SYSTEMATICS AND BIOLOGY OF THE APHYONIDAE (PISCES, OPHIDIOIDEA)

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I. INTRODUCTION

A systematic revision is presented including the description of two new genera and four new species. Also, much emphasis has been placed on the condition of the gonads, one of the few ways in which it may be possible to learn something about the biology of these rare, deep-living fishes. Consequently, all specimens were opened, and the gonads and other viscera studied. A histological examination was made of the gonads, preferably of both a male and a female of each of the aphyonid species. Osteological studies were based on radiographs only, except for one species which was also cleared and stained. The holotypes of all described species were re-examined, as many of the old descriptions are short and inadequate.

The first described aphyonid fish, *Aphyonus gelatinosus* Günther, 1878, was caught during the Challenger Expedition in 1874. Since then, 64 additional specimens of aphyonids have been caught. Of these, 42 belong to one species and the remaining to 12 species. Most aphyonids can thus be referred to as rare species, although many of them were found at unfrequently sampled deep pelagic depths.

JORDAN & EVERMANN (1898, p. 2499) were apparently the first to use the name Aphyoninae, as they placed the then existing genera, *Aphyonus* and *Barathronus,* in a separate subfamily under the Brotulidae. The subfamily designation was apparently overlooked by NYBELIN who later (1957, p. 308) established a new subfamily, Aphyoninae, which included, i.a., the two genera of JORDAN & EVERMANN's subfamily of the same name.

The first to propose the family name Aphyonidae was ZUGMAYER (1911 a, p. 131), but not quite in the same sense as used in this paper. He mentioned that if more genera besides *Leucochlamys* were found, lacking the ventral fins and with the anus placed on the posterior half of the body, they should be arranged in a special family, the Aphyonidae. ZUGMAYER's proposal of this family-name seems strange as on the same page he mentioned that *Aphyonus* differs from *Leucochlamys* by the presence of ventral fins in the former, whereby *Aphyonus* per definition is excluded from the Aphyonidae (sensu ZUGMAYER).

Abbreviations

BM	– British Museum, London.
CNHM	– Chicago Natural History Museum.
FRSH	– Fisheries Research Station, Hongkong.
ISH	– Institut für Seefischerei, Hamburg.
MCZ	– Museum of Comparative Zoology, Harvard.
MNHN	– Muséum National d'Histoire Naturelle, Paris.
MOM	– Muséum Océanographique, Monaco.
NHMG	– Naturhistoriska Museet, Göteborg.
UMML	– University of Miami, Marine Laboratory.
USNM	– United States National Museum, Washington D. C.
WHOI	– Woods Hole Oceanographic Institution.
ZMA	– Zoölogisch Museum, Amsterdam.
ZMB	– Zoologisches Museum, Berlin.
ZMUC	– Zoologisk Museum, Universitetet, København.
ZSIC	– Zoological Survey of India, Calcutta.
SL	– Standard length.
TL	– Total length.

