DEEP-SEA EELS: FAMILY SYNAPHOBRANCHIDAE

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INTRODUCTION

Among the fishes collected by the Galathea Expedition were 12 eels of the family Synaphobranchidae; these were taken off Durban (Station 186, 3620 metres: 3 specimens; St. 190, 2720 m.: 5 specimens), off Kenya (St. 241, 1510 m.: 1 specimen), in the Strait of Malacca (St. 324, 1140 m.: 2 specimens), in the Tasman Sea (St. 601, 4400 m: 1 specimen) and in the Kermadec Trench (St. 668, 2640 m: 1 specimen). This material was sent to the author for study, a part in November, 1960, another in May, 1961 and a third shipment in September, 1961. Unfortunately, the second shipment of specimens, including the three from St. 186 and two from St. 190, was destroyed in a disastrous fire in a Post Office mail store in Wellington during July, 1961. This accident to such valuable material is very much regretted. However, while there is little point in speculation as to the identity of the specimens destroyed, taking into consideration the area and depth in which they were captured, it is probable that these specimens belonged to the same species as the remainder from St. 190.

The eels listed above represent three genera and five species so providing finally for me a complete coverage of the family. Four species are described and figured here the exception being one species which has been fully treated elsewhere (CASTLE 1960, pp. 392-396, fig. 67, A-E).

Measurements of these eels were made to the nearest 0.1 mm and were as follows: – standard length: snout tip to extremity of upper hypural; head: snout tip to posterior (or upper) extremity of branchial aperture; snout: snout tip to anterior margin of conjunctival membrane; interorbital: least fleshy space between dorsal margin of eyes; eye: horizontal diameter of conjunctival membrane; upper jaw: snout tip to posterior extremity of exposed surface of maxilla; postorbital: posterior margin of eye to anterior extremity of pectoral base; branchial aperture: distance between most anterior

and posterior extremities; posterior branchial interspace: transverse distance between posterior extremities; pectoral: length from middle of base to tip of fin when held against the body; snout-vent: snout tip to anterior edge of anus; preanal: snout tip to origin of anal; predorsal: snout tip to origin of dorsal; depth just before eye: depth at anterior margin of eye with mouth closed; depth at vent: depth of body without median fins. Pectoral rays were counted on the right side by removing the skin from the base of the fin and counting the rays under a low-power microscope; median fin-rays were counted in a similar manner by shining a lowintensity light through the fin; caudal fin-rays were counted by removing the skin from the right side of the caudal fin; the number of vertebrae were estimated by counting the number of lateral line pores and where these became indefinite or were lacking posteriorly an incision was made through the skin on the right side and the remaining segments counted. Teeth patterns were taken as camera lucida drawings of impressions made in a sheet of plasticine inserted into the mouth and the upper and lower jaws gently pressed together.

I have had invaluable help from a number of sources in the preparation of this paper. I wish to express my thanks to the Galathea Committee for permission to study the material; the late Dr. ANTON BRUUN at whose suggestion this study was undertaken and whose constant interest and criticism cannot go unmentioned; Professor CARL HUBBS of Scripps Institution of Oceanography for bringing a synaphobranch specimen to my attention and to Dr. R. H. ROSENBLATT for measurements and a radiograph of this specimen; Dr J. A. F. GARRICK of the U.S. National Museum for measurements and a radiograph of the type specimen of Histiobranchus infernalis; finally, Professor L. R. RICHARDson of the Department of Zoology for his advice and encouragement during the course of this study.

SYSTEMATIC ACCOUNT

Notes on the Genera of Synaphobranchidae

The Synaphobranchidae includes exclusively deepwater eels widely distributed in both the Atlantic and the Indo-Pacific Oceans. BRUUN (1937) and NORMAN and TREWAVAS (1939) have contributed greatly to our knowledge of the systematics and biology of the eels of this family. Two genera are at present recognised (CASTLE 1961, p. 19). These are Synaphobranchus Johnson, 1862, which has ventral, horizontal, almost confluent branchial apertures and Diastobranchus Barnard, 1923, having ventrolateral, oblique, widely separated branchial apertures. Synaphobranchus currently includes two subgenera: Synaphobranchus with a short abdomen and dorsal fin originating near the level of the vent and Histiobranchus Gill, 1883, which has a long abdomen and an anterior origin to the dorsal, over the pectoral region. Histiobranchus originally held generic rank when it was first established for Histiobranchus infernalis by GILL (1883, p. 255), but has been considered a subgenus by REGAN (1913, p. 235) and by NORMAN and TREWAVAS (1939, p. 354).

I have briefly discussed elsewhere (1961, p. 19) the relationship of Ilyophis Gilbert, 1892 to the Synaphobranchidae, noting its close similarity to the latter but still retaining the family Ilyophidae. Synaphobranchus (with its two subgenera, Synaphobranchus and Histiobranchus) and Diastobranchus were recognised as members of the Synaphobranchidae. In this earlier account of mine I had based my views on an examination of the following material: - two small examples of Ilvophis (?) brunneus Gilbert from off South Africa; numerous specimens of Diastobranchus capensis Barnard from New Zealand and two from South Africa; four specimens of Synaphobranchus affinis Günther from New Zealand and a number of specimens of S. brevidorsalis Günther and S. oregoni Castle from the Gulf of Mexico; a radiograph of the type specimen of Ilvophis brunneus. The Galathea collection has provided the following further material: - an adult of Ilyophis brunneus; four specimens of "Histiobranchus" bathybius (Günther); a single specimen of a new species of "Histiobranchus"; one specimen each of Synaphobranchus kaupi Johnson and S. brevidorsalis. In addition the present author has been able to examine radiographs of the type specimen of "Histiobranchus" infernalis and of another large histiobranch from the eastern Pacific. Examination of this material shows that "Histio-

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branchus" and *Ilyophis* should be regarded as genera of the Synaphobranchidae.

