Dept. Coll. One skull prepared from a specimen seined from York Bay, Wellington Harbour; February, 1954; Dom. Mus. No. 2495.

DESCRIPTION. Proportional measurements (in per cent of total length) and counts from the above 23 specimens: total length 142.7mm–429.5mm, standard 98.4–99.2, head 14.8–19.3, snout 3.5–5.1, eye 2.5–4.8, interorbital 1.9–3.4, cleft of mouth 4.6–6.9, postorbital 8.5–9.5, branchial aperture 1.9–2.9, branchial interspace 3.3–6.4, pectoral 3.5–6.9, snout-vent 40.9–45.5, preanal 41.6–46.6, predorsal 17.2–20.0, depth just before eye 3.7–5.1, depth at pectoral origin 5.3–7.3, depth at anal origin 4.9–6.5, depth at midpoint of caudal region 3.8–4.7. Pectoral rays 12–13, dorsal rays before level of vent 43–55, dorsal rays 180–224, anal rays 129–160, caudal rays 5+4, lateral line pores before level of vent 33–38, vertebrae 120–127.

A small but robust eel with a body which is rounded in section especially along the trunk, with prominent myomeres and with the vent placed only a little in advance of the midpoint of the body. The head is depressed, with a sharp snout, underslung mouth, large eye, and the throat is thrown into many folds of skin. The fins are conspicuous and the caudal is noticeably rounded and abbreviated. Live specimens are very active animals, escaping easily from all but the finest mesh, and are strikingly coloured sliver to silver-bronze on the anterior part of the body with a brilliant silver iris.

Head sharply conical, depressed anteriorly, relatively long, contained about 6.5 times in total length but poorly differentiated from the trunk, the throat swollen in some individuals but nearly always thrown into narrow longitudinal folds which curve up around branchial region; snout sharp, bony, its length contained about 3.5 times in head, always projecting in advance of tip of lower jaw by just less than diameter of pupil; lower jaw rounded in ventral view, rather shovel-like, slender; mouth subterminal, oblique, with cleft of mouth extending to level of anterior margin of pupil and contained about 3.0 in head; upper lip weak, but limits of maxilla clearly distinguishable on side of snout; lower lip thick, fleshy, overlapping side of lower jaw; tongue well-developed, pointed, extending forwards to a point level with anterior margin of posterior nostril.

Teeth comparatively small, but larger on the shaft of the vomer than on the other dentigerous bones, sharply conical and closely packed except those on the shaft of the vomer where they are rounded and more widely spaced. Maxillary teeth in a broad band of about four longitudinal rows anteriorly of about 38 teeth each with the teeth slightly smaller anteriorly than posteriorly and more rounded medially than laterally. Premaxillary-ethmoid teeth small, about 20 in number, in an inconspicuous, broadly triangular patch which does not project much in advance of maxillary bands. Vomerine teeth clearly separated from those of the premaxillary-ethmoid patch and in a long, cigar-shaped band extending to a level two-thirds of the way along the maxillary bands; the teeth small and acute on the head of the vomer but larger, rounded and molariform on the shaft and in about five longitudinal rows of about 15 teeth at the broadest point of the patch. Teeth on the dentary similar in number, size and distribution to those of the maxillary bands.

Anterior nostril small, subterminal, placed on the ventral surface of snout just in advance of premaxillary-ethmoid patch of teeth. On superficial examination the nostril appears to be subtubular with the tube directed anteroventrally to ventrally; on closer examination the tube is found to have a scroll-like rim with an anterior free flap (see text-fig. 1, E). Posterior nostril inconspicuous, slit-like, placed just in advance of eye, level with horizontal diameter and with a simple, raised rim but no external tube. Eye subcircular to oval, large, contained about three times in postorbital; fleshy interorbital narrow, less than eye. Branchial aperture lateral, having a concave free edge, oblique, with lower extremity a little posterior to upper, which is slightly below middle of pectoral base. Vent usually protruding into profile, especially in gravid females.

Dorsal and anal fins delicate in life, although fleshy in preservative; caudal fin with the rays relatively short and the tip of fin rounded so that the fin forms a burrowing tip to the body. Pectoral fin elongate-oval in shape with its posterior margin rounded, originating clearly above midlateral level with the base oblique and the fin directed more or less posteriorly; a little longer than snout.

Lateral line conspicuous but scarcely raised above surface of trunk, originating very high on head, descending to meet midlateral level just posterior to level of vent but fading out at extreme posterior tip of tail. Cephalic sensory pores few, restricted to one occipital pore which occasionally has a small pore lateral to it, two or three postorbital pores, two inconspicuous but larger pores on the ventral aspect of opercular region, four to five minute pores along dentary and two pairs of small pores on ventral aspect of snout; of these the first pore lies medially to the base of the anterior nostril, the second in advance of it on the extreme ventral tip of snout. A pair of inconspicuous slit-like openings of the mucous cavities of the snout are present on the anterodorsal tip of snout. There are no discernible minute papillae on the head or above lateral line.

Colour in life olive-grey posterior to vent and above lateral line from level of pectoral base to vent; side of trunk conspicuously silvery-olive but becoming creamy-white ventrally; opercular region bright silver to silver-bronze; branchiostegal region pink; iris very brightly silver tinged with gold with crescentic dorsal and ventral black patches; dorsal and posterior part of anal fins with a relatively narrow black edging which becomes wider around caudal fin; caudal pink in some specimens; fin-rays pigmented with minute black spots. The bright silver colour and the prominent myomeres showing through the skin are unmistakeable features of this eel.

REMARKS. Griffin (1936, p. 17) gives comparative measurements of the preanal length in "four specimens, three of which came from the Manukau Harbour, Auckland, and one from Sydney, N.S. Wales". These preanal lengths are 36%, 38%, 39% and 42% of total length, but unfortunately Griffin does not say which of these belonged to the Sydney specimen. In view of the observed preanal length in other Australian examples it is unlikely to be the last-mentioned, and this is undoubtedly a true *Gnathophis habenatus habenatus*. Although Griffin gives a vertebral count of 44 + 78 for the New Zealand species this has probably been taken from Waite (1911, p. 164) so that the identity of the three other specimens from Manukau and Sydney cannot easily be determined. The shorter preanal length in these specimens suggests that (a) they belong to the Australian subspecies, *G. habenatus longicaudatus*, most unlikely for the Manukau examples, or (b) they have been confused with the new species of *Gnathophis* described below in which the vertebrae number 139–147, but in which the preanal length is short, ranging from 37.8% to 41.0% of total length, more likely for the Manukau examples especially since the new species is more abundant in the northern waters.

Griffin's figures of the tooth pattern in his specimens are not helpful, since the number of teeth on the vomer is far greater than ever observed by the present author; in addition, the toothed area on the dentary as shown is much wider than usual and there is an abnormal amount of variation in the size of teeth on various parts of the dentigerous surfaces.

G. habenatus habenatus is occasionally captured in shallow trawls along the New Zealand coast, mainly in Cook Strait and south of it, but its more frequent locality is Wellington Harbour. Indeed, although Richardson gives as the type locality "Cook's Strait" it is likely that his specimen came from Wellington Harbour where H.M.S. *Erebus* and H.M.S. *Terror* spent some days. From March to June the species is abundant in Wellington Harbour although it can only be captured using a very fine mesh seine net and sufficient hauling rope to enable the net to work over the green-grey mud some distance from the shore in which the eels are possibly buried during the day. These eels are more easily captured in the early or late evenings when the tide is at its lowest. An indication of the abundance of this species in Wellington Harbour during the early winter is shown by one haul on June 26, 1962, when about 150–200 individuals appeared in the seine net. Stomachs of specimens of *G. habenatus habenatus* collected from this area contained crustaceans and polychaetes but these were always too far digested to be identified.

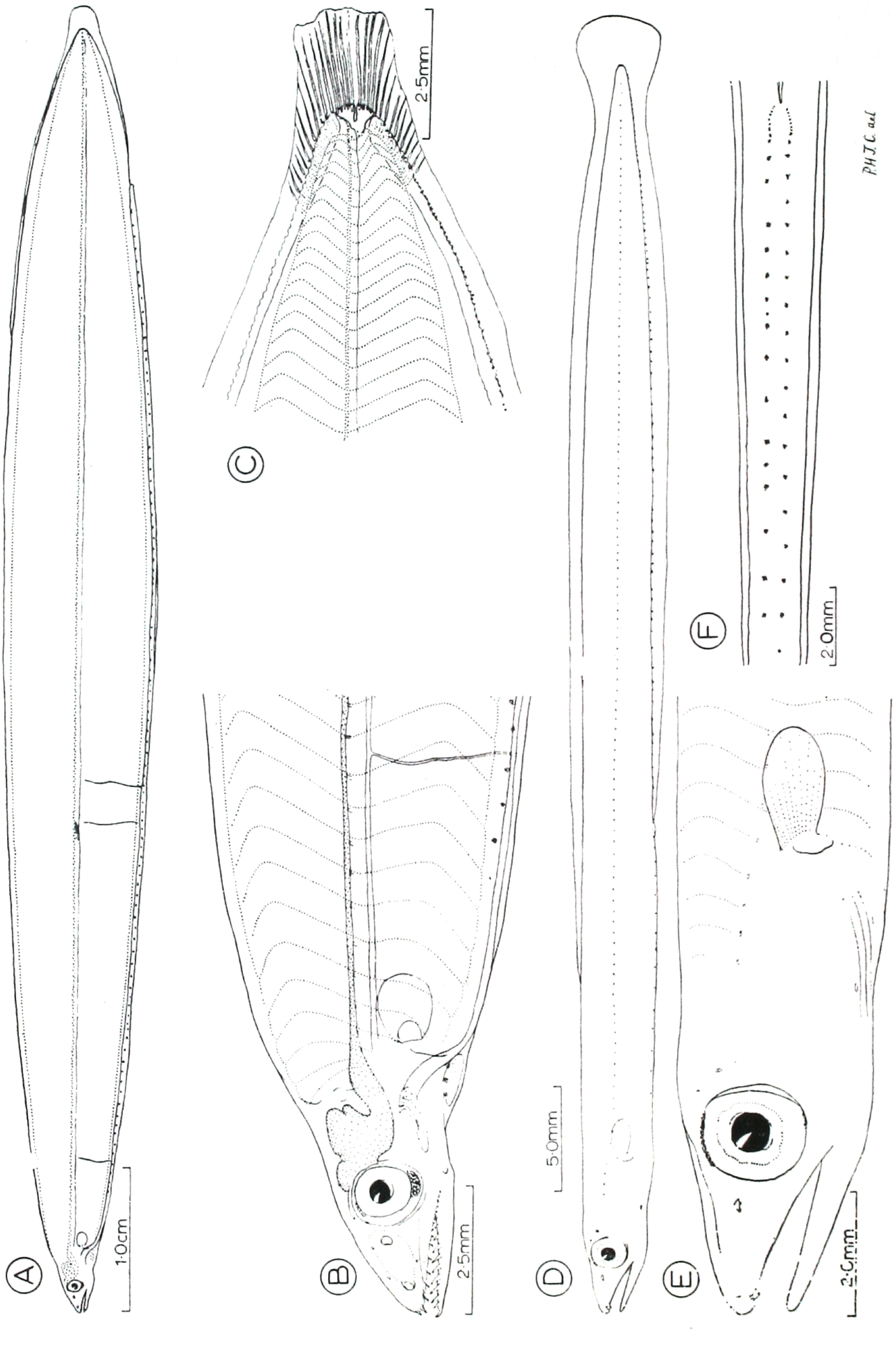
The majority of specimens collected from Wellington Harbour over a period of years appear to be close to spawning, the females having relatively large eggs of about 1.0mm or more diameter, the males having well-developed testes. Some of the females on capture were so gravid that the abdomen was greatly swollen and slight pressure caused large numbers of ova to be extruded (pers. comm. by Mr J. M. Moreland, Dominion Museum, Wellington). In eight specimens collected in June, 1962, five were gravid females (total lengths 310.0mm–373.9mm) and three were mature males (289.8mm–320.0mm) while in the total number of 23 specimens examined 18 could be sexed, of which 12 were females and six were males. Males of this species tend to be a little smaller and more slender than females in the same catch but there are otherwise no discernible differences in morphological characters between the sexes, although the males are a little brighter in colour than the females. However, if a long series of individuals were examined morphological differences would possibly show up, as has already been shown for *Conger myriaster* (Brevoort) and *Muraenesox cinereus* (Forskål) by Takai (1959, p. 547).

The abundance of near-spawning individuals of both sexes of *G. habenatus habenatus* in Wellington Harbour may indicate that the eels are assembling preparatory to breeding. The species appears to be absent from the harbour during middle spring to late summer. No young stages of any eels have been collected from Wellington Harbour plankton despite regular weekly collections over two years from an area adjacent to Evans Bay where many of the adult eels have been seined. It is now known from the study of a large collection of leptocephali of *G. habenatus* from eastern Australian waters that this species must spawn some distance off the New South Wales coast over the continental shelf with the adults living in the estuaries and the shallow coastal waters. This pattern may also be true of the New Zealand population and indeed the fully-gravid condition of the specimens collected in Wellington Harbour suggests that the spawning area cannot be far off the New Zealand coast.

Only five leptocephali of *G. habenatus* have been taken from New Zealand, one on the west coast of the South Island, the remainder from the Cook Strait area. All of these are advanced in development and three appear to be undergoing regressive metamorphosis. They are all large leptocephali and thus may have travelled some distance from their spawning place. As yet, no small leptocephali are known from New Zealand waters and thus it is not possible at the present state of knowledge to consider the location of a spawning area for this species in our waters. However, a large number of leptocephali of *G. habenatus* have been made available to the author in this study and an account of the larval development of this species is given below. As indicated above, *G. habenatus* is spawning off the New South Wales coast and the leptocephali are transported to the Tasmanian and New Caledonia areas. It is possible that the larvae of this species are transported further to the New Zealand region giving rise to what is known as *G. habenatus habenatus*. The shorter tail in this subspecies may be due to a prolonged pelagic life of the leptocephali. There is always the remote possibility that spawning of New Zealand individuals does not take place, or if it does the young perish at an early age due to inadequate or unfavourable environmental conditions.