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Methods and terminology

Counts were made and measurements taken in accordance with HUBBS & LAGLER (1958) except that the upper jaw symphysis is used as the anteriormost point and not the tip of the snout. Owing to the indistinctness of the eyes, measurements involving the eyes are most often omitted. – The accuracy of the measurements makes it reasonable to give the morphometric characters with an absolute uncertainty of 0.1 when the characters form less than 10 % of the standard length (e.g., length of snout 8.4 % ± 0.1 of the SL), with an absolute uncertainty of 0.5 in the interval 10-50 % (e.g., length of postorbital 16.5 % ± 0.5 of the SL), and with an absolute uncertainty of 1 in the interval 50-100 % (e.g., length of preanal 56 % ± 1 of the SL). – When references to tables, plates and figures are spelled with a capital T, P and F they refer to the present work. Beginning with a non-capital letter they refer to other publications. – Quite often the depth indications seem very accurate, but this is usually due to conversion of fathoms into metres. – Except for *Barathronus bicolor* all species of the aphyonids are represented by so few specimens that an osteological examination based on clearing and staining is excluded. Radiographs from a lateral as well as from a dorsal view were taken of all the specimens. Unfortunately, many of the details are difficult to see on radiographs, especially when dealing with so poorly ossified fishes as the Aphyonidae. – In order to examine, e.g., lateral line papillae, fin-rays and pseudobranchs, an air-jet was used. The air from an ordinary aquarium pump was led through a pointed glass tube, making it possible to dry a given area of the fish so that finer details could be more easily distinguished. – The following method was used when measuring the diameter of the eggs. The ovary was divided into small portions and placed under the microscope. By means of a drawing-tube and 60 times magnification, the diameter of the eggs was drawn and subsequently measured on the paper. – The gonads were embedded in tissuemat, cut in 8 and 10 μ sections and stained with Alcian blue (AB)-Kernechtrot, periodic acid Schiff (PAS)-Ehrlich's hematoxylin and AB-PAS-Ehrlich's hematoxylin.

The following oceanographic terms are those proposed by BRUUN (1956 and 1957): Epipelagic, mesopelagic, bathypelagic, abyssopelagic, bathyal, and abyssal. – The term "viviparous" is used for all species in which the eggs are fertilized within the female even if a minor part of the development of the embryo takes place outside the female. About half of the more than 200 ophidioid species are referred to viviparous groups, owing to the presence of a copulatory apparatus and/or to the presence of fertilized eggs in the ovaries. Only very few species, i.a., two aphyonids, are actually known to bring forth free larvae. Like most other authors I do not distinguish between species in which the embryos are nourished through a placenta and those in which they are nourished by a yolk supply. The term "oviparous" is used for species in which the eggs are fertilized after or during the extrusion (cf. NIELSEN, JESPERSEN & MUNK 1968, p. 240). – The terminology of the copulatory apparatus is that defined by TURNER (1946). – The terms used for the rows of sensory papillae are those proposed by ROBINS (1959, p. 5). – The anterior caudal vertebra is that provided with the anterior haemal spine. The last vertebra with the haemal arch pierced by the caudal vein is considered the last caudal vertebra. – A distinct longitudinally running muscle is seen on either side of the abdominal part of the body (cf. Fig. 12). According to TAKAHASI (1917), this is the musculi infracarinales mediales, which here apparently originate anteriorly on the pectoral girdle and insert posteriorly at the cranial part of the anal fin. In lower teleosts, the m. infracarinales mediales connect the ventral and the anal fins, but most probably the m. infracarinales anteriores (connecting the pectoral and the ventral fins) are not developed in fishes in which the ventral and the pectoral fins or fin girdles are situated in the same transversal plane. The m. infracarinales mediales appear as a chain of rectangular to square-shaped muscular "fields". In the specific description the ratio between the length and the width of the middle muscular "fields" is normally given. The length is the cranio-caudal and the width is the dorso-ventral measurement.

Material

Due to the kindness of many colleagues I have been able to examine all aphyonid specimens that have come to my knowledge. The collection comprises a total of 65 specimens belonging to 13 species and six genera. Below is listed all the species examined with indication of the number of recorded and additional (old and new) specimens. For those specimens, of which the gonads have been examined histologically, the histological serial number (Ser. No.) is included:

Aphyonus gelatinosus Günther, 1878, including *A. mollis* Garman, 1899. Three specimens of which one is new. Ser. Nos. 17 (♀) and 64 (♂).

Aphyonus brevidorsalis n. sp. Only the holotype is known. Ser. No. 4 (♂).

Barathronus affinis Brauer, 1906. Only the holotype is known. Ser. No. 46 (♀).

Barathronus bicolor Goode & Bean, 1886. 42 specimens of which 36 are new. Ser. Nos. 41-57-60-63 (♀♀) and 38-39-58-59-61-62 (♂♂).

Barathronus bruuni n. sp. Only the holotype is known. Ser. No. 66 (♀).