GILBERT (1892, p. 351) described the Ilyophidae in these terms: "Apodal fishes, with a conical and slender snout, moderately strong jaws, with sharp teeth in bands; teeth in a band upon the vomer. Gape lateral. Gill openings separate, horizontal, inferior. Branchiostegals long, curved, as in Simenchelyidae. Lips obsolete. Tongue obsolescent. Scales present, minute. General aspect similar to that of Synaphobranchidae". Later authors have followed GILBERT. However, there has not always been confidence in this action. LEA (1913, p. 15) examined a young specimen of Ilvophis brunneus and found that it was strikingly similar to the young of Histiobranchus infernalis in the number of vertebrae, pectoral and caudal fin-rays, shape of hypural and the presence of lateral processes on the bases of the caudal fin-rays. LEA found it difficult indeed to separate the young of these two genera. Confusion has also arisen as to the correct placing of Diastobranchus capensis, an established member of the Synaphobranchidae, as at least one author (SMITH 1949, p. 386) places it in the Ilyophidae as a second species of Ilyophis. GILL (1890, p. 162) initially confused the issue when he noted that the branchiostegal rays of the Synaphobranchidae were abbreviated and did not curve around the posterior margin of the opercular bones. This is an error which I have already pointed out (1961, pp. 19-20). In fact, the branchiostegals of all synaphobranchs are quite similar to those of Ilyophis brunneus in being elongate and curving around the opercular series. Gilbert states of *Ilyophis* "vent remote from head"; but the preanal length is actually the same as is found in Synaphobranchus, being about one-third of the body length, while that of Histiobranchus is nearly half the body length. The apparent greater length of the abdomen in *Ilyophis* is due mainly to the minute size of the pectoral. The scales of Ilyophis are minute but otherwise as found in Diastobranchus, "Histiobranchus" and some species of Synaphobranchus. The nature and distribution of the teeth are essentially the same as in recognised Synaphobranchidae, that is, acute, slightly recurved, uniserial to cardiform on the jaws, forming an oval patch on the premaxillary-ethmoid and an elongate patch on the vomer. In the nature of the branchial apertures, Ilyophis is intermediate between Synaphobranchus and Diastobranchus in having the apertures almost

horizontal, separate, but placed well below the level of the pectoral fin.

The remaining character which has been used to distinguish Ilyophis from the Synaphobranchidae is the vertical and not oblique hyomandibula. In the Synaphobranchidae the mouth is long, extending variously behind the eye (half to twice the diameter of the eye) in Diastobranchus, Synaphobranchus and Histiobranchus. Ilyophis has a shorter mouth than any of these, extending to a little less than half the diameter of the eye behind the posterior margin of the eye and associated with this is a nearly vertical hyomandibula, closely similar to the condition in Diastobranchus. There seems accordingly little reason in separating Ilyophis on this character alone as there are greater differences between the other recognised genera of Synaphobranchidae than there is between the member with the shortest gape, Diastobranchus, and Ilyophis. In view of the essential similarity in all other features Ilvophis is here regarded as a member of the Synaphobranchidae.

Eels of this family possess reduced, usually elongate scales which are similar to those of the Anguillidae. Only one other family of eels, the Simenchelyidae, possess scales; but there are few similarities in morphology which would otherwise suggest that the Simenchelyidae is a close relative of the Synaphobranchidae. The monotypic genus, Simenchelys Gill, has a small mouth with a hyomandibula directed obliquely forwards, and as TREWAVAS (1932, p. 656) has shown, frontals separated by a suture and a well-developed, laminar, palatopterygoid, features which have been confirmed by the present author. These characters are shown among the eels by only one other family, the Anguillidae, while the Synaphobranchidae includes eels with a long mouth, a vertical or backwardly-oblique hyomandibula, ankylosed frontals and a palatopterygoid which is reduced to a cartilaginous strip or absent entirely.

The additional material provided to the present author by the *Galathea* Expedition calls for the reinstatement of *Histiobranchus* as a full genus. Adult histiobranch eels are clearly set off from members of the genus *Synaphobranchus* and *Diastobranchus* in the following manner. (1) They have a very long abdomen, about equal to 35 % of the total length, so that the vent lies only slightly in advance of the midpoint of the body; the various species of *Synaphobranchus* have a short abdomen, about 16.5 % of the total length, so that the vent lies at the

end of the anterior third of the body. Diastobranchus has an even shorter abdomen, only about 12 % of the total, with the vent placed at the end of the anterior quarter of the body. (2) The branchial apertures of Histiobranchus are slightly divergent, well separated posteriorly by a distance equal to three-quarters of the horizontal diameter of the eye and almost confluent anteriorly; those of Synaphobranchus are essentially parallel and insignificantly separated; Diastobranchus has completely separated divergent, branchial apertures which are ventrolateral. (3) While the origin of the dorsal fin is somewhat variable in Histiobranchus, the dorsal always lies over the pectoral region but is seldom in advance of the level of the vent in Synaphobranchus. When taken together with the considerable difference in the lengths of the abdomen in these two genera, the difference in the dorsal origin is thus well marked. Diastobranchus always has the dorsal origin well behind the level of the vent. (4) In Histiobranchus the mouth is long, reaching more than twice the diameter of the eye behind the eye; in Synaphobranchus the mouth seldom reaches more than the diameter of the eye behind the eye. Diastobranchus has an even shorter mouth.

There are a number of other characters which distinguish members of the genus Histiobranchus from other synaphobranchs, e.g. teeth, scales, size of pectoral, but these are not considered to be reliable generic features. The two characters already discussed, the length of abdomen and length of mouth, indicate rather gross anatomical differences (the length of the body cavity and the angle of the hyomandibula respectively) which can be of generic diagnostic value. The remaining two, the dorsal origin and the disposition of the branchial apertures, are supporting characters. With regard to the former an objection may be raised that, as in Anguilla, the position of the dorsal origin is only a specific character. However, it should be noted that the dorsal origin is relatively constant about the level of the pectoral in all genera of Congridae and in this case may be regarded as a familial character while in the Muraenidae the origin of the dorsal is used as a generic character. The value of this feature must therefore be determined for each group of eels on its own merit. With regard to the disposition of the branchial apertures it is unwise to use this at more than generic level. A number of similar genera of ophichthids, e.g. Hemerorhinus, Callechelys, and Sphagebranchus are distinguished from one another, among other things, in having the same differences

in disposition of the branchial aperatures as described here in the Synaphobranchidae.