L. Gnathophis habenatus ?longicaudatus. Text-figs. 2, A-F; 5, A-C.

MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography* (*Cronulla*) *Collection* (*85 specimens*): 5.5mm total length, 7.0, ca. 10.0, 10.8, ca. 12.0, *Warreen* Station 3/40, 32° 47′ S., 152° 40′ E, 11/1/40, N100 (100 cm. net), O (oblique tow), 0–200m; ca. 6.0, 6.2, 15.8, St. 31/40, 34° 08′ S., 151° 32′ E., 25/4/40, N100, O, 200m; 6.2, 15.7, St. 31/40, 34° 08′ S., 151° 32′ E., 25/4/40, N70, O, 200m; 8.3, St. 104/38, 34° 03.5′ S., 151° 39′ E, 15/12/38, N200, H (horizontal tow), 100m, 30mins (minutes); 8.9, St 7/40, 30° 13′ S., 153° 33′ E, 14/1/40, N70, V (vertical tow), 250–0m; 9.5, 10.6, 12.5, 14.9, *Discovery* St 2724, 34° 05′ S., 151° 29′ E, 9/10/50, N100B, 108–0m; 10.2, 84.5, *Warreen* St 132/39, 30° 15′ S., 153° 33′ E., 5/5/39, N100, H, 100m, 60mins; 11.2, St. 24/40, 34° 08.5′ S., 151° 36.5′ E, 27/2/40, N70, O, 200m; 11.3, 17.0, St 127/39, 33° 18′ S., 152° 13′ E., 3/5/39, N70, H, 100m, 60mins; 13.2, 15.0, 16.9, 20.3, 23.0, St 127/39, 33° 18′ S., 152° 13′ E., 3/5/39, N100, H, 100m, 60mins; 14.0, St. 22/42, 39° 46′ S., 148° 36′ E, 18/4/42, N70, H, 50–0m; 14.6, *Discovery* St 2723, 34° 08′ S., 151° 33′ E, 9/10/50, N100B, 93–0m; 14.7, 23.1, 23.5, 23.5, 24.3, 24.3, 25.2, 25.3, 26.1, 31.1, 31.6, 32.4, 65.5, 67.3, 74.6, 79.0, 82.7, 85.0, 87.1, *Warreen* St unknown, ca. 34° 04′ S., 151° 15′ E., ?/39, no other data; 15.0, St 40/39, 35° 06′ S., 150° 51′ E, 25/1/39, N70, H, 25m, 30mins; 19.8, 20.8, 27.5, St 129/39, 32° 34′ S., 152° 55′ E., 3/5/39, N100, H, 100m, 60mins; 21.2, off Eden, Victoria, 9/3/48, V, 46–0m; 21.9, 27.2, 27.4, probably Port Hacking, New South Wales, ?/1/43; 26.8, St 3/49, 32° 03′ S., 114° 53.5′ E, 7/4/49, N70, H, surface, 10mins; 30.0, St 118/39, 37° 10′ S., 150° 24′ E., 17/4/39, N70, H, 100m, 30mins; 37.0, 37.5, 45.0, 55.0, 64.5, St 26/40, 32° 34′ S., 152° 55′ E, 20/4/40, N100, O, 0–200m; 37.5, *Discovery* St 2718, 33° 55′ S., 153° 02′ E., 9/10/50, N100B, 117–0m; 38.8, *Warreen* St 27/40, 31° 08′ S., 153° 05′ E., 21/4/40, N70, V, 50–0m; 46.3, 58.2, 62.3, 81.2, St. 205/39, 34° 03′ S., 151° 11.5′ E, 4/8/39, N200, H, surface, 15mins; 57.3, 96.7, St 37/48, 28° 48′ S., 113° 36′ E., 2/9/48, N70, H, surface, 15mins; 62.0, *Derwent Hunter* St 16/52, Port Fairy wide, 27/8/52, N70, V, 730–0m; 65.4, *Warreen* St 224/39, 35° 03′ S., 151° 09′ E., 4/10/39, N200, H, surface; 78.8, St 195/39, 24° 21′ S., 153° 22′ E., 7/7/39, N100, O, 0–200m; 81.8, St 64/38, 34° 04.5′ S., 151° 14′ E., 10/11/38, N200, H, 25m, 30mins; 82.9, St 64/38, 34° 04.5′ S., 151° 14′ E., 10/11/38, N100, H, surface, 30mins; 84.1, St 214/39, 36° 14′ S., 150° 25′ E., 3/9/39, N70, O, 200m; 85.2, 86.9, St 138/39, 30° 56′ S., 153° 21′ E., 16/5/39, N100, H, 100m, 60mins; 89.0, *Discovery* St 2710, 37° 06′ S., 150° 48′ E., 6/10/50, N100B, 84–0m; 90.4, *Warreen* St 36/48, 28° 48′ S., 113° 47′ E, 1/9/48, N70, H, surface, 15mins; 109.9, St. 302/39, 37° 29′ S., 150° 20′ E.,



TEXT-FIG. 2 (A-C).—*L. Gnathophis habenatus ?longicaudatus* (Ramsay & Ogilby, 1888), 90.4mm total length, I.F.O. (Cronulla), *Warreen* St. 36/48, Western Australia, 1/9/48. Fig. A—Lateral view to show position of major vertical blood vessels and intestinal pigment. Fig. B—Lateral view of head. Fig. C—Lateral view of caudal region to show pigment on tips of hypurals and anal bases. Figs. D-F—*Gnathophis habenatus longicaudatus* (Ramsay & Ogilby, 1888), 60.8mm total length, Western Australian Museum No. P5240, Western Australia, 16/5/62. Fig. D—Lateral view to show posterior dorsal origin, ventral pigment and fan-like caudal. Fig. E—Lateral view of head to show dorsal and ventral iris pigment. Fig. F—Ventral view of abdomen to show pigment spots.

15/11/39, N100, O, 200m; 115.0, 116.4, St 55/38, 39° 58′ S., 148° 57′ E, 16/10/38, N200, H, 100m, 30mins; 124.9, St 55/38, 39° 58′ S., 148° 57′ E., 16/10/38, N100, H, 100m, 30mins; 138.2, St 284/39, 42° 35′ S., 148° 38′ E., 12/11/39, N100, O, 200m.

Australian Museum Collection (*7 specimens*): ca. 69.0, Aust. Mus. regd. no. IB.3786, Budgewoi Beach, N.S.W., 17/7/57; 71.8, Aust. Mus. regd. no. IA.2478, Manly, N.S.W., 1907; 72.5, Aust. Mus. regd. no. IA.7047, Palm Beach, N.S.W., 12/9/36; 76.3, Aust. Mus. regd. no. I. 3250, Dee Why, N.S.W.; ca. 77.5, Aust. Mus. regd. no. IB.4503, Collaroy Beach, N.S.W., 27/8/59; 78.0, Aust. Mus. regd. no. IA.3765, Bellingen, N.S.W., State Fisheries Dept; 78.8, Aust. Mus. regd. no. IB.2586, Newport Beach, N.S.W., 15/10/50.

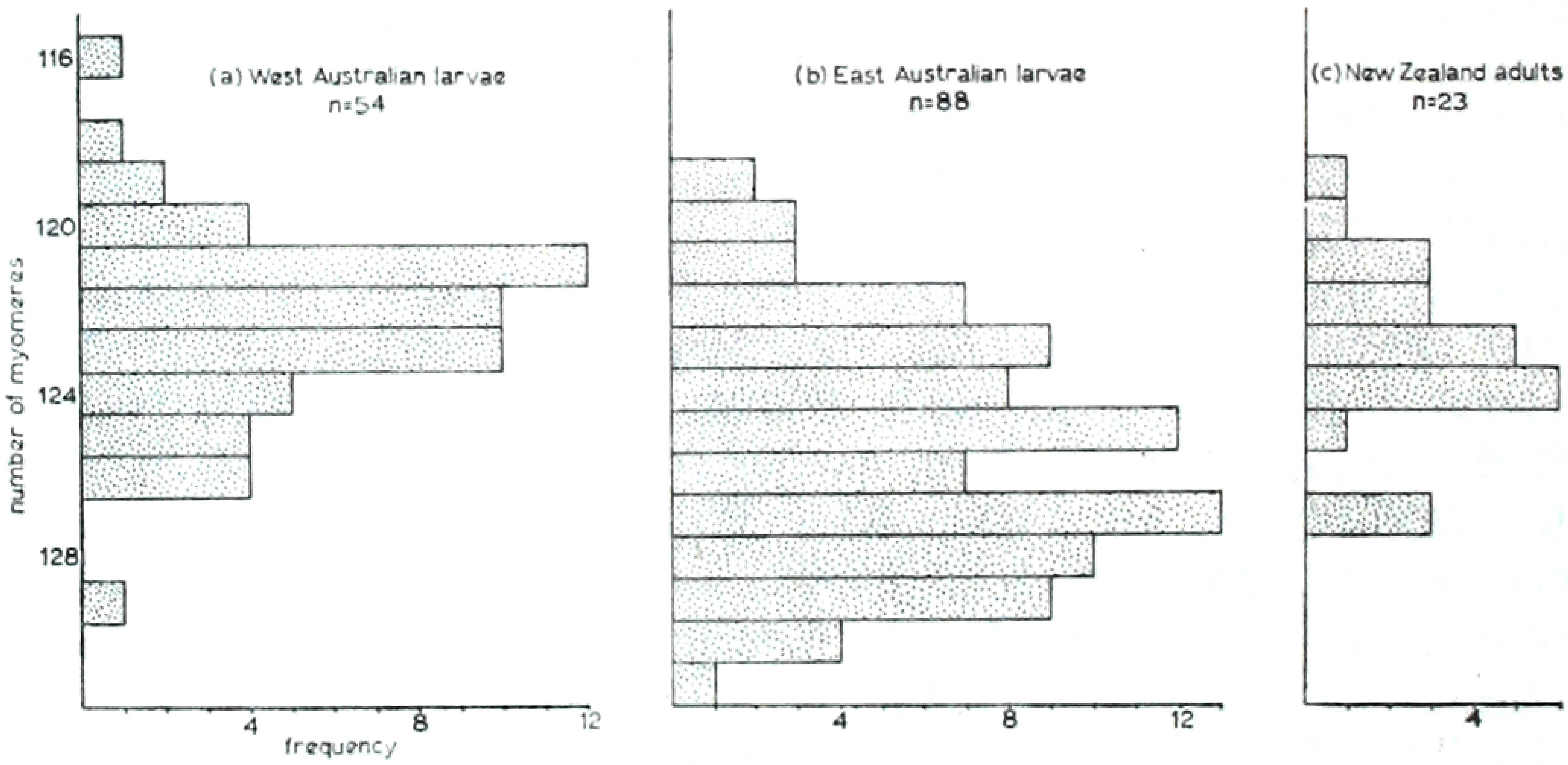
Western Australian Museum Collection (*89 specimens*): Egg with developing prelarva, Accession No. P5306, *Lancelin*, 37 miles west of West End, Rottnest Island, Western Australia, 12/11/62 (0450–0520 hrs), larval net in 37 metres; 9.0, P5278, 40mls, 3/7/62(0200), 1n, 37m; 15.1, P5305, 44mls, 3/7/62(0300–0330), 1n, 110m; 15.9, P5302, 34mls, 3/7/62(0030–0100), N70, surface; 18.1, P5304, 44mls, 3/7/62 (0300–0330), 1n, 110m; 26.3, P5164, 48mls, 24/1/62 (0015–0045), N70, surface; 26.4, P5160, 49mls, 1/8/61(0500–0530), N70, surface; 26.5, P5162, 50mls, 6/10/61(0000–0030), 1n, 27m; 30.3, P5243, 44mls, 9/5/62(0515–0545), N70, surface; 30.8, 33.2, 76.8, P5170, 50mls, 20/6/61 (2300–2330), 1n, 91m; 34.7, P5175, 39mls, 20/6/61(2115–2145), 1n, 55m; 37.1, P5288, 43mls, 7/6/62(0140–0210), 1n, 37m; 42.5, P5307, 44mls, 3/7/62(0300–0330), N70, surface; 43.3, P5152, 21mls, 23/8/61(0000–0030), 1n, 110m; 43.4, P5163, 35mls, 13/7/61(1900–1930), N70, surface; 45.3, P5301, 42mls, 3/7/62(0230–0300), N70, surface; 45.8, P5303, 44mls, 3/7/62(0300–0330), 1n, 110m; 46.9, P5300, 42mls, 3/7/62(0230–0300), N70, surface; 51.8, P5290, 38mls, 3/7/62 (0100–0130), 1n, 37m; 51.8, P5294, 42mls, 3/7/62(0230–0300), N70, surface; 54.2, P5281, 44mls, 3/7/62(0300–0330), 1n, 110m; 55.2, P5232A, 45 mls, 9/5/62 (0100–0130), 1n, 37m; 55.4, P5311, 42mls, 3/7/62, 1n, 37m; 60.8 (glass-eel), P5240, 21mls, 16/5/62(0050–0120), 1n, 37m; 67.0, P5153, 52mls, 31/7/61 (0230–0300), N70, surface; 67.3, P5310, 42mls, 3/7/62, 1n, 37m; 68.2, P5312, 39mls, 7/6/62(0500–0530), 1n, 37m; 70.0, P5227, 18mls, 4/4/62(0200), N70, surface; 70.7 P5283, 42mls, 3/7/62, 1n, 37m; 80.0, 103.0, 107.5, P5179, 50mls, 5/7/61(2050–2120), 1n, 27m; 80.5, P5284, 38mls, 7/6/62(0530–0600), 1n, 37m; 81.4, P5293, 38mls, 3/7/62, N70, surface; 82.5, 86.7, 89.5, 91.9, P5173, 50mls, 15/11/61(0200–0230), 1n, 110m; 82.5, P5148, 51mls, 15/11/61(0120–0150), 1n, 55m; 83.0, P5238, 20mls, 4/4/62(0430), 1n, 37m; 83.2, P5161, 40mls, 13/12/61 (0010–0040), 1n, 37m; 83.9, P5158, 47mls, 12/9/61(0200–0230), 1n, 55m; 84.0, P5149, 35mls, 13/7/61(1900–1930), 1n, 27m; 85.5, P5286, 45mls, 7/6/62(0005–0035), 1n, 37m; 86.9, P5235, 50mls, 9/5/62 (0030), 1n, 37m; 88.1, P5249, 50mls, 9/5/62, 1n, 37m; 88.5, P5245, 40mls, 9/5/62(0100–0130), 1n, 37m; 92.5, P5157, 38mls, 13/7/61(1945–2015), N70, surface; 93.0, P5250, 50mls, 9/5/62, 1n, 37m; 100.6, P5231, 20mls, 4/4/62(0330), 1n, 110m; 110.5, P5174, 53mls, 13/7/61, 1n, 55m.