Barathronus diaphanus Brauer, 1906. Four specimens of which one is new. Ser. Nos. 68 (♀) and 54 (♂).

Barathronus parfaiti (Vaillant, 1888). Two specimens, both old. Ser. No. 31 (♂).

Barathronus sp. One unrecorded specimen. Ser. No. 67 (♂).

Leucochlamys cryptophthalmus Zugmayer, 1911. Only the holotype is known. Ser. No. 29 (♂).

Leucochlamys galatheae n. sp. Two specimens, both new. Ser. Nos. 30 (♀) and 27 (♂).

Leucochlamys jonassoni Nybelin, 1957. Only the holotype is known.

Meteoria erythrops n. gen. et sp. Two specimens, an old and a new. Ser. No. 71 (♀).

Nybelinia (n. gen.) *erikssoni* (Nybelin, 1957). Two specimens, an old and a new. Ser. No. 24 (♂).

Sciadonus pedicellaris Garman, 1899, including *S. kullenbergi* Nybelin, 1957. Two specimens, both old.

Family diagnosis

An ophidioid family of rather long, slender fishes with a more or less transparent, scaleless and somewhat loose skin. The unpaired fins are united. The eyes are poorly developed, sometimes hardly visible. Owing to the transparency of the skin, the musculi infracarinales mediales are distinct as a longitudinally running, narrow band on either side of the abdominal cavity. Pyloric caeca and a swimbladder are not developed. There are no free spines on the gill covers. The number of precaudal vertebrae varies from 31 to 38. The anteriormost neural arches and spines are equal in length to the following ones, in contrast to, e.g., the Brotulidae, in which the anterior ones are the shorter. All aphyonids are viviparous.

Relationships

The Aphyonidae are referred to the perciform suborder Ophidioidea (sensu Regan 1929, p. 322). This suborder comprises the following five families:

Ophidiidae – Brotulidae – Aphyonidae – Carapidae, incl. Carapinae and Pyramodontinae (Robins & Nielsen in press) – Gadopsidae (cf. Gosline 1968, p. 17).

According to Marshall (1960, p. 111), the Aphyonidae (sensu Nybelin 1957), provided they consist entirely of deep-dwelling, bathypelagic fishes, are most probably united by neotenic characters, which does not indicate genetic affinity, but rather a convergent adaptation to the food-poor deep-pelagic environment. This means that Marshall indirectly stated that the present aphyonid genera should be referred to other ophidioid families. Of these the Carapidae and the Gadopsidae can be excluded for various reasons (cf. Table 1). The remaining two families, the Ophidiidae and the Brotulidae, are closely related. The most important character separating them, is the position of the ventral fins, which is mental in the former and jugular in the latter family. If Marshall is followed, most of the aphyonid genera should consequently be placed among the Brotulidae, while two of the genera, *Meteoria* and *Leucochlamys,* which lack ventral fins, would be more difficult to place. The Brotulidae (in the present sense) include an oviparous and a viviparous group. A small, intermediate group comprising 3-4 genera is excluded here. Common to the viviparous group is, among other things, that the anterior nostril is placed on the upper lip, the number of well developed rakers on the anterior gill arch never exceeds 3-4, and the head is partly scaled or scaleless. Among the aphyonids, *Barathronus* and *Aphyonus* have the nostrils close together midway between the eye and the upper lip while the remaining genera have the anterior nostril more or less close to the upper lip; three genera have more than 3-4 well developed rakers on the anterior gill arch, and the other three genera have no long rakers at all; finally, none of them are provided with scales. This means that if the aphyonids were placed among the Brotulidae, the two sets of characters typical of the oviparous and the viviparous group of brotulids would be invalidated. Besides, as shown in the family diagnosis above, there are so many non-neotenic characacters typical of the Aphyonidae, that it seems quite natural to maintain this family.

In Table 1 the Aphyonidae are compared to the other ophidioid families. It is difficult to find the ancestors or relatives of the Aphyonidae, because only few fossils of ophidioids are known, and only

Table 1. Major differences between the ophidioid families.