The characters discussed above which are so well marked in the adult show that there is every justification to support GILL's view that Histiobranchus is indeed worthy of generic status. However, it has been suggested to me that there is such close similarity between the larvae of Diastobranchus (L. Synaphobranchus danae) and Synaphobranchus that this is an argument against splitting up the genus Synaphobranchus into several genera. The larvae of Synaphobranchus and Histiobranchus are, as BRUUN (1937, pp. 10-11) has shown, closely similar; but this only reflects the closer similarity of adults of these two genera than say, of Diastobranchus and Ilyophis. BRUUN's larva, L. Synaphobranchus danae, has 172 myomeres and this has suggested to a number of writers, including the present author, that the adult could be Diastobranchus capensis which has 164-174 myomeres (CASTLE 1961, p. 27). The Galathea specimen from New Zealand has 162 vertebrae, well outside the number found in any other species of Histiobranchus, and therefore could also be the possible adult species of BRUUN's larva. BRUUN (1937, p. 13) has pointed out that this larva has the dorsal origin more in advance of the level of the vent in terms of myotomes than in any other synaphobranch larvae. This would appear to be resultant upon a greater frequency of myotomes in this larva than in others and need not necessarily indicate that the larva belongs to a different genus. However, at the present state of our knowledge of synaphobranch larvae, there is insufficient material to determine conclusively the true adult of L. Synaphobranchus danae. The single histiobranch collected from southwest of New Zealand is therefore named as a new species.

Histiobranchus Gill, 1883

Histiobranchus Gill, 1883, p. 255.

At present, three species of *Histiobranchus* are recognised (GREY 1956, pp. 143-145): *H. bathybius* (Günther, 1877) from Japan, the Bering Sea, Central North Pacific and off Zanzibar, *H. infernalis* Gill, 1883 from the North Atlantic as far as Davis Strait and *H. australis* (Regan, 1913) from the South Atlantic and the South Indian ocean. The descriptions of these three species are based on a limited range of material and the distinctions are uncertain. *H. bathybius* is recorded to have more

numerous vertebrae (131-140) than the Atlantic form, *H. infernalis* (126-134). *H. australis* (130) has been distinguished from these two in having the origin of the dorsal fin a short distance behind the level of the tip of the pectoral fin. The histiobranch eels collected at *Galathea* St. 190 and St. 668 are in morphological characters intermediate between *H. infernalis* and *H. australis* and therefore throw immediate doubt upon the recognised separation of these two species. Furthermore, examinations of the type specimen of *H. infernalis* and a histiobranch collected off the west coast of Mexico indicate that *H. infernalis* – *H. australis* is probably identical with *H. bathybius* from the North Pacific. The reasons for this are discussed below.

The type specimen of *H. infernalis* (USNM No. 3279: 467.0 mm total length; *Albatross* St. 2037, $38^{\circ}30.5'$ N, $69^{\circ}08'25''$ W; 1731 fathoms; 18/7/1883) has been examined by Dr. J. A. F. GARRICK, U.S. National Museum, and a radiograph prepared. The specimen is in a very poor condition being soft and tending to fragment with the vertebral column broken a short distance behind the head. Nevertheless, Dr. GARRICK has been able to make a number of measurements and these were supplemented by counts of vertebrae, fin-rays, etc. from the radiograph by the present author.

A large histiobranch eel (SIO 59-269-26A; 681 mm total length; collected between 22°11.2'N, 107°46.1'W and 22°25.5'N, 107°49.5'W off the west coast of Mexico by the Scripps Institution of Oceanography; 1638-1640 fathoms; 15/5/59), provisionally identified as *Histiobranchus infernalis*, has also been measured by Dr. R. H. ROSENBLATT of this institution and a radiograph prepared. Additional measurements and counts were made by the author from this radiograph.

Some data from these two specimens, the *Gala*thea specimens and a number of other histiobranchs collected from several localities ranging from the North Atlantic to the North Pacific, are presented in Table 1. These latter data have been extracted from BRUUN (1937) and NORMAN and TREWAVAS (1939). Table 1 shows the essential identity of the three species, *H. bathybius*, *H. infernalis* and *H. australis*.

Further measurements of the type of H. infernalis, the Scripps specimen and the *Galathea* material are presented in Table 2 so that detailed comparisons may be made.

Table 1 shows that in number of vertebrae, the type of H. *infernalis* falls into the middle of the

Locality	Hand	Mauth	Destand	n Prodovol Procest Vesterer		
Locality	Head	Mouth	Pectoral	Predorsal	Preanal	Vertebrae
North Pacific "H. bathybius" 368-618 mm						
(5 specimens)	11.8-13.7	7.8-8.8	3.3-3.8	13.9–16.3	44.9–47.6	131-140
East Pacific SI059-269-26A 681 mm	13.5	8.5	3.4	15.8	46.1	129
Southwest Pacific Galathea 527 mm	13.2	8.6	3.6	15.6	49.0	126
South Indian Ocean <i>Galathea</i> 569–663 mm	131 136	80.01	27 1 1	145 10 0	18 0 10 5	107 121
(5 specificity)	15.1-15.0	0.9-9.4	5.7-4.4	14.5-10.0	40.0-49.5	127-131
South Indian Ocean Type of H. australis						
357 mm	14.3	8.2	3.6	20.4	47.6	130
Atlantic "H. infernalis" 126-900 mm (9						
specimens)	9.4-13.3	9.1-9.2	3.1-3.9	13.5-15.4	40.5-47.8	126-134
		(2)				(131–140
						in larvae)
West Atlantic USNM No. 33279 Type of			damaged on			
H. infernalis 467 mm	12.9	9.8	both sides	14.8	46.0	137

Table 1. Histiobranchus bathybius (Günther, 1877). Proportions (in per cent total length) and counts in specimens from various localities.

range recorded for H. bathybius; on the other hand, the Scripps specimen, which could be expected to be referable to H. bathybius on geographical grounds, falls readily within the range recorded for H. infernalis. The four Galathea specimens from the southern hemisphere include the type of H. australis in their range of vertebrae but are themselves included in the range recorded for H. infernalis. There are therefore no clear distinctions between histiobranchs from these areas on vertebral counts. This view is supported by BRUUN's record of the range of myomeres in Atlantic larval specimens (131-140).

With regard to the predorsal length as a distinguishing character for H. *australis*, the three *Galathea* specimens from the type locality show a very

 Table 2. Proportional measurements (in per cent total length) and counts from various specimens of *H. bathybius*.