Since this paper was written the following additional 36 specimens became available: 59.5, P5535, 22mls, 20/9/62(0215), 1n, 37m; 52.0, P5540, 44mls, 10/10/62(0230), N70, surface; 34.6, P5541, 43mls, 10/10/62(0330), 1n, 110m; 39.7, P5542, 42mls, 10/10/62(0415), 1n, 37m; 35.0, 37.5, 39.4, 42mls, 10/10/62 (0415), N70, surface; 37.1, P5544, 41mls, 10/10/62(0500), N70, surface; 85.9, P5546, 32mls, 24/10/62(0010), N70, surface; 79.1, P5547, 33mls, 24/10/62(0110), 1n, surface; 47.3, 53.7, 70.6, 71.2, 85.3, 85.4, P5550, 43mls, 7/11/62(0010), 1n, 37m; 43.5, 46.4, P5551, 44mls, 7/11/62(0100), 1n, 37m; 50.8, 52.8, 70.8, 84.1, P5552, 45mls, 7/11/62(0140), 1n, 37m; 37.8, 42.3, 47.5, 51.6, 59.2, 91.7, P5553, 44mls, 7/11/62(0230), N70, surface; 61.9, 64.2, P5554, 7/11/62, 1n, 110m; 75.4, P5555, 42mls, 7/11/62(0440), 1n, 37m; 47.5, 52.6, 71.1, P5558, 41mls, 15/11/62(0100), 1n, 37m; 85.0, P5559, 40mls, 15/11/62(0320), 1n, 110m; 57.8, P5560, 39mls, 15/11/62(0410), 1n, 37m.

Centre d'Océanographie de l'Institut Français d'Océanie Collection (*5 specimens*) : 60.4, IFO Station P As 8, 23° 01′ S., 158° 05′ E., 9/5/58 (0637hrs), 0.5m net, no. 2 mesh, 2 oblique tows in ca. 300 metres; 71.2, 85.1, St 7–6, 22° 35′ S., 166° 16′ E., 26/7/62, 5ft midwater trawl (Isaacs-Kidd), H, ca. 50m; 79.1, St G 26, 23° 17′ S., 165° 44′ E., 4/4/62, 3ft midwater trawl (Isaacs-Kidd), H, ca. 16m; 107.3, St 7–3, 22° 35′ S., 166° 16′ E, 17/7/62, 5ft midwater trawl (Isaacs-Kidd) H, ca. 35m.

New Zealand Collections (*5 specimens*) : 98.0, VUW Zoo. Dept. Coll., probably Cook Strait, no other data; 111.1, Dom. Mus. No. 1834, 1ml north of Stephen's Island, Cook Strait, 100 fathoms, 17/12/54; 111.5, Cant. Mus. Coll., Grey River, Westland, about a mile from river mouth, 24/10/54; 114.0, Dom. Mus. No. 2527, Port Underwood; 116.9, VUW Zoo. Dept. Coll., Queen Charlotte Sound, no other data.

DESCRIPTION. 191 specimens: total lengths 5.5mm–138mm, myomeres ca. 116–131, dorsal fin-rays 121–215, anal fin-rays 96–173. Description made from a specimen which has just begun metamorphosis, DFO (Cronulla) Coll. *Warreen* St 36/48 (measurements in mm) : total length 90.4, head 4.6, snout 1.5, eye 1.0, upper jaw 1.9, postorbital 2.4, branchial aperture 0.6, pectoral 1.1, snout-vent 79.2, predorsal 68.3, depth just before eye 1.9, depth at pectoral origin 3.6, depth at midpoint between pectoral and vent 10.5, depth at anal origin 7.1. Branchio-

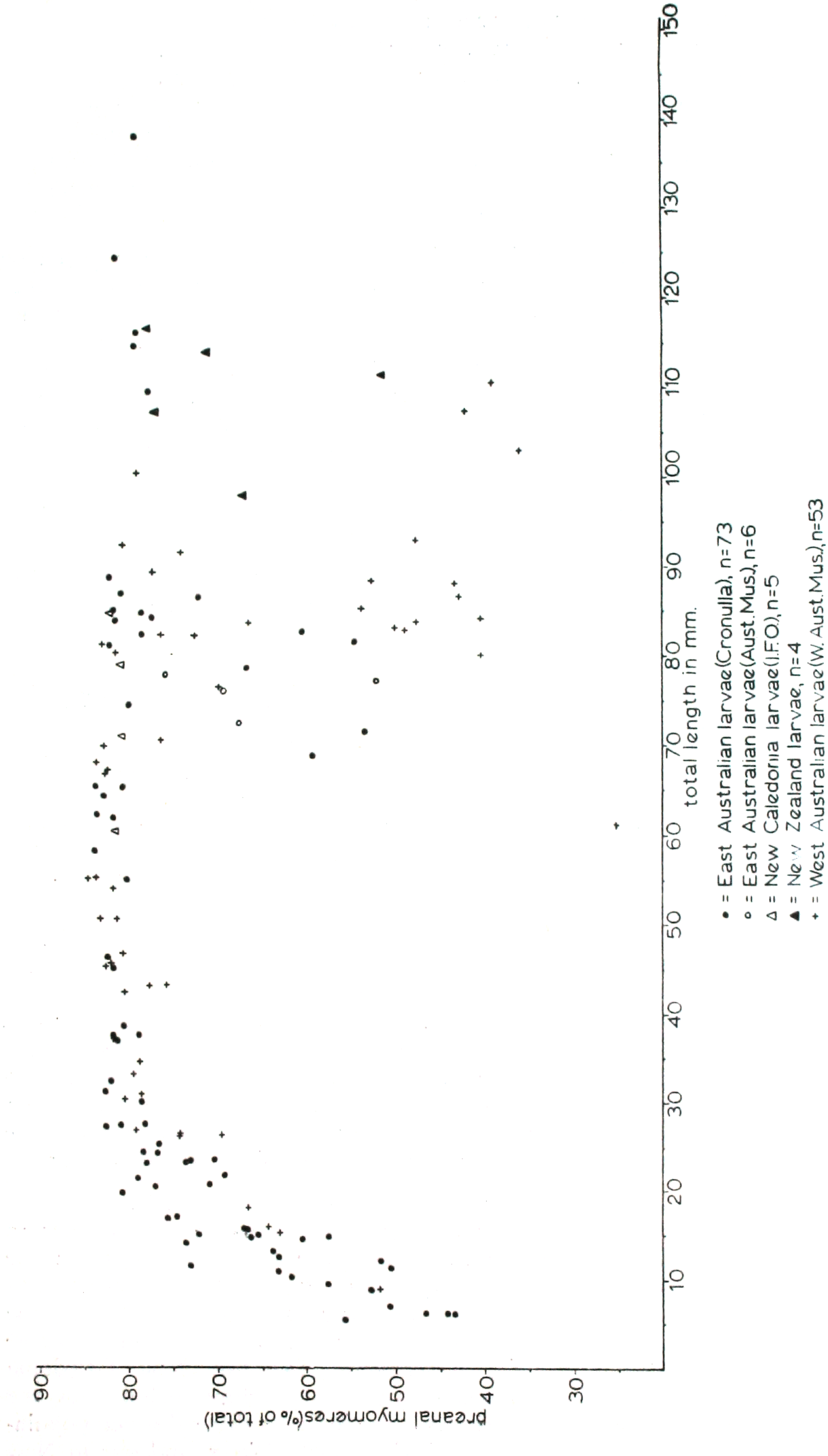


TEXT-FIG. 3.—*Gnathophis habenatus*, frequency of myomeres in leptocephali and adults from Western Australia, Eastern Australia and New Zealand.

stegal and pectoral rays not formed, dorsal rays before level of vent 109, total dorsal rays 163, anal rays 136, caudal rays 5 + 4. Teeth $\frac{1 + 1 + V + 9}{1 + X + 3}$. Myomeres 97 + 26 = 123. a–d = 33. Vertical vessels at 12, 37, 41. Anterior margin of gall-bladder at 37.

Body relatively elongate, much compressed except along the head, not deep, the maximum depth 8.5 in total length, reducing more gradually in front of the midpoint. Head short, about 19 in total, distinct from trunk; snout sharply conical, about one-third of head, its dorsal profile barely convex; anterior nostril a short tube directed forwards, with a simple rim; posterior nostril widely open,

$$\frac{\mathbf{1 + 1 + V + 9}}{\mathbf{1 + X + 3}}$$



TEXT-FIG. 4.—*Gnathophis habenatus*, variation in number of preanal myomeres (expressed as a percentage of the total) with total length in 141 leptocephali.

oval; eye oval, the greatest diameter vertical, but horizontal diameter contained about twice in snout; cleft of mouth oblique, extending to beneath anterior edge of pupil; teeth similar in size and formula to those of *Anguilla* but directed a little more anteriorly; branchial aperture small, barely curved. Pectoral fin short, a little less than twice in postorbital, with a thick, fleshy base but a thin web; fin-rays not sufficiently well-developed to be counted. Dorsal fin low but with a distinct anterior margin over the 64th myomere. Anal fin similar but with the basal structures not so well developed. Caudal fin conspicuous, partly separated from posterior tips of dorsal and anal fins.

Pigmentation in formalin in the form of a minute, black, crescentic patch on the anterodorsal aspect of the eyeball and a larger, conspicuous brown to black patch below the posteroventral margin of the iris; a series of three round melanophores on each side of the throat, each with a compact, central dark area and a lighter surrounding area; a paired ventral somatic series of about 95 rounded melanophores following the course of the intestine from the ninth segment, thence on each segment to the vent; a series of minute, stellate, more diffuse melanophores on the bases of the anal fin-rays with an average of about two spots for every three rays; a row of darker, more conspicuous spots on the tips of the hypurals; a few spots on the bases of the terminal dorsal rays; a few deep spots on the posterior part of the spinal cord and vertebral column.

Vertical blood-vessels to the intestine numerous, occurring at segments 12, 20, 23, 27, 29, 31, 37, 41, but of these only those at 12, 37 and 41 are conspicuous. Gall-bladder easily seen, its anterior margin at myomere 37.

REMARKS. Whitley (1937, pp. 8–9, fig. 3) describes a leptocephalus from Maroubra, Sydney (Aust. Mus. regd. no. IA.6893) which he refers to *Gnathophis habenatus longicaudatus*. I have examined this specimen and find that it agrees well with Whitley's description but that it is a typical muraenid leptocephalus showing little similarity other than in number of myomeres to the larvae of *G. habenatus*. It has a short head, no pectoral, a rounded tail and pigment in a series of minute, rounded spots ventral to the gut anterior to the gall-bladder but dorsal to the gut between the gall-bladder and the vent, with pigment spots on the jaws, branchial region and occiput. There is no crescentic black patch below the iris and the eye is round, not oval. The Maroubra specimen is described by Whitley as agreeing in myomere number, 127, with a practically metamorphosed specimen of *G. habenatus longicaudatus* from Cape Everard, Victoria (Aust. Mus. regd. no. IA.6263). The Maroubra specimen does not now have a silver iris, a characteristic feature of late *Gnathophis* larvae, but this may have faded. As I have yet to examine in detail the muraenid leptocephali from the east Australian area I cannot finally identify this specimen, but there is little doubt that it belongs to the Muraenidae. The Cape Everard specimen, which I have not seen, is quite probably referable to *G. habenatus longicaudatus* in view of its area of capture.

Although there are otherwise no observable morphological differences between leptocephali of *G. habenatus* collected from western Australia through to eastern Australia, New Caledonia and New Zealand, there are slight differences in the average number of myomeres in each group. Text-fig. 3 shows that east Australian larvae have slightly more numerous myomeres than do those from the west and also New Zealand adults of *G. habenatus habenatus*, the average numbers being 125.6, 122.3 and 123.2 respectively. The five New Caledonia larvae have an average of 126.6 myomeres and are therefore included in the east Australian group. The differences shown may indicate three distinct populations, one spawning off west Australia, one off New South Wales, and one in New

Zealand waters, but this subject will be discussed in more detail later. The two peaks occurring in the frequency diagram of east Australian larvae may possibly indicate a difference in total number of myomeres with sex but this has not been confirmed in the adult specimens of *G. habenatus habenatus* from Wellington Harbour.

Dakin & Colefax (1940, p. 204, figs. 289 and 290) describe and illustrate the eggs and larvae of two eel species taken off the coast of New South Wales. The larvae have over 150 myomeres, and there is no pectoral fin even in a larva of 11.2mm. These characters rule out the identification of these species with the gnathophid eels considered in this paper.