	Ophidiidae	Brotulidae	Carapidae	Gadopsidae	Aphyonidae
United unpaired fins	+	±	+	—	+
Swimbladder	+	+	+	—	—
Pyloric caeca	+	+	+	+	—
Scales	+	+	+	+	—
Spines on gill cover	+	+	+	+	—
Spiny fin-rays	—	—	—	+	—
Viviparity	—	±	—	?	+
Number of precaudal vertebrae[1]	13-20 [14]	9-19 [47] 23[2]	15-18 [3]	17-18 [1]	31-48 [13]

+ = present; — = absent.

1. The numbers in the brackets indicate the number of species examined.
2. This number refers to *Dipulus caecus* Waite, 1905.

a minor part of the more than 200 brotulid species are properly described.

Especially the number of precaudal vertebrae distinguishes the Aphyonidae from the remaining families. The vertebral number derives mainly from my own examination of radiographs, and a smaller part was taken from the literature.

It appears from the "Resumé of opinions" below that there are two main points of disagreement concerning the systematic position of the Ophidioidea. Some authors arrange this suborder in more or less close contact with the Gadiformes, while others place them near the Blennioidea among the Perciformes. Within recent years, important reasons are given in favour of both opinions (GREENWOOD ET AL. 1966 and GOSLINE 1968, see below). As the discussion is still at a preliminary stage I here follow REGAN (1929) who referred the Brotulidae (incl. the Aphyonidae) to the suborder Ophidioidea, order Percomorphi.

Resumé of opinions

Presented alphabetically below are the subfamilies and/or the families to which various authors have referred members of the Aphyonidae (in the present sense). After the subfamily- or family-name follows the ordinal name in brackets. Most of the papers are commented upon, and in these instances the English form of a family-name indicates that the name is used in the present sense (cf. p. 10). The following list shows that aphyonids have been referred to four families and to eight orders.

Aphyonidae (Ophidioidei) – MEAD, BERTELSEN & COHEN (1964, p. 583) were the first to recognize a full family for the aphyonid genera. Actually, the name Aphyonidae was proposed already by ZUGMAYER (1911a, p. 131), but not quite in the same sense as normally used (cf. p. 8).

Aphyonidae (Perciformes) – RASS (1967, p. 229). GOSLINE (1968, p. 17) divided the suborder Ophidioidei into six families.

Aphyoninae (Acanthopteri) – JORDAN & EVERMANN (1898, p. 2499) placed the two described aphyonid genera in their own subfamily within the Brotulidae. This was the first time any assemblage of aphyonid genera was given suprageneric rank. NYBELIN (1957, p. 308) included the four old aphyonid genera described in the present paper.

Brotulidae (Teleocephali) – GOODE & BEAN (1896, p. 314) included here the aphyonids and the brotulids.

Brotulidae (Anacanthini) – GARMAN (1899, p. 146) referred aphyonids and brotulids to this family. ZUGMAYER (1911a, p. 129) followed GARMAN.

Brotulidae (Jugulares) – ROULE (1917, p. 66) arranged the aphyonids and the brotulids in this family. JORDAN (1923, p. 736) placed the aphyonids and the brotulids in the series Brotuliformes.

Brotulidae (Percomorphi or Perciformes) – REGAN (1912, p. 277) placed the aphyonids and the brotulids in this family in the division Ophidiiformes, suborder Blennioidea. NORMAN (1939, p. 84) placed the four old aphyonid genera in one group of his key to the Brotulidae. In addition, he placed here *Parabrotula* Zugmayer, 1911 and *Spectrunculus* Jordan & Thompson, 1914, but the former is now referred to the Zoarcidae (NIELSEN 1968), and the latter is a postlarval brotulid. Later NORMAN (1966, p. 497) placed the aphyonid genera together with 45 other genera in the Bythitinae under the Brotulidae.