	West Atlantic, Type of <i>H. infernalis</i>	East Pacific SIO	South Indian (3)	S. Pacific
Total length (mm):	467	681	569–663	527
Standard:	98.5	97.4	97.0–97.5	97.5
Head:	12.9	13.5	13.1-13.6	13.2
Snout:	3.2	3.6	3.24.2	3.8
Eye:	1.5	1.6	1.5-1.8	1.8
Interorbital:	ca. 2.1	3.1	2.9-3.2	2.5
Upper jaw:	9.8	8.5	8.9-9.4	8.6
Branchial aperture:	2.0	2.3	1.9-2.4	1.9
Posterior br. intersp	1.2	1.2	1.3-1.7	1.1
Pectoral:	damaged	3.4	3.7-4.4	3.6
Snout-vent:	ca. 45.0	46.0	46.8-48.1	47.º
Preanal:	46.0	46.1	48.0-49.5	49.0
Predorsal:	14.8	15.8	14.5-18.8	15.6
Depth at vent:	5.8	8.4	6.2-8.3	9.1
Pectoral rays:	<u> </u>	16	15-16	17
Anal rays:	206	192	188-203	200
Dorsal rays before vent:	114	118	8798	123
Dorsal rays:	331	317	265-288	302
Caudal rays:	7+7	8+8	6-8+7-9	6+7
Lateral line pores (or vertebrae) before vent:	52	51	47-50	49
Lateral line pores (or vertebrae):	137	129	127-131	126

wide range, as indicated in Table 1. In comparative terms, while one of these specimens has the dorsal origin immediately behind the level of the pectoral base and another has the origin a short way along the pectoral (both conditions as found in H. bathybius and H. infernalis) the third has the dorsal origin a short distance behind the level of the pectoral fin tip, close to the condition in H. australis. It is therefore unwise to use the dorsal origin as a distinguishing character for H. australis, and, lacking any other known differences, H. australis is regarded as identical with H. infernalis if not with H. bathybius. NORMAN (1939, p. 45) records a specimen of H. bathybius from off Zanzibar which may on geographical grounds be conveniently grouped with these specimens. It may be noted here that the predorsal length in the type specimen of H. australis is exaggerated by the slightly longer head than normal.

There are no significant differences in the relative lengths of the pectoral fin in specimens from the various areas; any small differences that appear are probably due to difficulties in measuring the length of the fin with its delicate fin-rays. The pectorals are easily damaged, as is the case in the type of H. *infernalis*.

Table 1 also shows that the preanal length varies considerably in H. bathybius and H. infernalis. NORMAN and TREWAVAS (1939, p. 358) record the range for the latter (from BRUUN, 1937, p. 6) as 40.5-45.9 % but this is obviously an error; BRUUN's figures are 40.5-47.8 %. There is no essential difference between these two species in this character but specimens from the Southern Hemisphere appear to have a greater preanal length. However, in view of the variability of this proportion it is considered to be of little use as a distinguishing character. The preanal length probably becomes relatively less on growth, while the head shows a tendency to lengthen at a greater rate than other proportions of the body. These changes are not unusual in eels. With regard to this matter examination of Table 1 shows that there is a conspicuously large range of variation in the length of the head of "H. infernalis" from the Atlantic, 9.4-13.3 per cent of total length. It has been suggested to me that this may possibly indicate that these measurements have been made from a mixture of two species. However, closer examination of BRUUN's figures (1937, p. 6) shows that the lowest figure (9.4) occurs in the largest eel (900 mm) and there is a noticeable tendency for progressively smaller eels to have

relatively larger heads. There is therefore little conclusive evidence that BRUUN was dealing with more than a single species from the Atlantic.

The above discussion shows that there are no morphological reasons for considering that H. bathybius, H. infernalis and H. australis are more than a single species as suggested by GREY (1956, p. 143) and they must therefore be recognised under the name H. bathybius Günther, 1877. Objections may be raised that because histiobranchs breed in more than one area (BRUUN, 1937) a corresponding number of species must be recognised as in the Atlantic species of Anguilla. This is not supported by adult morphology and it is the opinion of the present author that the breeding pattern of the Synaphobranchidae is only superficially similar to that of Anguilla. The Atlantic and Pacific histiobranchs may not even be as distinct geographically as it now appears. If the major barrier to dispersal of adult Synaphobranchidae is indeed temperature, as BRUUN suggests (1937, p. 8), the tolerable range being 1.4°-11.5° C., then there seems to be no reason why histiobranchs should not be found between the Bering Sea and Davis Strait. Waters of 1.5°-ca. 4° C. are present in depths of about 500 m and less around this coast. The shallow water would not seem to be a barrier as GREY (1956, pp. 144-147) records H. infernalis in 644 m and S. kaupi in 236 m in the northwest Atlantic.

Histiobranchus bruuni n.sp. (Fig. 1 A-C and F)

Material:

Galathea Station 601, Tasman Sea $(45^{\circ}51'S, 164^{\circ}32'E)$ 4400 m, 14/1/51. – Type specimen, 300 mm total length. Deposited in the collection of the University Zoological Museum, Copenhagen as No. P 32444.

Description:

Proportional measurements in per cent of total length: standard 97.5; head 11.8; snout 3.3; eye 1.5; least fleshy interorbital 2.3; upper jaw 9.0; postorbital 8.3; branchial aperture 2.3; posterior branchial interspace 1.3; pectoral 3.7; snout-vent 47.3; preanal 48.7; predorsal 13.3; depth just before eye 2.3; depth at vent 4.3. Pectoral rays 17; anal rays 200; dorsal rays before level of vent 125; dorsal rays 346; caudal rays 7+8; lateral line pores before level of vent 65; vertebrae 162. Female with minute eggs.

Body moderately elongate, slender, compressed,



Fig. 1 A-C, F: *Histiobranchus bruuni* n. sp., 300 mm total length, *Galathea* St. 601, Tasman Sea. Fig. A, lateral view, median fins expanded. Fig. B, lateral view of head. Fig. C, ventral view of head. Fig. F, pattern of upper teeth. Fig. 1 D, E, G: – *Histiobranchus bathybius*, 656 mm total length, *Galathea* St. 190, off Durban. Fig. D, lateral view, median

fins expanded. Fig. E, lateral view of head. Fig. G, pattern of upper teeth.

Fig. 1 H: - Ventral view of throat of Synaphobranchus kaupi, 266 mm total length, Galathea St. 241, off Kenya, to show branchial apertures.