A number of leptocephali have been described from other parts of the world which bear at least superficial resemblances to those of *G. habenatus.* The best known of these is *L. Congermuraena mystax* from the central and southern Atlantic Ocean. Except for the absence of the minute crescentic patch of black pigment above the eye (which in any case may easily be overlooked) and the greater number of myomeres (132–147) this species is strikingly similar in form and pigmentation to the leptocephali of *G. habenatus.* Lea's description (1913, pp. 18–21, figs. 12–15, pl. 3, nos. 1–2) of the leptocephali of the Atlantic species so closely agrees with the material described here that it seems likely that *Congermuraena mystax* (Delaroche) is a *Gnathophis.* Leptocephali of this genus are readily distinguishable from those of *Ariosoma* which have pigment present on the lateral surface before the lateral line on each myoseptum, a round eye and more numerous ventral spots; from those of the deep-water genus *Pseudoxenomystax* which have a relatively deep body, a round eye without black pigment below the iris and pigment on the anal bases; and from *Conger* which may have large spots on the lateral surface but always possesses distinct spots above the anal fin.

Indo-Pacific congrid leptocephali of the *Gnathophis* group are otherwise known only from several species described from the Pacific coast of Central America. *Leptocephalus cingulus* (Garman, 1899) has 131–133 myomeres but ventral pigment is absent. With this number of myomeres this species could possibly be the young of *G. catalinensis*; the absence of ventral pigment has been observed in specimens of *L. Gnathophis habenatus* which have been preserved for some years in formalin. *Leptocephalus cinctus* (Garman, 1899), listed by Ancona (1928, p. 106) as a possible synonym of *L. Congermuraena mystax* has 138 myomeres and a silver iris and may also be referable to *G. catalinensis,* but this is known from one specimen and there is no record of the range of vertebrae in this species. *L. dentatus* (Garman, 1899) and *L. obtusus* (Garman, 1899) both have pigment below the lateral line and thus do not fall readily into the *Gnathophis* group of leptocephali. They are probably larvae of *Ariosoma gilberti* (Ogilby, 1898) which inhabits the Pacific coast of Central America.

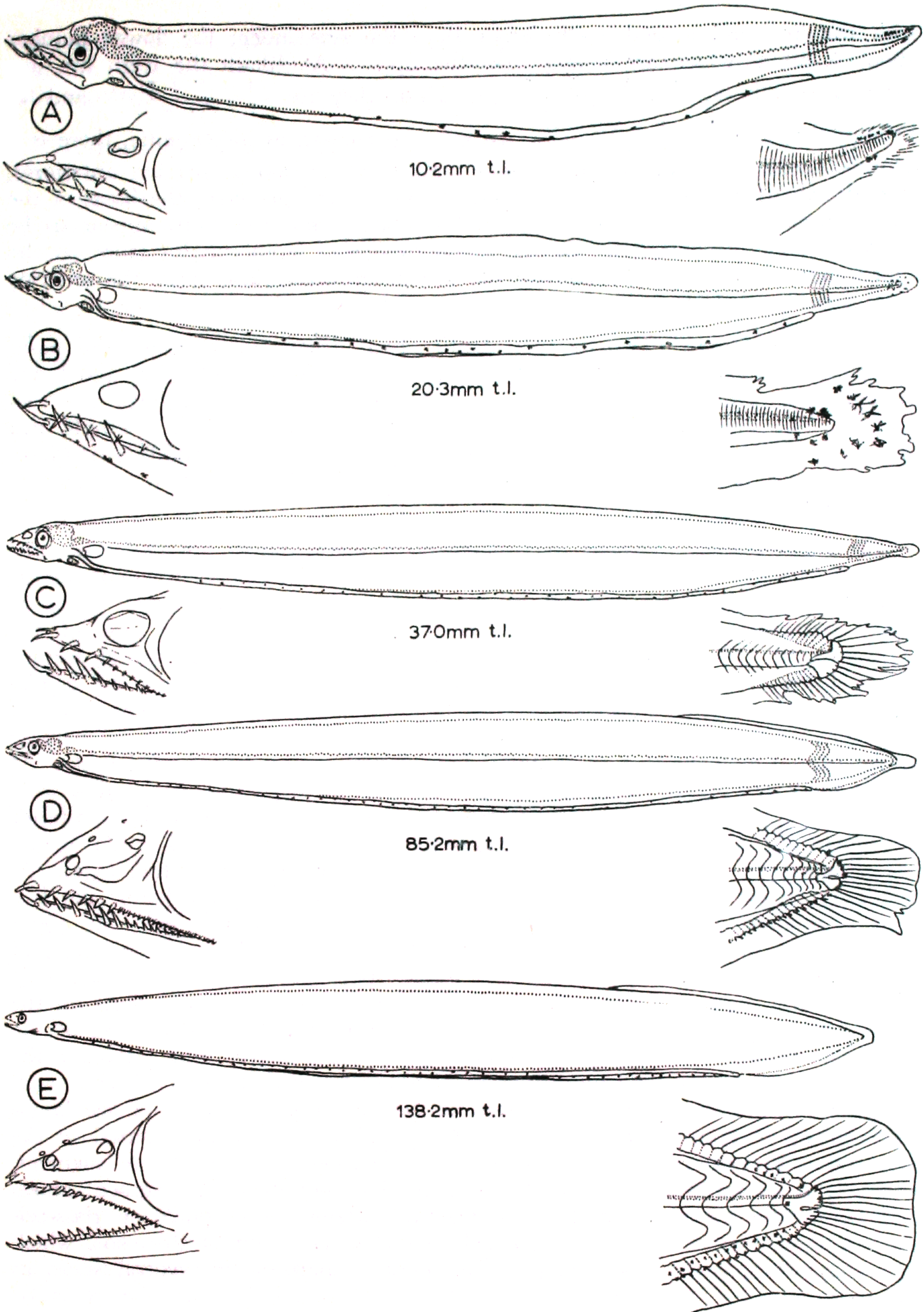
Growth and Metamorphosis (Text-figs. 4, 5, A-E). The 191 leptocephali of *Gnathophis habenatus* examined in the preparation of the above description range in total length from 5.5mm to 138.2mm. The collections include one egg with an almost completely developed embryo. About 150 of these specimens are leptocephali in various stages of metamorphosis in which the vent is in the process of movement towards its final position in the elver and the body undergoing contraction in length. Included in the latter group are two almost metamorphosed glass-eels, that is, elvers which have the general form of the adult and still have the pigment of the leptocephali. The material examined is sufficient, therefore, to give a very good indication of the morphological changes taking place during active growth of the leptocephalus and the metamorphosis to the elver. In these periods of development there are changes in (a) myomere shape, (b) the number of preanal myomeres indicating movement of the vent, (c) the number of dorsal and anal fin-rays, (d) the number and disposition of the teeth, (e) the condition of the nasal organ, (f) the distribution of pigment.

(a) *Myomere Shape.* At a length of below 10.0mm the myomeres are shallow V-shaped with the dorsal and ventral limbs of the future W-shaped myomere only just appearing in the myomeres at the middle of the body length. Post-anal myomeres have at best only a very slight V-shaped flexure. The tendency for the V to deepen and become W-shaped increases steadily until at about 40mm total length all myomeres are W-shaped, although the post-anal segments have very short dorsal and ventral limbs.

(b) *Number of Preanal Myomeres* (Text-fig. 4). During growth from about 5mm to 30mm in total length the vent undergoes a rapid actual movement from a position located at about myomere 55 posteriorly to myomere 100 in a total of about 125. The vent remains in this relative position until the total length reaches about 80mm when in most cases metamorphosis begins. There is then a rapid reduction in the length of the gut so that the vent moves forwards (or regresses) to reach a final position in the elver at about the 37th myomere. This movement is illustrated for the 154 specimens in Text-fig. 4. To eliminate as wide a variation as possible in the plot of preanal myomeres against total length due to variation in the total number of myomeres the number of preanal myomeres in each specimen was reduced to a percentage of the total number. It was also found that a plot of preanal length against total length produced a much wider scatter due to the relatively large errors made in measuring the preanal lengths especially of the smaller specimens, since these often could not be laid very flat and they were easily stretched beyond their normal lengths. It is important to note that, as the change in the number of preanal myomeres shows, there is an actual movement of the vent at first posteriorly and then after metamorphosis begins, anteriorly. This method of analysis eliminates the factors of differential growth rates of the preanal region or of the tail. As Text-fig. 4 shows, there is a great variation in the size of the leptocephalus at which metamorphosis begins. The usual length of the body at the onset of metamorphosis is between 70mm and 90mm, but many larvae reach much greater lengths without sign of metamorphosis. The significance of the latter is discussed in greater detail below.

(c) *Number of Dorsal and Anal Fin-rays.* The dorsal fin-rays begin to differentiate so that their basal structures are sufficiently well developed to be counted at a total length of about 37.0mm. At this length the difference between the dorsal and anal origins is about 25 complete myomeres and throughout growth and metamorphosis the dorsal origin advances towards its final position above the middle of the pectoral at about the same rate as the advance of the vent. The anal rays do not differentiate until the body length is about 55mm, when they number about 120. There is a slow increase in the number of dorsal and anal fin-rays to their final numbers of about 180 and 140 respectively. Longer leptocephali, showing little sign of normal metamorphosis, have a greater number of dorsal fin-rays, about 205–210.

(d) *Teeth* (Text-fig. 5). At a length of about 5mm the larva has 2–3 very acute teeth on the upper jaw, of which the first is long, needle-like, curved slightly downwards but generally directed forwards. On the lower jaw there are also 2–3 similar teeth, the first of which is directed anterodorsally. The lower teeth always project outside the upper and are usually fewer in number during all stages of development. At 20mm total length the upper teeth number about 5,



TEXT-FIG. 5.—*L. Gnathophis habenatus ?longicaudatus,* growth and early metamorphosis, showing in each figure lateral views of body, snout and tip of caudal region. Fig. A—10.2mm total length, I.F.O. (Cronulla), *Warreen* St. 132/39, Eastern Australia, 5/5/39. Fig. B—20.3mm total length, I.F.O. (Cronulla), *Warreen* St. 127/39, Eastern Australia, 3/5/39. Fig. C—37.0mm total length, I.F.O. (Cronulla), *Warreen* St. 26/40, Eastern Australia, 20/4/40. Fig. D—85.2mm total length, I.F.O. (Cronulla), *Warreen* St. 138/39, Eastern Australia, 16/5/39. Fig. E—138.2mm total length, I.F.O. (Cronulla) regd. no. B137, *Warreen* St. 284/39, off Tasmania, 12/11/39.

with the first and second teeth larger than the remainder; the lower number about 4, all of which are longer than the upper. At 40mm the teeth are distributed as follows: $\frac{1 + 1 + \text{II} + 9}{1 + \text{IV} + 4}$, at 85mm they are $\frac{1 + \text{V} + 21}{1 + \text{VI} + 12}$, and at 138mm they are $\frac{1 + 1 + \text{VI} + 19}{1 + \text{VIII} + 7}$. In some specimens, as in *Anguilla,* there is a minute, needle-like tooth on the dorsal surface of the snout, directed anteriorly, immediately above the most anterior tooth. As growth proceeds, the bases of the larval teeth become overgrown by the fleshy snout and the teeth appear to be shorter in later leptocephali. As the metamorphosing leptocephalus takes on the appearance of the elver the larval teeth are progressively lost, from the anterior part of the jaws posteriorly.

(e) *Nasal Organ* (Text-fig. 5). Until about 40mm total length the nasal organ has a single wide opening with a slightly raised rim. The upper and lower margins later grow together at the midpoint of this opening to form the two nostrils. The anterior nostril becomes tubular but remains with a simple rim until well after metamorphosis of the elver, when the scroll-like condition develops. The posterior nostril remains widely open until the elver, when it narrows to form a slit.

(f) *Pigmentation* (Text-fig. 5). Changes in pigmentation are the most conspicuous changes in the development of the larva. The early leptocephalus at 5mm total length shows pigment in the characteristic somatic ventral series as about six rather irregularly-spaced, rounded spots beginning at the level of the 20th segment. There are one or two minute black spots on the ventral surface of the lower jaw and a few minute specks of black pigment above the caudal tip. A larva of 10mm shows an increase in the number of ventral spots to about 12; there are two or three spots on the lower jaw and there has been an increase in the caudal pigment to a short dorsal line of spots and a few ventral flecks. At 20mm there are about 18 ventral spots, 4–5 spots on the lower jaw and a wide scattering of pigment on the caudal fin. At about the time when the posterior movement of the vent has ceased the pigment on the lower jaw and caudal region has disappeared and there remain about 30–40 spots in the ventral series. At this time, however, a small crescentic patch of pigment appears below the iris. This is retained throughout the metamorphosis to the juvenile eel. At about 70mm–80mm in length the ventral series consists of about 45 spots beginning at about the 10th segment; there are 1–3 round spots on the throat on each side of the heart; pigment has appeared on the bases of the anal rays, deep on the ends of the hypurals, on the posterior dorsal rays and on the posterior tip of the vertebral column. Metamorphosis then rapidly takes place, and although the throat pigment is lost the ventral series is retained until the end of the metamorphosis as are the spots on the bases of the anal rays. In some of the larger leptocephali of 120mm or more a second row of spots develops internal to the first row. Just after the beginning of metamorphosis the silver iris pigment, which is so characteristic of the adult eel, develops but the black pigment above and below the iris is retained. Late metamorphosing leptocephali or glass-eels show a short line of very closely-packed spots on each side of the vent, which is perhaps due to the telescoping of the posterior part of the ventral series as the vent regresses (Text-fig. 2, F).