Brotulidae (Brotuliformes) – ROULE (1934, p. 191) included the aphyonids and the brotulids in this family while the Ophidiidae were arranged with the Zoarcidae in the order Zoarciformes.

Brotulidae (Ophidiiformes) – MCALLISTER (1968, p. 117) placed the aphyonids and the brotulids here.

Ophidiidae (Anacanthini) – GÜNTHER (1887, p. 99) referred the aphyonids, the brotulids and the ophidiids to this family. VAILLANT (1888, p. 15).

Ophidiidae (Gadiformes) – GREENWOOD, ROSEN, WEITZMAN & MYERS (1966, p. 397) in this family included the aphyonids, the brotulids and the ophidiids. The Gadiformes is referred to the superorder Paracanthopterygii.

Zoarcidae (Acanthopterygii) – BRAUER (1906, p. 300) arranged here the aphyonids, the brotulids, and the zoarcids. WEBER (1913, p. 551).

Genera

There are seven nominal aphyonid genera, but only six are recognized here, as *Alexeterion* Vaillant, 1888 is considered a synonym of *Barathronus* Goode & Bean, 1886. Table 2 gives some of the generic differences within the Aphyonidae.

There is no doubt about the close relationship of *Sciadonus* and *Leucochlamys*. Besides the characters in Table 2 the form of the female copulatory apparatus also shows much similarity in the two genera. *Meteoria* is apparently more closely related to the abovementioned genera than to any other aphyonids, judging from many meristic characters,

Table 2. Major meristic differences between the aphyonid genera.

	Aphyonus 2 spp.	*Nybelinia* 1 sp.	*Barathronus* 5 spp.	*Meteoria* 1 sp.	*Sciadonus* 1 sp.	*Leucochlamys* 3 spp.
Dorsal fin	72-116	86	64-81	48-50	90-93	68-104
Caudal fin	6-7	8	10 (9)	8	6	6-7
Anal fin	58-68	52-53	50-73	34	46	43-48
Ventral fin	1	1	1	0	1	0
Pectoral fin	17-18	23-25	21-25	13-15	12-14	9-14
Well developed gill rakers on ant. arch	3-9	7	24-33	0	0	0
Total vertebrae	71-84	76-78	70-86	68-70	82	68-86
Precaudal vertebrae	31-33	40	31-37	39-41	43-44	39-48
Caudal vertebrae	39-53	36-38	37-50	29	38-39	29-38

but in contrast to the two former genera the copulatory apparatus in *Meteoria* is not provided with claspers. Common to *Sciadonus, Leucochlamys* and *Meteoria* are relatively few fin-rays, absence of well developed gill rakers, and a very short caudal part of the body (30-35 % of the standard length). The few fin-rays indicate a more advanced stage than the remaining aphyonid genera.

Barathronus and *Nybelinia* are related (about the same number of pectoral, caudal and ventral fin-rays), but still they differ in many characters (cf. p. 23). *Aphyonus* is closest to *Nybelinia* (see Table 2). *Barathronus, Nybelinia* and *Aphyonus* all have relatively many fin-rays, well developed gill rakers on the anterior arch and a rather long caudal part of the body (35-50 % of the standard length).

In two of the three genera, containing more than one species, *Barathronus* and *Leucochlamys,* the form of the male and female copulatory apparatus is rather constant. The third genus is *Aphyonus* which consists of two species with a differently shaped male copulatory apparatus (Figs. 4 and 11).

Barathronus differs from all the other aphyonid genera, first and foremost in possessing so few neotenic characters. The vertebral centra are sand-glass shaped in adult specimens, there are well developed gill rakers and laminae, ribs and parapophyses are present on almost all precaudal vertebrae, large otoliths are developed, the dentition is strong, e.g., with dentigerous palatines etc. This difference between *Barathronus* and the other aphyonid genera is probably due to the biology of *Barathronus* which is the only aphyonid genus definitely occurring on or in near contact with the bottom at bathyal depths.