Fig. 1 I: - Ventral view of throat of *Diastobranchus capensis*, 1130 mm total length, Cook Strait, New Zealand, to show branchial apertures.

especially so along caudal region; depth of body a little greater at middle of trunk than at vent and here contained about seventeen times in length; trunk long. Head short but gape very long; median fins inconspicuous in preserved specimens; pectoral short.

Scales present over whole of area above lateral line from level of anterior extremity of branchial aperture to tip of caudal region; scaled area below lateral line commencing at about level of pectoral with a shallow line of scales immediately below the lateral line; this becomes progressively deeper to about level of vent where the whole of lateral surface is covered; no scales on head or fins. Each scale is elongate-oval in shape and embedded in a shallow depression covered by a thin epidermis; scales are placed at an angle to lateral line and at near right angles to one another.

Head not clearly set off from trunk, about 8.5 in total length, conical, angle of jaw conspicuous;

snout moderately short, 3.5 in head, not projecting in advance of lower jaw; jaws slender, the lower curving upwards at its tip; gape slightly oblique, long, contained 1.3 times in head and extending behind eye for a distance equal to 2.5 times horizontal diameter of eye; lips absent; tongue scarcely developed.

Tooth-bearing bones the maxillae, premaxillaryethmoid, vomer and dentaries. Teeth in general sharply conical and recurved but larger on premaxillary-ethmoid than on other bones. Maxillary teeth triserial on anterior half of bone and noticeably larger than the cardiform posterior teeth; premaxillary-ethmoid teeth about 25 in number and in an elongate-oval patch which stands out for almost two-thirds of its length in advance of tips of maxillae; a toothless area equal to one-quarter the length of this patch separates it from vomerine patch; the latter is about 1.5 times the length of premaxillary patch and bears about 25 teeth in two

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to three longitudinal rows; teeth on dentary similar in form and distribution to those on maxilla.

Anterior nostril subterminal, placed at level of midpoint of premaxillary-ethmoid patch of teeth, subtubular with tube directed anteriorly; posterior nostril separated from anterior nostril by a distance equal to diameter of eye and placed just in advance of eye, with no external tube. Eye oval, large, about 4.5 in postorbital; least fleshy interorbital about equal to branchial aperture. Branchial apertures ventral, horizontal, almost confluent anteriorly but separated by a distance equal to half their length posteriorly. Vent only slightly protruding into lateral profile, placed almost at midpoint of length.

Median fins fleshy, their posterior tips confluent with caudal and rays distinct. Dorsal moderate, its height in life difficult to estimate but on gentle extension at level of vent contained 3.5 times in body at that point; originating at a level one-third of pectoral length behind pectoral base; 125 rays lie before level of vent with a total of 346. Anal a little more strongly developed than dorsal; its depth at its midpoint contained twice in body depth at that point; with 200 rays. Caudal with 15 rays distributed as 7+8. Pectoral elongate-oval in shape, slender, originating a little below midlateral level, its length only a little greater than that of snout; rays 17.

Lateral line conspicuous, arising very high on head and reaching midlateral level just posterior to level of vent. Pores distinct except along posterior part of caudal region and numbering 66 before level of vent of which nine lie in advance of pectoral base. Cephalic sensory pores also conspicuous as is characteristic of small specimens of members of the family Synaphobranchidae; a series of three lie in advance of origin of lateral line, eight are distributed around eye, a line of four above nostrils and two below; ten pores lie along dentary, the most posterior pore about halfway between level of eye and angle of mouth. Two rows of minute mucous pores lie in advance of anterior nostril with another line along postero-ventral corner of eye and small groups of pores are scattered over dorsal surface of head.

Vertebrae 162. Colour in preservative: brown on head, pinkish on remainder of body, fins a little lighter.

Named for the late Dr. ANTON F. BRUUN whose earlier work (1937) forms an invaluable basis of our knowledge of the family Synaphobranchidae and whose interest in this study was interrupted by his untimely death in late 1961.

Histiobranchus bathybius (Günther, 1877) (Fig. 1 D, E, G)

For synonymy and literature see GREY 1956, p. 144.

Material:

Galathea Station 190, off Durban ($29^{\circ}42'$ S, $33^{\circ}19'$ E), 2720 m, 3/2/51. – Three females, 569-663 mm total lengths, eggs from 0.2 mm-1.5 mm. Galathea Station 668, Kermadec Trench ($36^{\circ}23'$ S, $177^{\circ}41'$ E), 2640 m, 29/2/52. Bottom temp.: 2.0° C. – One male, 527 mm total length.

Description:

Proportional measurements of specimen of 656 mm total length recorded first (remainder in parentheses), in per cent of total length: standard length 97.5 (97.0-97.5); head 13.6 (13.1-13.6); snout 3.7 (3.2-4.2); eye 1.5 (1.7-1.8); least fleshy interorbital 2.9 (2.5-3.2); upper jaw 8.7 (8.2-9.4); postorbital 9.1 (8.5-8.9); branchial aperture 2.4 (1.9-2.1); posterior branchial interspace 1.3 (1.1-1.7); pectoral 3.7 (3.6-4.4); snout-vent 48.1 (46.8-47.9); preanal 49.5 (48.0-49.0); predorsal 14.5 (15.6-18.8); depth just before eye 3.5 (3.2-4.0); depth at vent 7.2 (6.2-9.1). Pectoral rays 15 (16-17); anal rays 200 (188-203); dorsal rays before level of vent 98 (87-123); total dorsal rays 285 (265-302); caudal rays 6+7 (6-8+7-9); lateral line pores before level of vent 47 (49-50); vertebrae 127 (126-131).

Body moderately elongate, massive, compressed, especially so along caudal region; depth of body much greater along trunk than at head or along caudal, at the belly contained 11.0 times in total length; trunk long. Head conspicuous, gape long; median fins high, especially along caudal region; pectoral short.

Scales present over whole of body surface except a large area of head and fins. Scaled area extending onto top of head in advance of origin of lateral line. Individual scales as in *H. bruuni*.