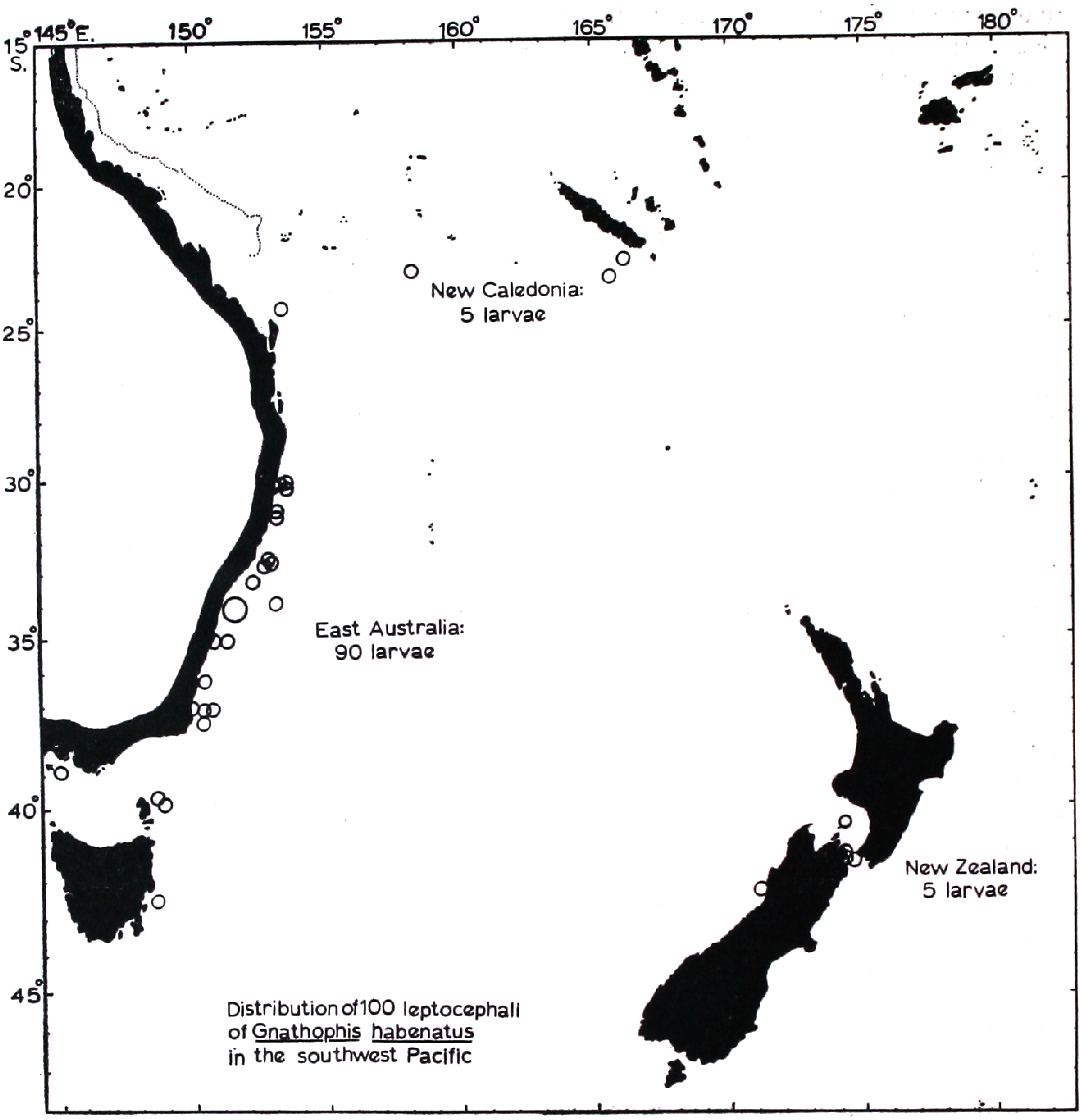
(g) *Other Changes.* At the end of the period during which there is an active movement of the vent posteriorly the caudal fin begins to differentiate from the tips of the dorsal and anal fins to form a distinct caudal fan. This is carried to the extreme in the elver, which, in common with the elvers of *Anguilla,* have a broad caudal fin (Text-fig. 2, D). There is no observable change in the relative position of the gall-bladder during development. In all specimens where this structure was seen its anterior margin stood within about two segments of the 37th myomere.

GEOGRAPHICAL RANGE AND LOCATION OF THE SPAWNING AREAS. The 155 larvae have a wide geographical range. A total of 90 specimens were collected from the eastern Australian coast between latitudes of about 24° S. and 43° S.—i.e., from the middle of the Queensland coast to Maria Island, Tasmania, and off Port Fairy, Victoria; 92 specimens were collected from Western Australia from 29°S. to 32° S.; 5 specimens from the New Caledonia region between the South Bellona Reef and Nouméa; 5 specimens from New Zealand consisting of one from the west coast of the South Island and the remainder from the Cook Strait region. Leptocephali of *Gnathophis habenatus* therefore appear to be more numerous in the areas relatively close to the western and eastern coasts of Australia in latitudes between 24° S. and 43° S. This does not reflect more frequent trawling in these areas since the waters of the New Caledonia region have been examined extensively in the years 1957–62 by the Institut Français d'Océanie, and although large collections of other leptocephali have been made, there have only been a few specimens of *G. habenatus* in these collections. The New Zealand region has been by no means ignored by institutions working this area, but the only specimens of this species collected have been occasional beachcast individuals.

In the eastern Australia-New Caledonia-New Zealand area the smallest leptocephali were collected from a locality some 20 miles from the New South Wales coast over the continental slope near the latitude of Sydney. The largest leptocephali were collected on the periphery of the area of distribution, but in general no simple pattern of increasing size towards the periphery is shown in these collections. Text-fig. 5 shows in greater detail the distribution of this group of 100 specimens. The indications are that the spawning area for eastern Australian *G. habenatus* is very likely to be off the New South Wales coast. The large variation in the total lengths of leptocephali collected at a number of stations would suggest spawnings at different times and that a few larvae may remain in the same area for some time, possibly as a result of countercurrents. The northward range of leptocephali along the Queensland coast and out to New Caledonia suggests that the leptocephali are not completely dependent upon the East Australian Current for their movement, and it is probable that countercurrents are important in the dispersal of the larvae.

As shown in Text-fig. 4, metamorphosis begins in most specimens at about 70mm–90mm total length. However, a few specimens in the collection are much larger than this, reaching 138.2mm. This greater length occurs only in specimens which were collected far from the indicated spawning area. For example, the five Cronulla specimens of greater length than 90mm were all collected from the coast of Victoria to Maria Island, Tasmania; one other large specimen was taken from near Nouméa, and the five New Zealand specimens are all larger than most specimens beginning metamorphosis on the Australian coast. On the other hand, four of the seven Australian Museum specimens beachcast near Sydney—that is, close to the spawning area, are all at stages in metamorphosis at a size which is less than all other metamorphosing specimens.

The geographical range of the material from Western Australia is more restricted than that from eastern Australia. The smallest specimens amongst these 92 larvae is an egg with its developing prelava taken from a position located 37 miles west of Rottnest Island in 37 metres; the largest specimen measures 110.5mm and is undergoing metamorphosis. There are two glass-eels in this collection, one



TEXT-FIG. 6.—*Gnathophis habenatus*, the distribution of 100 larvae in the south-west Pacific; each small circle represents at least one specimen; large circle represents 37 larvae.

of which has almost completed metamorphosis. The presence of very young leptocephali in this collection indicates that *G. habenatus* is also spawning off the coast of Western Australia as well as off the east coast, probably in the area west of Rottnest Island over the continental slope.

The eastern Australian collection contains only a few metamorphosing individuals and was made over a considerable area. The western Australian collection, made over a much smaller area, contains nearly one-half as metamorphosing larvae. This latter collection includes specimens which cover essentially the same size-range as the eastern Australian material excepting the few larger larvae from the furthest limits of the distribution of the latter. In both collections metamorphosis appears at a length of some 80mm, which accordingly can be regarded as the usual or normal size for metamorphosis indicating perhaps that the process is physiological and endogenous. In contrast, there are the larger metamorphosing larvae in the eastern Australian collections, of extreme size in the New Zealand collections and rare in the western Australian collections.

If the stimulus to metamorphosis is entirely endogenous, the few largest larvae may be consequent from individual irregularities in the time of onset of the process. Such individuals, because of their relatively low numbers associated with a "faulty" mechanism for metamorphosis, would not ordinarily be regarded as providing or maintaining a population of adults. The absence as yet of adults from New Caledonia and northern Queensland, supports the idea of a failure to complete normal metamorphosis.

The relative abundance of the species in New Zealand with knowledge only of large metamorphosing larvae on our coasts, suggests that a postponement of metamorphosis to sizes well above 90mm to 100mm may well be normal. Setting aside the question of a subspecific distinction in this matter (relating to the difference in preanal lengths in the adults of *G. habenatus habenatus* and *G. h. longicaudatus*) there remains the probability that the mechanism of metamorphosis is endogenous but subject to retardation in operation, a retardation dependent on an environmental control. The demonstration of adults at the extremes of the larval distribution to the north in Australia and New Caledonia and large collections of larvae for the New Zealand area are required before further analysis of the possible mechanism can be undertaken.

It has been shown that New Zealand specimens of *G. habenatus* differ from Australian specimens in having a slightly greater preanal length in the adult as well as slightly fewer vertebrae. If metamorphosis has been delayed by a prolonged larval life to produce a longer larva it is possible that this would have an effect on the morphological characters of the adult. This has already been shown for *Conger myriaster* by Takai (1959, p. 548). In order that a larger than normal leptocephalus metamorphose into a young eel with the characteristically short preanal length of *G. habenatus longicaudatus* then the amount of regression of the vent would be relatively greater. The vent may only be capable of a certain degree of regression for morphological reasons (although I can suggest no such specific reason) and the adult would have a relatively long preanal length, as in the New Zealand *G. habenatus habenatus*.

BATHYMETRIC DISTRIBUTION. Many of the hauls in which leptocephali of *G. habenatus* were collected were oblique or vertical and a precise depth range is therefore not available. The hauls ranged from the surface to 730m, but the majority of specimens were taken in depths ranging from the surface to 200m. The species appears to be most abundant in about 50m–100m in common with the larvae of many species of eels.

Gnathophis incognitus n. sp. (Text-fig. 7, A-H).

1936. ? *Poutawa habenata* (Richardson). Griffin (partim), *Trans. roy. Soc. N.Z.*, 66: 16.

MATERIAL EXAMINED. Type specimen: gravid female, 445.0mm total length; Kaikoura coast in 40–50 fathoms; commercial otter trawl; 4/5/61; Dom. Mus. No. 3073. Paratype: male, 350.0mm total length; off Portland Island, Hawke Bay in 30–40 fathoms; commercial otter trawl; 17/5/56; Dom. Mus. No. 1926. Paratype: 237.4mm total length; off Plate Island, Bay of Plenty, in 70–100 fathoms; commercial otter trawl; 16/8/56; Dom. Mus. No. 1983. Paratype: 202.0mm total length; Hawke Bay; Dom. Mus. No. 530. Paratype: 200.5mm total length; Bay of Plenty; Dom. Mus. No. 2612. Three specimens: 70.0mm, 80.1mm and 84.3mm total lengths; Denham Bay, Raoul Island, Kermadec Islands; beach cast; June, 1955; Cant. Mus. Coll. One specimen: 249.0mm total length; Hawke Bay; Cant. Mus. Coll. No. P.137.0. One specimen: 317.0mm total length; Otago, 1893; Otago Mus. Coll. No. A.9.

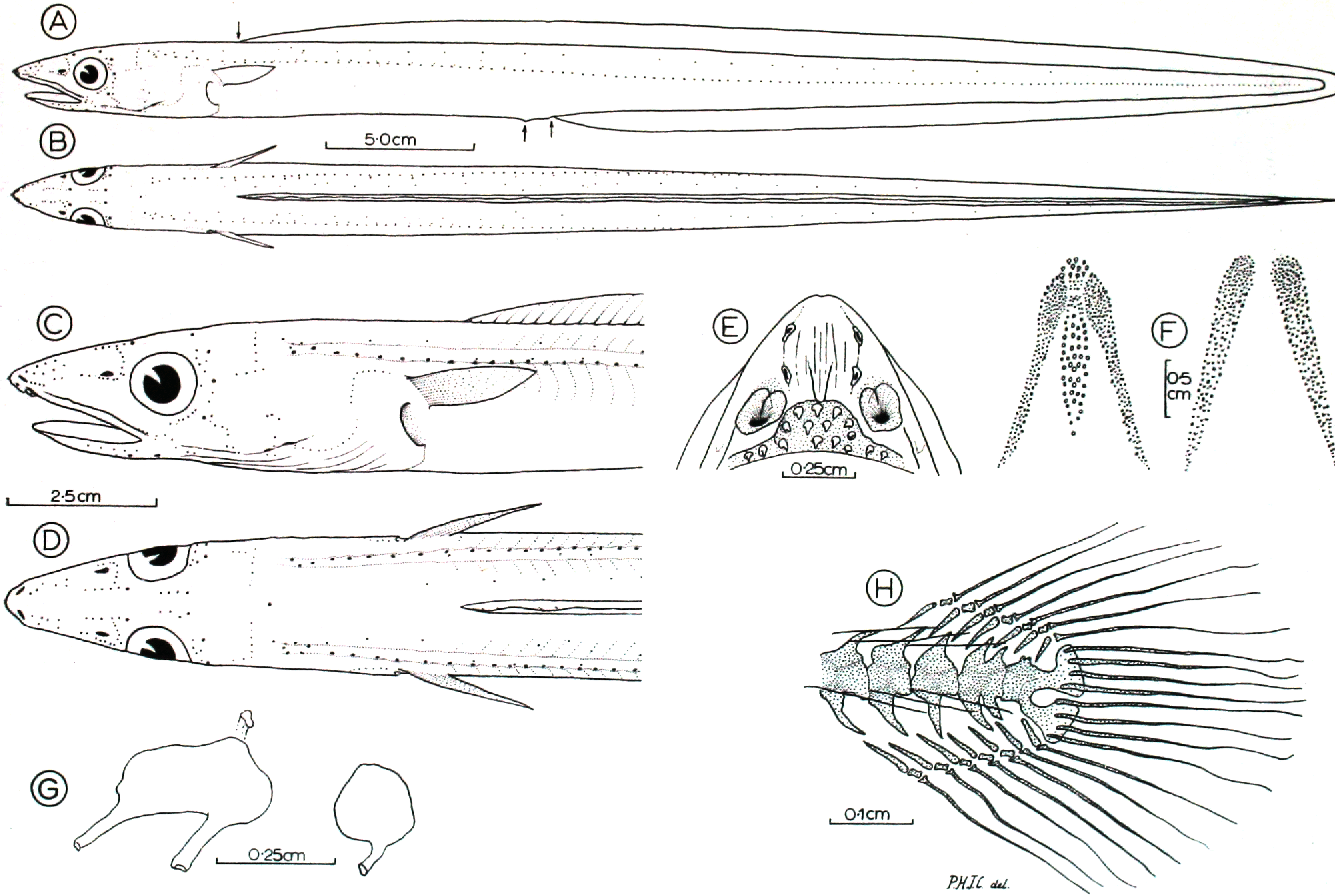
DESCRIPTION. Proportional measurements (in per cent total length) and counts from the type and the four paratypes (in parentheses): standard length 98.8 (98.4–98.9), head 15.5 (15.1–16.6), snout 4.4 (4.4–4.7), eye 2.7 (3.1–3.5), interorbital 1.8 (1.9–2.6), cleft of mouth 5.9 (5.8–6.6), postorbital 7.9 (7.8–8.2), branchial aperture 1.8 (1.5–1.8), branchial interspace 4.8 (3.0–3.4), pectoral 4.7 (4.7–6.0), snout-vent 38.4 (37.5–37.9), preanal 41.0 (37.8–39.6), predorsal 16.9 (16.9–17.6), depth just before eye 3.8 (3.1–4.3), depth at pectoral origin 5.6 (4.8–5.3), depth at anal origin 5.5 (4.3–5.2), depth at midpoint of caudal region 3.4 (3.1–3.6). Pectoral rays 13 (12–13), dorsal rays before level of vent 41 40–56), dorsal rays 211 (210–227), anal rays 160 (157–177), caudal rays 5 + 4 (5 + 4), lateral line pores before level of vent 37 (35–38), vertebrae 145 (139–147).