More detailed comparisons between related genera are given in connection with the respective generic descriptions.

Two genera, *Parabrotula* Zugmayer, 1911 and *Leucobrotula* Koefoed, 1952, seem rather closely related to the Aphyonidae, in being viviparous, pelagic, and showing many neotenic characters such as rectangular-shaped vertebral centra viewed laterally (cf. p. 79). NORMAN (1939) grouped the then described genus, *Parabrotula,* with the aphyonid genera in his key to the Brotulidae. However, the two genera were recently removed from the Brotulidae to the Zoarcidae (NIELSEN 1968).

Key to the genera of *Aphyonidae*

I. Caudal fin-rays 10 (9), a total of 24-33 rakers on the anterior gill arch all well developed (Fig. 28), palatines generally dentigerous, ribs and well developed parapophyses present, sand-glass shaped vertebral centra in adults .... *Barathronus* Goode & Bean, 1886 p. 28

II. Caudal fin-rays 6-8, a total of 9-25 rakers on the anterior gill arch of which 0-9 are well developed, no palatine teeth, ribs and parapophyses hardly developed, rectangular shaped vertebral centra in adults.

  A. Pectoral fin-rays 23-25, a total of 25 rakers on the anterior gill arch of which 7 are well developed .... *Nybelinia* n. gen. p. 22

  AA. Pectoral fin-rays 9-18, a total of 9-14 rakers on the anterior gill arch.

    B. Anal fin-rays 58-68, a total of 13-14 rakers on the anterior gill arch of which 3-9 are well developed, 31-33 precaudal vertebrae, pseudobranchs present, mouth almost horizontal .... *Aphyonus* Günther, 1878 p. 13

BB. Anal fin-rays 34-48, a total of 9-14 rakers on the anterior gill arch all very short (Fig. 46), 39-48 precaudal vertebrae, no pseudobranchs, mouth oblique.

- C. Pectoral fin peduncle not elongated, 48-50 dorsal and 34 anal fin-rays, outer row of rakers on the anterior gill arch edentate, female copulatory apparatus without claspers . . . . *Meteoria* n. gen. p. 57
- CC. Pectoral fin peduncle pedicellate, 68-104 dorsal and 43-48 anal fin-rays, outer row of rakers on the anterior gill arch dentigerous, female copulatory apparatus with a pair of claspers.
  - D. Ventral fins present, anterior nostril tube-formed, no fangs on vomer . . . . *Sciadonus* Garman, 1899 p. 62
  - DD. Ventral fins absent, anterior nostril with a low rim, fangs on vomer . . . . *Leucochlamys* Zugmayer, 1911 p. 69

II. SYSTEMATIC ACCOUNT

Aphyonus Günther, 1878

Aphyonus Günther, 1878, p. 22, type species *Aphyonus gelatinosus* Günther, 1878 by monotypy.

This genus was described on the basis of a single specimen caught by the Challenger Expedition between North East Australia and New Guinea. The type species is kept in the British Museum.

GÜNTHER (1878, p. 22) gave a preliminary description of the genus, and in his "Report on the Deep-Sea Fishes" (1887) he published a more detailed description. In two characters, however, his descriptions differ, i.e., whether or not teeth are found on the palatines, and in the description of the texture of the skin. The description 1878 read "Palatine teeth" and "Loose skin" while that from 1887 stated "Palatine teeth none" and "Skin covering the muscular parts is not loose". The present reexamination did not reveal any teeth on the palatines and showed that the skin was more or less loose.