Head more distinct from trunk than in the species already described, sharply conical, depressed as a consequence of the great depth of trunk, contained a little more than seven times in total length; snout moderate, about 3.5 in head, pointed, not projecting appreciably in advance of lower jaw; jaws less slender than in *H. bruuni*, the lower curving upwards terminally; lips absent; mouth terminal with the gape slightly oblique and long, contained about 1.6 times in head, extending behind eye for a distance equal to twice diameter of eye; tongue scarcely developed. Teeth much as in the previous species but more numerous on the palate and posteriorly on the jaws. Premaxillary-ethmoid patch slightly broader and vomerine patch a little longer than in *H. bruuni*.

Nostrils as in *H. bruuni*. Eye not large, oval, contained 6.5 times in postorbital; least fleshy interorbital much greater than length of branchial aperture. Branchial apertures ventral, horizontal, relatively shorter than in *H. bruuni* but, nevertheless still separated posteriorly by a distance equal to half their length. Vent protruding into lateral profile, placed at almost the exact midpoint of total length.

Median fins as in *H. bruuni* but much more strongly developed. Maximum height of dorsal at a point halfway along caudal region and here nearly onethird of depth of body; originating just posterior to level of pectoral base, with 98 rays before level of vent and a total of 285. Anal a little lower than dorsal, with 200 rays. Caudal with 13 rays distributed as 6+7. Pectoral elongate-oval, short, its length barely equal to snout; 15 rays.

Lateral line much as in *H. bruuni* but placed relatively higher on body; with 47 pores before level of vent of which seven lie in advance of pectoral. Cephalic sensory pores much less conspicuous than in *H. bruuni;* none can be observed along lower jaw or on dorsal aspect of snout but otherwise distributed as in this species.

Vertebrae 127. Residual coloration over most of body, brown.

Synaphobranchus Johnson, 1862

Synaphobranchus Johnson, 1862, p. 169.

Four species are currently recognised (CASTLE 1961, p. 20): S. kaupi Johnson, 1862, S. affinis Günther, 1877, S. brevidorsalis Günther, 1887 and S. oregoni Castle, 1960. Briefly S. kaupi and S. affinis have scales rather similar to those of Histiobranchus and are clearly distinct from S. brevidorsalis and S. oregoni which have rounded to irregular scales. The four species are further separable on vertebral counts: S. kaupi has 142-151, S. affinis 131-138, S. brevidorsalis 133-134 and S. oregoni 143-145. Reference may be made to my earlier account for other characters which also serve to distinguish the species.

The two specimens of *Synaphobranchus* from the *Galathea* material are easily identifiable with *S. kaupi* (St. 241) and *S. brevidorsalis* (St. 324) the former having elongate-oval scales and 144 vertebrae, the latter with rounded to irregular scales and 131 vertebrae.

Synaphobranchus kaupi Johnson, 1862 (Fig. 1 H, Fig. 2 A-E)

Synaphobranchus kaupi Johnson, 1862, p. 169.

For synonymy and literature see GREY 1956, pp. 145-147.

Material:

Galathea Station 241, off Kenya ($4^{\circ}00'S$, $41^{\circ}27'E$), 1510 m, 15/3/51. Bottom temp.: about 3.2° C. – One specimen, 266 mm total length.

Description:

Proportional measurements in per cent of total length: standard length 97.7; head 12.9; snout 4.1; eye 1.7; least fleshy interorbital 2.0; upper jaw 7.9; postorbital 7.8; branchial aperture 1.3; pectoral 4.6; snout-vent 28.4; preanal 29.4; predorsal 39.7; depth just before eye 3.0; depth at vent 5.6. Pectoral rays 15; anal rays 257; anal rays before level of dorsal 30; dorsal rays 273; caudal rays 8+5; lateral line pores before level of vent 30; vertebrae 144.

Body elongate, slender, compressed especially along caudal region, its greatest depth at the belly where it is contained 16.5 times in total length but otherwise only gradually tapering to tip of caudal region; trunk short. Head and gape relatively short; median fins, especially dorsal, inconspicuous; pectoral long.

Scales present over whole of body except head and fins, with scaled area beginning above origin of lateral line. Scales much as in *Histiobranchus* but a little less elongate.

Head poorly differentiated from trunk, conical, contained a little more than seven times in total length; snout pointed with its anterior extremity turned downwards and not extending in advance of lower jaw, about 3.0 in head; jaws slender, the lower turned upwards at its tip; lips absent; gape slightly oblique, relatively short, contained about 1.6 times in head so that its posterior extremity falls behind posterior margin of eye at a distance equal to eye diameter; tongue absent.

Teeth carried on maxillae, premaxillary-ethmoid, vomer and dentaries; conical, recurved, the largest on premaxillary-ethmoid, smallest on posterior extremities of mandibles. Maxillary teeth much as in *Histiobranchus* but relatively less numerous; premaxillary-ethmoid teeth in an oval patch, numbering about a dozen in this small specimen of *S*. *kaupi*; this patch stands out almost completely in advance of tips of maxillary patches and is sepa-



Fig. 2 A-E: – Synaphobranchus kaupi, 266 mm total length, Galathea St. 241, off Kenya. Fig. A, lateral view, median fins expanded. Fig B, lateral view of head. Fig. C, pattern of upper teeth. Fig. D, left upper pharyngeal. Fig. E, scale pattern at level of vent.

Fig. 2 F-I: - Ilyophis brunneus, 463 mm total length, Galathea St. 324, Strait of Malacca. Fig. F, lateral view, median fins expanded. Fig. G, lateral view of head. Fig. H, pattern of upper teeth. Fig. I, ventral view of head.

rated from vomerine patch by a distance equal to one and a half times length of premaxillary-ethmoid patch; vomerine teeth uniserial, the dentigerous area equal in length to two and a half times length of anterior patch; teeth on dentary much as on maxilla.

Nostrils as in *Histiobranchus*, the posterior naris placed a little more in advance of eye. Eye moderate, oval, about 4.0 in postorbital; least fleshy interorbital about 1.5 times length of branchial aperture. Branchial apertures ventral, horizontal, almost confluent at surface of throat posteriorly, barely separated anteriorly. Vent protruding a little into lateral profile and placed in advance of end of anterior third of body.

Median fins rather less developed than in *Histio-branchus* but otherwise similar. Dorsal low, its greatest depth at a point halfway along its length and contained rather more than four times in body depth at that point; originating a little less than length of head behind level of vent; with 273 rays. Anal more strongly developed than dorsal, its maximum height halfway along its length and con-

tained about three times in depth of body at that point, with 273 rays of which 30 lie before level of dorsal. Caudal with 13 rays distributed as 8+5. Pectoral moderately attenuated, originating a little below midlateral level, its length slightly more than snout; rays 15 (right side).