Body slender, not greatly elongate and little compressed, with prominent myomeres and the vent placed appreciably in front of the midpoint of the body. Head depressed with a sharp bony snout, inferior mouth and large eye. Median fins well-developed but delicate.

Head conical, relatively long, contained about 6.5 times in total length but not clearly differentiated from trunk; snout acutely pointed, bony, about 3.5 in head, projecting in advance of lower jaw by an amount equal to about half diameter of eye, usually a little less; lower jaw rounded in ventral view, slender; mouth conspicuously subterminal, moderately oblique, with cleft extending not beyond a point level with anterior edge of pupil and about three times in head length; upper lip weak, lower thick and fleshy; tongue well-developed.

Teeth generally small but larger on premaxillary-ethmoid than on other dentigerous bones, relatively sharp and conical except on the main part of the vomer, numerous, closely-packed to form broad bands. Maxillary teeth in about four or five longitudinal rows of about 35 teeth, those of the outer row slightly larger than the remainder and the dentigerous area expanding anteriorly with the teeth small and cardiform; a few of the teeth in the medial row molariform. Premaxillary-ethmoid teeth about 12 in number, conspicuous, in an oval patch broader than long, its length contained five times in the length of the vomerine patch; premaxillary-ethmoid teeth almost all exposed in front of the tip of the lower jaw; about a dozen much smaller teeth between this patch and the anterior extremity of the vomerine patch so that the two patches are almost confluent. Vomerine teeth in about three to five longitudinal rows of about 16 teeth each forming a cigar-shaped patch which is about three-fifths as long as the maxillary patch; the teeth large and rounded, short, molariform, more widely spaced than teeth on maxilla or dentary; about a dozen very small, sharp teeth at the anterior extremity of this patch almost in contact with those of the premaxillary-ethmoid patch. Teeth on the dentary similar in number, size and distribution to those on the maxilla although there are fewer minute teeth anteriorly; length of dentigerous area equal to total length of upper area including premaxillary-ethmoid patch, but tip of dentary level with tip of maxilla (not indicated in Text-fig. 7, F).

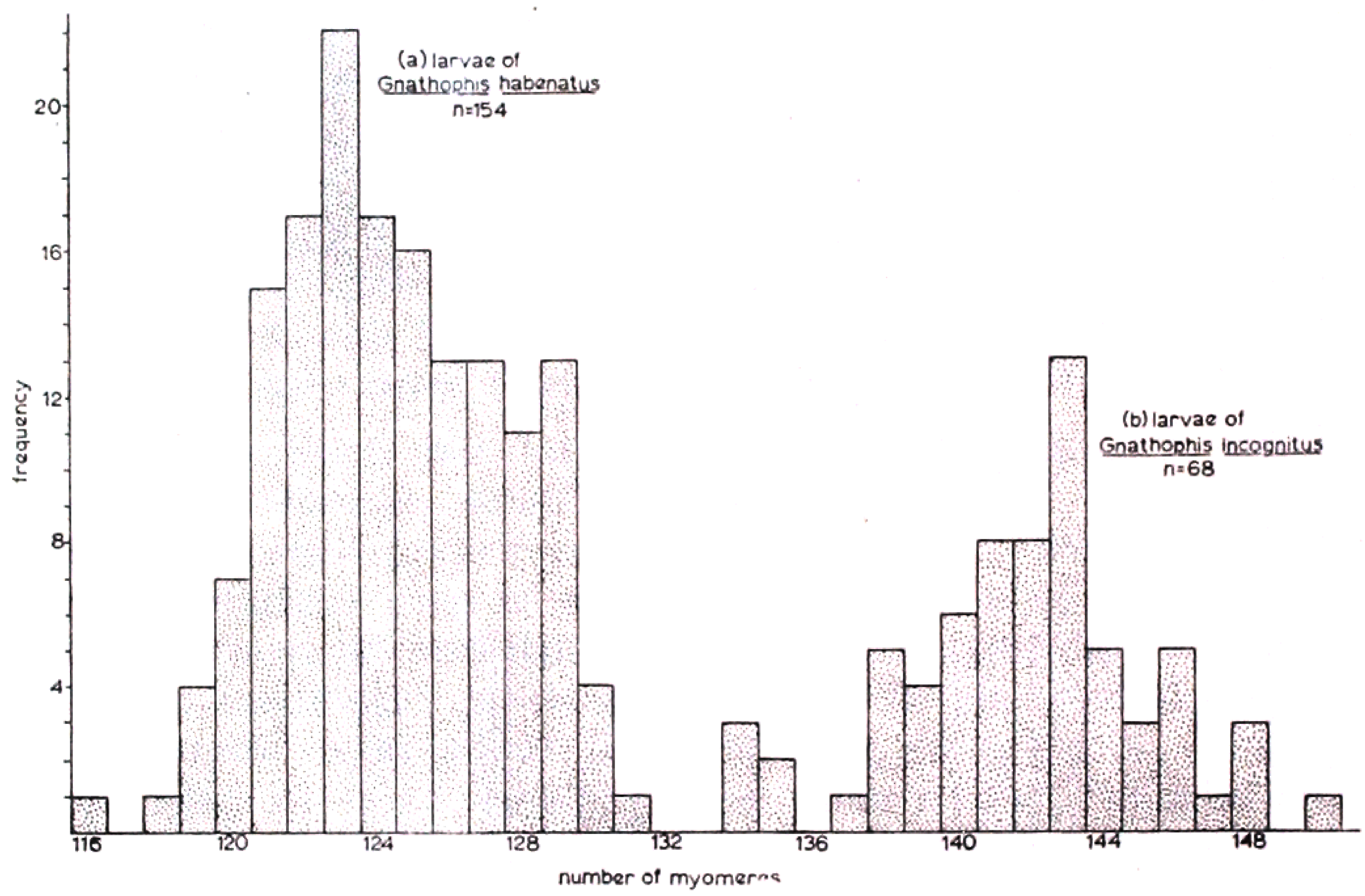
Anterior nostril small, subterminal, on ventral surface of snout level with anterior extremity of premaxillary-ethmoid patch of teeth; a short external tube with a small free flap so that the rim is not simple. Posterior nostril small, placed a little in advance of eye on a level slightly above the horizontal diameter; usually slit-like with a raised complete rim but no external tube. Eye circular to slightly oval, large, about three in postorbital; fleshy interorbital space narrow but difficult to determine accurately, usually considerably less than eye. Branchial aperture lateral with a concave free edge, slightly oblique, with the ventral extremity more posterior and with the dorsal extremity a little below middle of pectoral base.



TEXT-FIG. 7.—*Gnathophis incognitus* n. sp., type, 445.0mm total length, female, Dom. Mus. No. 3073, Kaikoura, 4/5/61. Fig. A—Lateral view, arrows indicate origin of dorsal, anterior margin of vent and origin of anal. Fig. B—Dorsal view. Fig. C—Lateral view of head to indicate minute sensory papillae and prominent myomeres. Fig. D—Dorsal view of head. Fig. E—Ventral view of snout to show anterior nostrils, pores and premaxillary-ethmoid teeth. Fig. F—Pattern of upper (left) and lower (right) teeth. Fig. G—Left preorbital bones, lateral view. Fig. H—Caudal skeleton (200.5mm t.l., Dom. Mus. No. 2612).

Vent protruding into the lateral profile, in the type specimen enlarged due to the gravid condition.

Median fins delicate in life, rather fleshy on preservation, their posterior tips confluent with the caudal; rays clearly visible. Dorsal fin well-developed, its maximum height near level of vent, when fully extended contained about three times in body depth at level of vent; originating only slightly in advance of level of midpoint of pectoral fin; rays rather few compared with most other congrid eels. Anal fin a little less strongly developed than the dorsal, its maximum height on full extension about halfway along caudal region and about 3.5 in depth of body at vent. Caudal fin rounded and the rays relatively short, giving an impression that the tail is used for burrowing. Pectoral fin elongate-oval in shape, slender, originating slightly above mid-lateral level and directed somewhat posterodorsally, its length a little greater than snout.



TEXT-FIG. 8.—Frequency of myomeres in (a) *Gnathophis habenatus* and (b) *G. incognitus*.

Lateral line very conspicuous as a raised ridge, arising high up on head and reaching midlateral level just posterior to vent. Pores simple, not carried on the ends of short tubes, clearly visible except along the most posterior part of the caudal region. Cephalic sensory pores restricted to one occipital pore, five or six circum-orbital pores, two opercular pores and a series along ventral aspect of lower jaw. Two small pores lie immediately in front of, and medial to, the anterior nostril on the ventral surface of the snout. An inconspicuous but long slit occurs dorsally on each side of snout tip. Several series of surface sensory organs, indicated by minute papillae, occur on the head and in a longitudinal row above the lateral line although the papillae of the latter series are sparse and widely spaced. The cephalic papillae are distributed in lines on the dorsal surface of the snout, behind eye, on lower jaw and in semicircular rows on operculum and in front of pectoral fin.

Colour in life olive-green over silver, with a silver iris; in preservative it is dark brown on dorsal aspect of head and above lateral line, lighter below, with the whole of the dorsal and the posterior part of the anal edged with a narrow black band.