Diagnosis:

The rather short body is enveloped in a loose, scaleless skin. The snout is swollen. The mouth cleft is almost horizontal. The dentaries, premaxillaries and vomer are dentigerous, while the palatines are edentate. The eyes are hardly visible in large specimens. Small lateral line papillae are developed on head and body. A weak, bifurcated spine is found on the operculum (not observed in the holotype of *A. gelatinosus*). There are 3-9 long rakers on the anterior gill arch. There is no inner row of rakers on the fourth gill arch. The length of the pectoral peduncle equals or is slightly longer than the width of the base of the pectoral fin. The pectoral radials are elongate and most narrow in the middle part. There are 17-18 pectoral fin-rays and single rayed ventral fins. The middle "fields" of the musculus infracarinalis medialis are very short and high. There are 31-33 precaudal vertebrae. The vertebral centra are rectangular in a lateral view. The ratio between the length and height of the last precaudal vertebral centrum is 0.5 approx. and for the 20th caudal vertebral centrum it is 0.8-0.9. The anterior neural spine is equal in length to the following spines. The male copulatory apparatus is very differently developed in the two species (cf. Figs. 4 and 11). No claspers are developed in the female. The genus is viviparous.

A comparison of the holotype with GÜNTHER's descriptions (1878 and 1887) showed a difference in a few characters. The information on the holotype is based on a radiograph and on a direct examination of the type. In the following points GÜNTHER's observations are mentioned in brackets:

a. The tail is short (tail tapering).
b. Teeth on premaxillaries (no teeth in upper jaw).
c. Gill laminae on fourth gill arch (fourth gill arch without laminae).

Relationships:

GÜNTHER (1887, p. 120) mentioned that *Aphyonus* resembles *Typhlonus* Günther, 1878 "... in so many points that one might be induced to regard it as an early stage of development of that fish". However, he added that "... no such direct relation can be obtained between them". I also find the two genera superficially rather alike, but they disagree considerably in most characters. Compare the redescription of *Typhlonus* (NIELSEN 1965, p. 41).

GÜNTHER (1887, p. 120) mentioned that the holotype of *A.gelatinosus* has the ovaries filled with eggs of a size indicating that they are ready for exclusion. GÜNTHER concluded that *Aphyonus* is "... a persistent and independent type, the lowest of all Anacanths, so far as is known at present, which has remained stationary at an early stage of development". (According to GÜNTHER (1880) the Anacanthini comprises Anacanthini Gadoidei (families Lycodidae, Gadidae, Ophidiidae, and Macruridae) and Anacanthini Pleuronectoidei (family Pleuronectidae)). The only feature, on which GÜNTHER based the above conclusion, is that "Notochord persistent, but with a superficial indication of the vertebral segments (as in some Leptocephaline forms)".

VAILLANT (1888, p. 283) in his description of *Alexeterion* (p. 28) mentioned that this genus differed from *Aphyonus* by lacking the ventral fins. – WAITE (1905, p. 77) stated that his new genus, *Dipulus,* was most closely related to *Aphyonus* and *Sciadonus,* but distinguishable from *Aphyonus* by the complete dentition, elongate form etc. (cf. p. 63). – ZUGMAYER (1911a, p. 131) found that *Leucochlamys* (p. 69) was rather close to *Aphyonus,* but they disagreed by the absence of ventral fins and presence of premaxillary teeth in the former. (The present re-examination shows that both genera have dentigerous premaxillaries).

Aphyonus differs from all other aphyonid genera by the almost horizontal mouth cleft. The key on p. 12 gives some of the more important generic characters. It appears that *Aphyonus* is most closely related to *Nybelinia* (p. 22) as agreement is observed, i.a., in the following characters: Number of rays in the caudal fin, total number of vertebrae, presence of ventral fins, number of well developed gill rakers, the form of the last precaudal and 20th caudal vertebral centrum.

Biology:

The four specimens known of the genus *Aphyonus* were all taken in trawls which fished pelagically as well as on the bottom. As mentioned in connection with *A.gelatinosus* (p. 19) it is difficult to decide whether *Aphyonus* is pelagic or benthic, as the number of neotenic developed characters is smaller than that found in most other aphyonid genera (Table 25, p. 80). Judging from the good condition of these fragile specimens it seems hardly possible that they were caught while trawling at the bottom, unless they came into the gear just before it left the bottom. The few food remains found in the stomachs (fragments of crustaceans) do not give any information as to whether the specimens were taken pelagically or at the bottom. The big mouth and the relatively short gill rakers indicate that it probably feeds on rather big prey. The fine, pointed teeth might only be fit for holding the prey. The development of spermatophores and a penis in both species indicate viviparity.