Lateral line as in *Histiobranchus* with 30 pores in advance of vent, of which eight lie before pectoral base. Cephalic sensory pores conspicuous, much as in *H. bruuni* but in addition with four behind angle of mouth. A number of groups of minute papillae are also present over surface of head.

Vertebrae 144. Colour in preservative, brownishpink on snout, cheeks and above a line drawn from occiput to one-third of way along anal fin; below this line dark blue-grey.

Synaphobranchus brevidorsalis Günther, 1887

Synaphobranchus brevidorsalis Günther, 1887, p. 255, pl. 63, fig. c.

For synonymy, description, figures and literature see CASTLE 1960, pp. 392-396, fig. 67, A-E.

Material:

Galathea Station 324: Strait of Malacca ($6^{\circ}38'N$, $96^{\circ}00'E$), 1140 m; 9/5/51. – One specimen, 472.5 mm total length.

Description:

Proportional measurements in per cent of total length: standard 97.3; head 12.1; snout 3.8; eye 2.2; interorbital 1.9; upper jaw 7.0; postorbital 8.7; branchial aperture 2.4; posterior branchial interspace negligible; pectoral 5.7; snout-vent 27.3; preanal 28.2; predorsal 42.3; depth just before eye 3.3; depth at vent 5.8. Pectoral rays 15; anal rays 233; dorsal rays 171; caudal rays 8+8; lateral line pores before level of vent 28; vertebrae 131. Colour dark brownish, especially along ventral aspect of abdomen; tinged violet on snout; pinkish-grey along body where scales have been lost. Male, almost mature, stomach empty.

Remarks:

This specimen is strikingly similar to examples of this species described from the Gulf of Mexico in my previous account (1960, pp. 392-396, fig. 67, A-E). There are slight differences in a number of the proportions, notably the length of the gape, interorbital and preanal length. With regard to the first of these, I have previously measured the length of gape to the angle of mouth when open but have since recognised that size of the mouth in synaphobranchs is more conveniently measured to the end of the exposed surface of the maxilla; this would account for the slightly longer gape in the Galathea specimen. The skin over the top of the head in this specimen is much contracted so that the actual interorbital distance is probably a little less than in life. The preanal length is shorter than in the Gulf of Mexico specimens but the difference is not enough to be considered specific especially as this is a character which seems to vary slightly with locality.

Ilyophis Gilbert, 1892

Ilyophis Gilbert, 1892, p. 351.

Ilyophis is represented by the single species, *I. brunneus* Gilbert, 1892, described from one specimen from the East Pacific (Galapagos). A few specimens have been recorded from other areas, namely Central, East and West Atlantic and off South Africa, making a total of five specimens, so that the species is not at all well known. PARR (1932, pp. 35-37) examined a radiograph of the type of Ilyophis

brunneus and determined the number of vertebrae to be 150-151 while his West Atlantic specimen had 147. He noted that the records of vertebral counts of Atlantic ilyophids suggested that a second species, which PARR refrained from naming, was also present in the Atlantic. However, PARR based his assumption on the record of FISH (1927, p. 303) whose information was taken directly from LEA (1913, p. 15). The latter author examined only a single, small East Atlantic specimen of *Ilyophis* and found the vertebral count to be 132, referring a number of leptocephali to this species to give a final vertebral count of 127-132.

The present author has examined a radiograph of the type of I. brunneus sent from the U.S. National Museum some years ago while the author was engaged in preliminary work on the Synaphobranchidae. This radiograph is apparently much clearer than PARR's since an accurate vertebral count of 146 can easily be made. This is almost identical with the count of 147 made from the West Atlantic specimen. The Galathea specimen described below has 141 vertebrae and almost identical dorsal and anal fin-ray counts to those determined from the radiograph of the type specimen i.e. type: anal rays 295, dorsal rays before vent 86, dorsal rays 398; Galathea specimen: anal 293, dorsal rays before vent 79, dorsal rays 378. There is therefore no hesitation in identifying the Galathea specimen from the Strait of Malacca with Ilyophis brunneus, there being no other significant morphological differences between the two specimens.

With regard to the possibility of the presence of another species of *Ilyophis* in the Atlantic, little can be added to PARR's suggestions except that LEA's specimen (later described by KOEFOED in 1927, p. 61) should be re-examined and the vertebral count checked. Even admitting a count of 132, with a possible range for *I. brunneus* of 132-147, this is not greatly different from the range which I have shown to be present in *Histiobranchus bathybius*, 126-140.

Ilyophis brunneus Gilbert, 1892 (Fig. 2 F-I)

Ilyophis brunneus Gilbert, 1892, p. 351.

For synonymy and literature see GREY 1956, pp. 142-143.

Material:

Galathea Station 324; Strait of Malacca ($6^{\circ}38'N$, 96°00'E), 1140 m, 9/5/51. – One specimen, 463.0 mm total length.

Description:

Proportional measurements in per cent of total length: standard 97.9; head 11.7; snout 3.1; eye 1.1; interorbital 1.6; upper jaw 5.4; postorbital 7.6; branchial aperture 1.4; posterior branchial interspace 2.4; pectoral 1.2; snout-vent 30.0; preanal 31.6; predorsal 10.9; depth just before eye 2.3; depth at vent 4.1. Pectoral rays 15; anal rays 293; dorsal rays before level of vent 79; dorsal rays 378; caudal rays 9+9; lateral line pores before level of vent 38; vertebrae 142. Female, almost mature. A small amphipod present in stomach.

Body greatly elongate, slender, markedly compressed, especially along caudal region; depth of body uniform from pectoral region to just short of tail tip, at the vent contained about 21 times in the total length; trunk relatively long. Head well differentiated from the trunk, gape long but not extending greatly behind eye. Median fins well developed; pectoral minute.

Scales present over the whole of body surface except most of head and fins; scaled area extending to level of origin of lateral line. Individual scales minute, elongate, more so than in *Histiobranchus* and distributed in a manner strikingly similar to that found in *Diastobranchus capensis*, the socalled "basket-work" pattern.