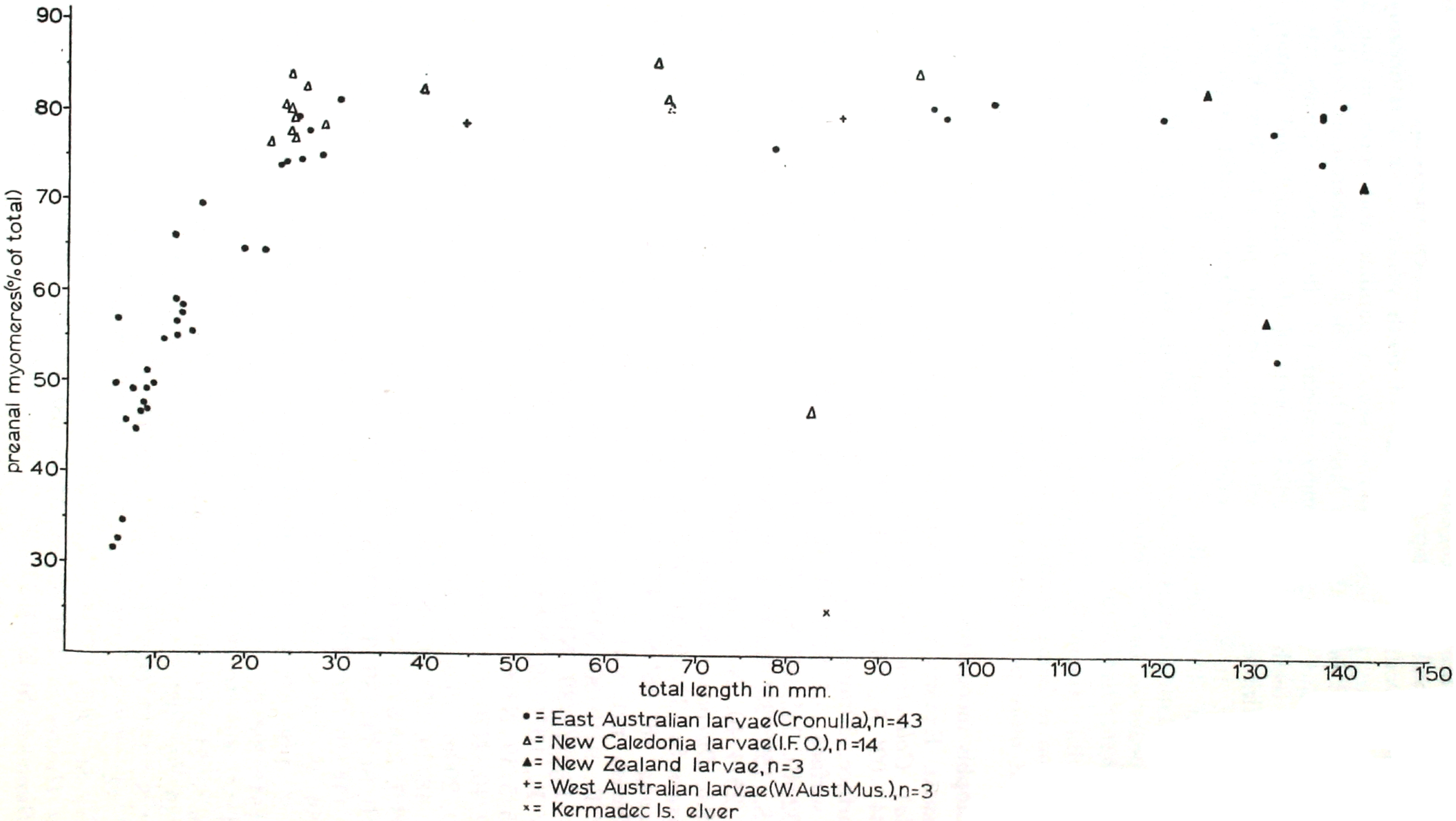
REMARKS. *Gnathophis incognitus* differs from *G. habenatus* in having 139–147 vertebrae, a small free flap on the anterior nostril (Text-fig. 7, E), premaxillary-ethmoid teeth in an oval patch of teeth which extends noticeably in front of the maxillary patches, numerous sensory papillae and pores on the head and body, a pointed pectoral fin, a lateral line which is rather more conspicuous as a raised ridge and a slightly longer caudal fin; the present species has only sparse molariform teeth on the medial aspects of the maxilla and dentary but more numerous minute, pointed teeth on the anterior parts of these bones than does *G. habenatus*. It is a more slender eel with a relatively short preanal region, usually less than 40% of the total length, and is duller in colouration. *G. incognitus* inhabits waters of about 30 fathoms to the edge of the continental shelf and appears to have a more northerly distribution in New Zealand than does *G. habenatus habenatus*.

G. incognitus resembles *G. xenicus* (Matsubara & Ochiai, 1951) of the Japanese region in being slender and long in the tail, but the latter has 152–154 vertebrae and more pores before the level of the vent.

L. Gnathophis incognitus

MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (45 specimens)*: 5.3mm total length, *Warreen* Station 44/39, 34° 02′ S., 151° 15.5′ E, 26/1/39, N100 (100cm net), H (horizontal tow), surface, 30mins; 5.5, 7.8, St 32/40, 34° 04′ S., 151° 14.5′ E., 25/4/40, N70, H, surface; 5.7, St 3/40, 32° 47′ S., 152° 40′ E., 11/1/40, N100, O, 0–200m; 5.9, St 32/40, 34° 04′ S., 151° 14.5′ E., 25/4/40, N70, O, 50m; 6.2, St 7/40, 30° 13′ S., 153° 33′ E., 14/1/40, N70, O, 200m; 6.6, St 32/40, 34° 04′ S., 151° 14.5′ E, 25/4/40, N70, H, surface; 7.2, 8.9, 8.9, off Eden, Victoria, 1/4/48; 8.2, ca. 9.6, *Discovery* St 2723, 34° 08′ S., 151° 33′ E., 9/10/50, N100B, 93–0m; 8.6, *Warreen* St 139/39, 31° 51.5′ S., 152° 50′ E, 17/5/39, N100, H, 25m, 60mins; 9.0, *Kywong*, 18° 46′ S., 147° 15′ E, Keeper Reef, Great Barrier Reef, 24/11/51. 50cm/40mesh net, surface, 15mins; 10.9, 12.8, *Discovery* St. 2722, 34° 04′ S., 151° 50′ E., 9/10/50, N100B, 114–0m; 12.0, 14.9, *Warreen* St 127/39, 33° 18′ S. 152° 13′ E., 3/5/39, N100, H, 100m, 30mins; 12.1, 14.0, St 105/39, 41° 17′ S. 148° 26′ E., 10/4/39, N200, H, 25m, 30mins; 12.1, St 132/39, 30° 15′ S., 153° 33′ E., 5/5/39, N100, H, 100m, 60mins; 12.4, St 24/40, 34° 08.5′ S., 151° 36.5′ E., 27/2/40, N70, O, 200m; 12.8, St 30/40, 30° 18′ S., 153° 32′ E., 22/4/40, N100, O, 200m; 19.8, St 22/42, 39° 46′ S., 148° 36′ E., 18/4/42, N70, H, 50–0m; 22.0, St 48/39, 35° 07′ S., 150° 50′ E., 7/2/39, N200, H, 25m, 30mins; 23.9, 24.3, 133.9, 138.8, St unknown, ca. 34° 04′ S., 151° 15′ E., ?/39, no other data; 25.0, 26.0, St 141/39, 34° 04′ S., 151° 15′ E, 30/5/39, N100, H, surface, 30mins; 25.7, St 144/39, 36° 15′ S., 150° 25′ E, 31/5/39, N200, H, 100m, 30mins; 26.0, St 142/39, 35° 03′ S., 151° 08′ E., 30/5/39, N70, V, 50–0m; 26.9, 30.1, St 183/39, 43° 13′ S., 148° 19′ E., 11/6/39, N200, H, 100m, 30mins; 28.2, St 140/39, 34° 09′ S., 151° 35′ E., 29/5/39, N100, H, 100m, 30mins; 78.5, *Derwent Hunter* St DH 94/55, 42° 50′ S., 150° 50′ E., 27/8/55, Hardy recorder, surface; 85.9, *Warreen* St 214/39, 36° 14′ S., 150° 25′ E., 3/9/39, N70, O, 200m; 95.9, 97.2, St 224/39, 35° 03′ S., 151° 09′ E., 4/10/39, N200, H, surface; 102.6, St 5/39, 35° 09′ S., 151° 06.5′ E., 6/1/39, N200, H, 100m, 30mins; 121.1, 138.8, St 185/39, 42° 37′ S., 148° 32′ E., 11/6/39, N200, H, 100m, 30mins; 133.3, *Discovery* St 2709, 37° 06′ S., 150° 35′ E, 5/10/50, N100B, 110–0m; 138.7, *Derwent Hunter* St DH 80/53, Maria Island wide, 2/10/53, N70, H, surface; 141.0, *Discovery* St 2710, 37° 06′ S., 150° 48′ E., 6/10/50, N100B, 84–0m.

Australian Museum Collection (1 specimen): 135.1, Aust. Mus. regd. no. IA.2058, no other data.



TEXT-FIG. 9.—*Gnathophis incognitus*, variation in number of preanal myomeres (expressed as a percentage of the total) with total length in 63 leptocephali and one elver.

Western Australian Museum Collection (*3 specimens*): 44.2, Accession No. P5234, *Lancelin,* 46 miles west of West End, Rottnest Island, Western Australia, 11/4/62 (0200hrs), larval net in 37 metres; 86.2, P5279, 39mls, 7/6/62 (0500–0530), ln, 37m; 120.0, P5233, 49mls, 9/5/62 (0100–0130), ln, 37m.

Centre d'Océanographie de l'Institut Français d'Océanie Collection (*15 specimens*): 22.7, IFO Station MWT 2, 10 miles west of the Bulari pass, off Nouméa, 30/11/61, 3ft midwater trawl (Isaacs-Kidd), H, 68m; 24.3, 26.6, 27.5, 28.2, St S 1m 6, 10mls west of Bulari pass, 30/11/61, 1.0m net, 117m; 24.9 St 7–2, 22° 35′ S., 166° 16′ E., 17/7/62, 5ft midwater trawl (Isaacs-Kidd), H, ca. 70m; 25.0, St S 6, 11° 51′ S., 159° 13′ E., 11/6/62, 5ft midwater trawl (Isaacs-Kidd), H, ca. 95m; 25.0, St S 1m B, 10mls west of Bulari pass, 28/11/61, 1.0m net, H, 90m; 25.2, St S 1m 1, 10mls west of Bulari pass, 30/11/61, 1.0m net, H, 68m; 28.3, St 7–8, 22° 35′ S., 166° 16′ E, 26/7/62, 5ft midwater trawl (Isaacs-Kidd), H, ca. 20m; 39.8, St MWT 3 I, 10mls west of Bulari pass, 1/8/61, 3ft midwater trawl (Isaacs-Kidd), H, 23m; 65.2, St D 6b, 18° 22′ S., 158° 15′ E., 15/5/60 (0211), 0.5m net, no. 2 mesh, 2 oblique tows in 0–300m; 67.0, St S 10, 17° 40′ S., 162° 25′ E, 22/6/62, 5ft midwater trawl (Isaacs-Kidd), H, ca. 95m; 82.7, St 57–5–4, stomach of yellow fin tuna (*Neothunnus macropterus*) longlined at 21° 33′ S., 166° 32′ E., 11/9/57; 94.1, St MWT 3 I, 10mls west of Bulari pass, 1/8/61, 3ft midwater trawl (Isaacs-Kidd), H, 40m.

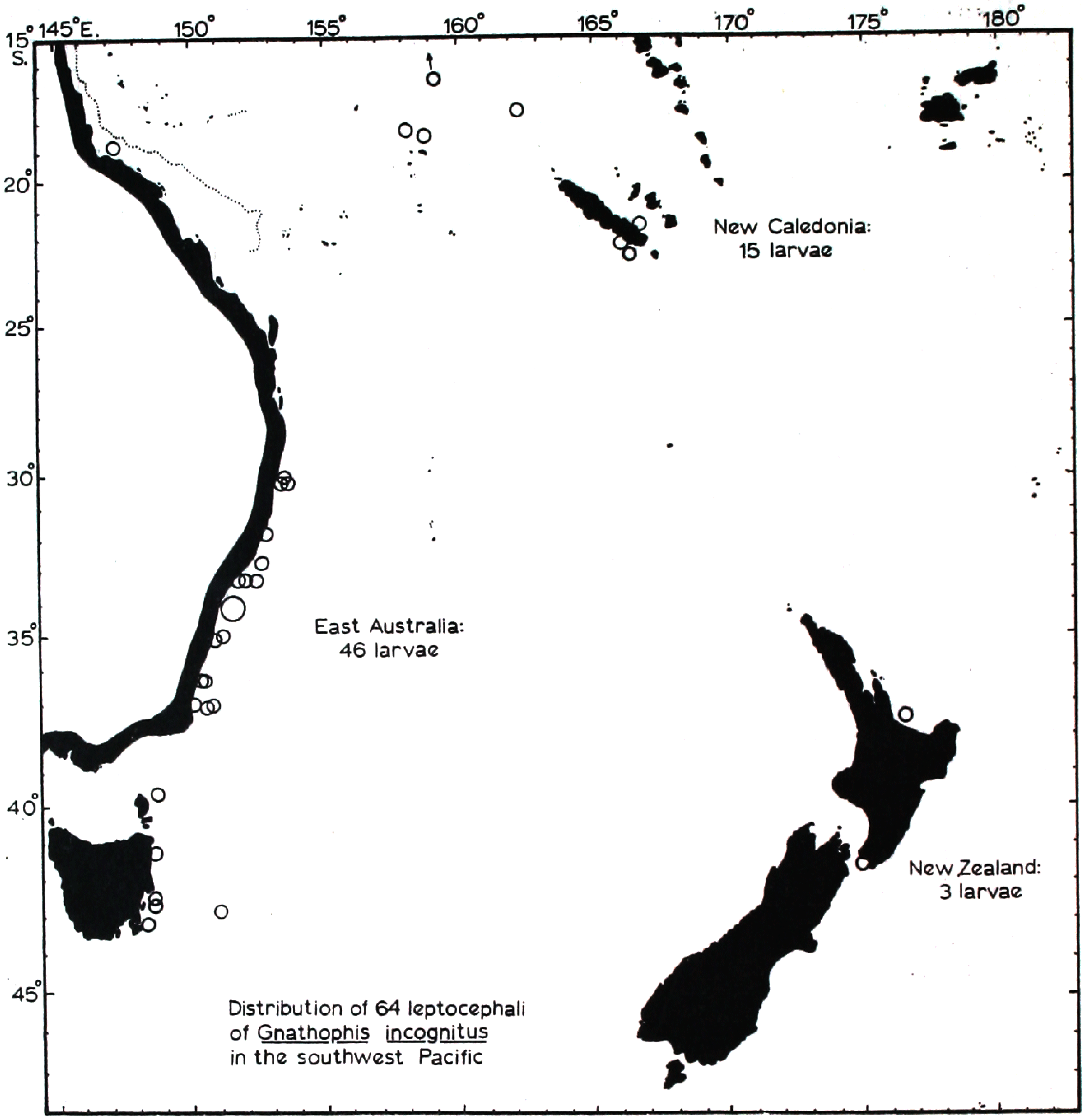
New Zealand Collections (*3 specimens*): 126.0, Dom. Mus. No. 2131, Dom. Mus. St. 210, net 4, Bay of Plenty, Feb/57, cone-net, 400m; 132.0, Dom. Mus. No. 1771, beachcast at Lake Ferry outlet, Palliser Bay, 17/9/55; 143.2, Dom. Mus. No. 1601, outlet at Lake Ferry, Palliser Bay, 13/10/54, whitebait net.

DESCRIPTION. 68 specimens: total lengths 5.3mm–143.2mm, myomeres 134–150, dorsal fin-rays 175–269, anal fin-rays 130–184. Vertical blood-vessels at 11, 37, 46. Anterior margin of gall-bladder at about myomere 37. a-d = ca. 33.