Head noticeably distinct from trunk with the occipital region slightly swollen, slender, its length about 8.5 in total length; snout long, 3.5 in head, tumid, projecting slightly in advance of the lower jaw, its tip hooked to show the anterior upper teeth; jaws slender; lips absent; mouth terminal and the cleft moderately long, contained about 2.3 times in head and extending beyond eye for a short distance which is less than diameter of eye; tongue feebly developed.

Teeth typically synaphobranch in appearance, that is, conical, acute, slightly recurved: on the jaws the teeth are distributed in about three to four rows anteriorly but become cardiform and minute posteriorly; more numerous in the lower jaw. Premaxillary-ethmoid patch oval but with its length clearly less than its width and with about 18 teeth; vomerine patch confluent with premaxillary-ethmoid patch, equal in length to about four-fifths of maxillary patch, essentially uniserial with the anterior eight teeth very large, scarcely recurved, followed by about the same number of much smaller teeth.

Nostrils essentially similar to those of the other species already described. Eye relatively small, contained about 6.5 times in postorbital; interorbital a little greater than length of branchial aperture. Branchial apertures ventrolateral, almost horizontal, separated anteriorly by less than their length, posteriorly by not quite twice their length. Vent protruding into the lateral profile, placed almost at end of anterior third of body.

Median fins well developed and continuous with caudal. Height of dorsal about uniform along most of its length, the maximum at about the middle of its length, and equal to one-third of the body depth, originating over the pectoral base, with 79 rays before level of vent and a total of 378. Anal height about the same as that of dorsal, with 293 rays. Caudal with 18 rays distributed as 9+9. Pectoral, tapering evenly from its base to its tip, minute, only a little longer than eye; 15 rays.

Lateral line originating inconspicuously high on head and reaching mid-lateral level just posterior to level of vent; with 38 pores before vent; fading out before end of caudal region. Cephalic sensory pores inconspicuous, more numerous behind eye but otherwise as in the other species described above.

Vertebrae 141. Colour light grey-brown, with the fins darker.

Notes on the Larvae of Synaphobranchidae

BRUUN (1937, pp. 10-15) has described seven types of synaphobranch larvae of which three have been referred to their adult species: L. Synaphobranchus kaupi and L. Synaphobranchus infernalis from the Atlantic and L. Synaphobranchus danae from the southwest Pacific. The four other species were collected in the Indo-Pacific from the east coast of Central Africa to Tahiti. Two of these species have pigment restricted to the tail region, exactly as in the Atlantic material, and have 129-138 myomeres and 124-129 myomeres (L. Synaphobranchus sului) respectively. Both species are here tentatively referred to Histiobranchus bathybius. The two remaining species have a more or less conspicuous black pigment spot before the level of the anus in addition to the caudal pigment shown in the other forms. They have 129-133 myomeres (L. Synaphobranchus indicus orientalis) and 134-138 myomeres (L. Synaphobranchus indicus occidentalis) respectively and are both tentatively referred to Synaphophobranchus brevidorsalis. This species has been recorded from about the same area as these larvae and is distinguished from all other Indo-Pacific synaphobranchs in having rounded to irregular scales; this distinction may well be supported by the clear difference in pigmentation of the larvae.

In the following key only adult forms are considered and myomere numbers are those of the adults taken from as many sources as possible. The key is simple to use. Where there is agreement with one number proceed to the following number; where there is no agreement proceed to the alternative indicated by parentheses.

KEY TO THE GENERA AND SPECIES OF SYNAPHOBRANCHIDAE

Family Synaphobranchidae: Scales present; branchial apertures inferior; mouth large with the upper jaw extending to behind the eye; teeth acutely conical, slightly recurved, in one to three rows (anteriorly) and cardiform (posteriorly) on the maxillae and dentaries, but larger and in an oval patch on the premaxillary-ethmoid and in one to three longitudinal rows on the vomer; palatopterygoid reduced, often to a cartilaginous strip or absent; no interfrontal suture.

- 1 (12) Branchial apertures ventral, separated if at all by less than their length,
- 3 (6) Scales elongate-oval in shape, distributed in groups so that the scales of one group are at right angles to scales of adjacent groups; branchial apertures about equal in length to diameter of eye,

- 6 (3) Scales rounded to irregular in shape, distributed in no regular pattern but giving a "paving-stone" effect; dorsal fin always originating behind level of vent,
- 7 (8) Vertebrae 131-134, branchial apertures equal to diameter of eye ...S. brevidorsalis Günther, 1887 from the Gulf of Mexico, North Indian Ocean, North and Central Pacific Ocean see CASTLE (1960, pp. 392-396, fig. 67 A-E).
- 8 (7) Vertebrae 143-145, branchial apertures equal only to length of pupil of eye. *S. oregoni* Castle, 1960 from the Gulf of Mexico see CASTLE (1960, pp. 388-392, fig. 66).
- 9 (2) Branchial apertures somewhat divergent, almost confluent anteriorly but separated by a distance equal to half their length posteriorly; mouth extending to about twice the diameter of eye behind posterior margin of eye; vomerine teeth small and in three to four longitudinal rows; abdomen long so that the vent is about in the middle of the body; pectoral equal to or less than

snoutGenus Histiobranchus,

- 12 (1) Branchial apertures ventrolateral, separated by more than their length posteriorly, but closer together anteriorly.

with the single species *I. brunneus* Gilbert, 1892 from the Central Atlantic, North Indian Ocean and Central East Pacific; 142-147 vertebrae.

14 (13) Branchial apertures oblique, their free edge straight, placed in front of and below pectoral fin but with their upper extremity at least level with pectoral base; mouth extending to nearly the diameter of eye behind posterior margin of eye; only one or two enlarged vomerine teeth anteriorly, uniserial and smaller posteriorly; abdomen very short so that vent is placed at the end of the anterior quarter of the body; dorsal originating well behind level of vent; pectoral long,

SUMMARY

Eels collected by the *Galathea* Expedition were *Histiobranchus bathybius* (Günther), a new species of *Histiobranchus, Ilyophis brunneus* Gilbert, *Synaphobranchus kaupi* Johnson, which are described and figured, and *S. brevidorsalis* Günther. The genus Ilyophis is here included in the Synaphobranchidae; Histiobranchus is reinstated as a genus; H. infernalis and H. australis are shown to be synonyms of H. bathybius. A key to the genera and species of Synaphobranchidae is given.

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