REMARKS. Larvae of *Gnathophis incognitus* are very closely similar to those of *G. habenatus* but may be distinguished from the latter mainly in having a greater number of myomeres. Text-fig. 8 shows the number of myomeres in larvae of the two species. The greatest proportion of specimens of *G. incognitus* have 143 myomeres while *G. habenatus* has 123 and the ranges of the two species do not overlap. The two species are therefore easily distinguished on this character alone, but there are other features which separate the two.

G. incognitus has the last vertical blood-vessel at myomere 46 and preanal myomeres numbering about 112 during the major part of the growth period of the larva. This may be compared with *G. habenatus,* which has the last vessel at myomere 41 and the preanal myomeres numbering about 100. There are slightly more numerous dorsal and anal fin-rays in *G. incognitus.*

Some of the small larvae identified as *G. incognitus* may possibly be referable to species of *Conger* since at the time of writing there are no known characters which could be used to separate very young larvae of the two genera, *Conger* and *Gnathophis.* At this early stage the differences in pigmentation which are the major characters by which older larvae of the two genera are separated are insufficiently developed to be useful. *Conger wilsoni* (Bloch & Schneider, 1801) with 146–147 vertebrae (Kanazawa, 1958, p. 257) and *C. cinereus cinereus* Rüppell, 1828, which has 139–147 vertebrae (Kanazawa, 1958, p. 235) may be the two species confused in these identifications. The former is a common species in eastern Australia and northern New Zealand, and the latter has been recorded from North Queensland (Whitley, 1935, p. 219).



TEXT-FIG. 10.—*Gnathophis incognitus*, the distribution of 64 larvae in the south-west Pacific, each small circle represents at least one specimen; large circle represents 15 larvae.

GROWTH AND METAMORPHOSIS. Similar changes in shape of myomeres, number of preanal myomeres, number and distribution of teeth, etc., and distribution of pigment take place in the growth of leptocephali of *G. incognitus* as already described for *G. habenatus*. The 68 specimens range in total lengths from 5.3mm to 143.2mm. Text-fig. 9 shows that during the earlier stages of growth from loss of the yolk-sac at about 5mm to a length of 30mm there is a rapid increase in the number of preanal myomeres from 35% to 80% of the total. There are insufficient larvae in stages of metamorphosis to state when this normally takes place in *G. incognitus* although one specimen from New Caledonia at 82.7mm total length has preanal myomeres about 55% of the total, indicating that metamorphosis is well under way. On the other hand, many of the other late larvae are at the same stage of metamorphosis at a total length of about 120mm–130mm. The larvae of this species appear to reach a greater maximum size than do those of *G. habenatus*, there being 12 specimens over

120mm total length in the collection of 68 specimens compared with only 2 specimens in the 154 of *G. habenatus*. Three early elvers of *G. incognitus,* total lengths 70.0mm, 80.1mm and 84.3mm from the Kermadec Islands by their colouration have evidently just undergone metamorphosis. The late glass-eel of *G. habenatus* from Western Australia already described is 61.2mm total length so it is possible that *G. incognitus* indeed has larger leptocephali and elvers.

GEOGRAPHICAL RANGE AND LOCATION OF THE SPAWNING AREAS. The 68 larvae of *G. incognitus* were collected from about the same area as were those of *G. habenatus.* A total of 46 of these larvae were collected on the east Australian coast mainly between 20° S. and 40° S. along the New South Wales coast and off Tasmania with a single specimen from the Great Barrier Reef, North Queensland. Fifteen larvae were taken off New Caledonia; three larvae were collected in the New Zealand region; but only three specimens were collected off the west Australian coast. The smallest leptocephali were taken from the same general locality off the New South Wales coast as were the smallest larvae of *G. habenatus,* while the largest were taken again on the periphery of the area of distribution—that is, from Tasmania to New Zealand. However, like *G. habenatus,* a number of the larger leptocephali were collected with the smaller larvae off New South Wales. Spawning of this species would therefore appear to take place in about the same area off eastern Australia as does *G. habenatus.* However, compared with the latter species there would seem to be two differences in distribution of *G. incognitus* (a) larvae are more abundant in the New Caledonia region, (b) larvae are much less abundant, even rare, off Western Australia, although a limited spawning probably takes place here also.

BATHYMETRIC DISTRIBUTION. No precise figures are available for the depths at which the leptocephali of *G. incognitus* are more abundant, but the range of depths of the tows in which this species were collected is 0m–400m with the larvae more frequent in 50m–100m.

SUMMARY

(1) The small silver eel originally described by Richardson (1848, p. 109) from Cook Strait, New Zealand, as *Congrus habenatus* should now be known as *Gnathophis habenatus.* Osteological and other characters show that it is congeneric with *Myrophis heterognathos* Bleeker, 1859, from Nagasaki, Japan, the type species of *Gnathophis* Kaup, 1859.

(2) *Gnathophis* is now recognised to have species in California and probably the Atlantic in addition to those known in Japan and New Zealand.

(3) *G. habenatus* has 120–129 vertebrae, scroll-like anterior nostrils and a small, triangular premaxillary-ethmoid patch of teeth and inhabits the shallow waters of harbours and river mouths from New Zealand to Lord Howe Island, south-east Australia, south-west Australia, and possibly St. Paul's Island, South Indian Ocean. It is distinct from *G. incognitus,* a new species described here, which has 139–147 vertebrae, minute epidermal papillae, anterior nostril with a simple free flap and a round premaxillary-ethmoid patch of teeth extending conspicuously in advance of the maxillary patches, known from deeper waters of New Zealand as far north as the Kermadec Islands.

(4) *G. habenatus* has been divided into two subspecies, *G. habenatus habenatus* and *G. habenatus longicaudatus* (Ramsay & Ogilby, 1888), which are separated solely on the length of the preanal region. *G. h. habenatus* is known from the New Zealand region and always has the vent a little in

advance of the middle of the body so that the preanal length is never less than 40% of the total. *G. h. longicaudatus* is typical of the Australian region and has a short preanal length, never greater than 40% of the total. This difference in preanal lengths may be due to differences in the lengths of the pelagic larval life of the two subspecies.

(5) *G. habenatus habenatus* is found abundantly in Wellington harbour in a gravid condition during late autumn and winter, suggesting a nearby spawning area.

(6) A large collection of leptocephali of the two species, some 250 specimens, shows that both *G. habenatus* and *G. incognitus* spawn off the New South Wales coast and off Rottnest Island, Western Australia, over the continental slope, although there is probably only a limited spawning of *G. incognitus* in the western area.

(7) During growth of the larvae of *G. habenatus* from 5mm to 30mm the number of preanal myomeres increases rapidly from about 55 to 100 in the total of about 125. The vent remains at this level until the total length reaches about 80mm at which time metamorphosis begins and the vent moves forwards to its final position in the elver at the 37th myomere. Small leptocephali have a few large somatic chromatophores in a ventral series from the pectoral region to the vent as well as small pigment spots on the lower jaw and the caudal tip. As growth proceeds to the full-grown leptocephalus the ventral spots increase in number to about 90 (beginning at the 10th myomere), spots appear on the throat, on the dorsal and anal bases, and a characteristic black crescent appears below the iris at a length of about 30mm. Leptocephali of *G. incognitus* undergo similar changes during growth but are distinguished from those of *G. habenatus* in having 134–150 myomeres and the last vertical blood-vessel at myomere 46. *G. habenatus* has leptocephali with 116–132 myomeres and the last vessel at myomere 41.

(8) Leptocephali of both species have been collected from New Caledonia, but as yet the adults are unknown from this area. Adults of *G. incognitus* are known only from New Zealand and the adult of *G. habenatus* has yet to be recorded from Western Australia.

LITERATURE CITED

ANCONA, U. d', 1928. Muraenoidi (Apodes) del Mar Rosso e del Golfo di Aden. Materiali raccolti dal Prof. L. Sanzo nella campagna della R.N. "Ammiraglio Magnaghii" 1923–24. *Mem. R. Com. talassogr. ital.*, 146: 1–146, 5 pls.

ASANO, H., 1962. Studies on the congrid eels of Japan. *Bull. Misaki mar. biol. St.*, 1: 1–143, 62 figs.

BLEEKER, P., 1858–59. Vijfde bijdrage tot de kennis der ichthyologischche fauna van Japan. *Act. Soc. Sc. Indo-Neerl.*, 5: 1–12, 3 tab.

——— 1864. *Atlas ichthyologique des Indes orientales Neerlandaises, 4.* Amsterdam, 132pp., 48pls.

CASTLE, P. H. J., 1960. Two eels of the genus *Pseudoxenomystax* from New Zealand waters. *Trans. roy. Soc. N.Z.*, 88 (3): 463–472, 2 figs.

——— 1961. Deep-water eels from Cook Strait, New Zealand. *Zool. Publ. Vict. Univ. N.Z.*, 27: 1–30, 6 figs.

DAKIN, W. J., & COLEFAX, A. N., 1940. The plankton of the Australian coastal waters off New South Wales, Part I. *Univ. Sydney Publ. Zool.*, mngrph. 1: 1–211, 936 figs., 4 pls.

GRIFFIN, T. L., 1936. Revision of the eels of New Zealand. *Trans. roy. Soc. N.Z.*, 66 (1): 12–26, 6 figs.

GÜNTHER, A., 1870. *Catalogue of the fishes in the British Museum. VIII.* British Museum, London, 549 pp.

HUTTON, F. W., 1872. *Fishes of New Zealand. Catalogue, with diagnoses of the species.* James Hughes, Wellington, 93 pp., 134 figs., 12 pls.

JORDAN, D. S. & HUBBS, C. L., 1925. Record of fishes obtained by David Starr Jordan in Japan, 1922. *Mem. Carneg. Mus.,* 10 (2): 93–346, 7 pls.

——— & SNYDER, J. O., 1901. A review of the apodal fishes or eels of Japan, with descriptions of nineteen new species. *Proc. U.S. nat. Mus.,* 23: 837–890, 22 figs.

KANAZAWA, R. H., 1958. A revision of the eels of the genus *Conger* with descriptions of four new species. *Proc. U.S. nat. Mus.,* 108: 219–267, 7 figs., 4 pls.

KAUP, J. J., 1856. *Catalogue of the apodal fish in the collection of the British Museum, London.* 163 pp., 19 pls.

——— 1859. Neue aalaenliche fische des Hamburger Museums, beschrieben und abgebildet durch Professor Dr. Kaup. *Abh. Naturw. Hamburg,* 4 (2).

LEA, E., 1913. Muraenoid larvae from the "Michael Sars" North Atlantic Deep-Sea Expedition, 1910. *Rep. Sars N. Atl. Deep Sea Exped.,* 3 (2): 1–48, 38 figs., 6 pls.

LOZANO REY, D. L., 1947. Peces ganoideos y fisostomos. *Mem. R. Acad. Madr.,* ser. cienc. nat, 11: xv + 839 pp., 190 figs., 20 pls.

MATSUBARA, K. & OCHIAI, A., 1951. On the conger eels related to *Arisoma nystromi* (Jordan et Snyder) found in the waters of Japan and China. *Mem. Coll. Agric. Kyoto,* 59: 1–18, 8 figs.

MORELAND, J. M., 1961. In Doogue & Moreland, *New Zealand Sea Anglers' Guide. 2nd ed.* A. H. & A. W. Reed, Wellington, 318 pp.

OGILBY, J. D., 1898. New genera and species of fishes. *Proc. Linn. Soc. N.S.W.,* 23: 280–289.

PHILLIPPS, W. J., 1927. Bibliography of New Zealand fishes. *N.Z. Mar. Dept. Fish. Bull.,* 1: 1–68.

RAMSAY, E. P., & OGILBY, J. D., 1888. Descriptions of two new fishes from Port Jackson. *Proc. Linn. Soc. N.S.W.,* 12: 1021–1023.

RICHARDSON, J., 1848. *The zoology of the voyage of H.M.S. Erebus and Terror 1839 to 1843, under the command of Captain Sir James Clark Ross, R.N., F.R.S., Fishes.* London.

ROSENBLATT, R. H., 1958. The status and synonymy of the eastern Pacific eel *Ariosoma gilberti* (Ogilby). *Copeia,* 1: 52–54, 1 tab.

SCHULTZ, L. P., et al, 1953. Fishes of the Marshall and Marianas Islands. Vol. 1. *Bull. U.S. nat. Mus.,* 202: xxxii + 685 pp., 90 figs., 74 pls.

SWAINSON, W., 1838. *The natural history and classification of fishes, amphibia and reptiles.*

TAKAI, T., 1959. Studies on the morphology, ecology and culture of the important apodal fishes, *Muraenesox cinereus* (Forskal) and *Conger myriaster* (Brevoort). *J. Shimonoseki Coll. Fish.,* 8 (3): 209–555, 153 figs., 14 pls.

WADE, C. B., 1946. Two new genera and five new species of apodal fishes from the eastern Pacific. *Allan Hancock Pacif. Exped.,* 9 (7): 181–202, 4 pls.

WAITE, E. R., 1911. Scientific results of the New Zealand Government trawling expedition, 1907. Pisces. Part II. *Rec. Canterbury (N.Z.) Mus.,* 1 (3): 157–272, 33 pls.

WHITLEY, G. P., 1935. Studies in ichthyology, No. 9. *Rec. Aust. Mus.,* 19 (4): 215–250, 1 pl.

——— 1937. Studies in ichthyology, No. 10. *Rec. Aust. Mus.,* 20 (1): 3–24, 5 figs., 1 pl.

——— 1956. In Graham, D. H., *Treasury of New Zealand Fishes. 2nd ed.* A. H. & A. W. Reed, Wellington, 424 pp., ill., with appendix.

P. H. J. CASTLE, M.Sc.,
Department of Zoology,
Victoria University of Wellington,
P.O. Box 196, Wellington, N.Z.