Distribution:

Fig. 5 shows that this genus is found in the western part of the Indian, Pacific and Atlantic Oceans.

Species:

Representatives of the genus *Aphyonus* are very rare. Three nominal species are described, *A.gelatinosus* Günther, 1878, *A.mollis* Goode & Bean, 1886, and *A.brevidorsalis* n.sp. (p. 20). However, it seems as if *A.gelatinosus* and *A.mollis* are synonymous (p. 16).

Key to the species of *Aphyonus:*

1. Number of dorsal fin-rays 106-116 and of anal fin-rays 65-68; 3-4 long rakers on the anterior gill arch. 51-53 caudal vertebrae. Depth at anterior end of dorsal fin 16.5-17.5 % of SL. The predorsal length represents 28.0-29.5 % of SL. The anterior dorsal ray issues above vertebrae Nos. 8-10 .... *A.gelatinosus* Günther, 1878
2. Number of dorsal fin-rays 72 and of anal fin-rays 58; 9 long rakers on the anterior gill arch. 39 caudal vertebrae. Depth at anterior end of dorsal fin 21.0 % of SL. The predorsal length represents 43.5 % of SL. The anterior dorsal ray issues above vertebra No. 22 .... *A.brevidorsalis* n.sp.

Aphyonus gelatinosus Günther, 1878
Fig. 1

Aphyonus gelatinosus Günther, 1878, p. 22.
– *mollis* Goode & Bean, 1886, p. 163.
– *gelatinosus:* Günther 1887, pp. 120-21, pl. XXVI, fig. A.
– *mollis:* Goode & Bean 1896, p. 342, fig. 299.
– –: Jordan & Evermann 1898, p. 2525.
– –: Brauer 1906, p. 407.
– *gelatinosus:* Brauer 1906, p. 407.
– –: Marshall 1954.
– –: Grey 1956, p. 220.
– –: Marshall 1960, pp. 111-12.
– –: Norman 1966, p. 497.
– –: Munro 1967, p. 466, pl. 64.

Material examined (3 specimens):

Holotype of *A.gelatinosus* (SL 132 mm, ♀); "Challenger" St. 184, between North East Australia and New Guinea (12°8′S, 145°10′E); 2560 m; trawl. 29. Aug. 1874. BM 50.900.

Holotype of *A.mollis* (SL 82+x mm, ♀); "Blake" St. 29[1], Gulf of Mexico (24°36′N, 84°5′W); 1746 m. 1877-78. MCZ 28002.

1 specimen (SL 121 mm, ♂); "Oregon" St. 4801, Gulf of Mexico (25°31′N, 96°15′W); 914 m; 40′ shrimp trawl. 7. Apr. 1964. USNM 202159.

It was mentioned by Murray (1885, p. 521) that three specimens were obtained of this fish. However, according to Günther (1887) it proved later that two of the specimens belonged to other genera.

Günther (1878, p. 22) gave a rather detailed description of the external morphology of this species; but regarding the meristic characters he only mentioned "Four branchial arches ..." and "Pectoral with ... thirty-three fine rays ...", observations which both proved to be incorrect since there are five gill arches and 17 pectoral rays. No morphometric characters were mentioned. However, this genus and species is so characteristic that no mistake could possibly be made, at the time of the description, even with lack of counts and measurements. In 1887 Günther added a few morphometric characters to the specific description.

According to Goode & Bean's description (1886, p. 163) of *A.mollis* it is closely related to *A.gelatinosus,* but these authors did not specify which characters they found so diverging as to justify the establishment of a new species. Since Goode & Bean made their description one year previous to the publication of Günther's enlarged description (1887) and furthermore a few divergences exist between Günther's original description and the holotype proper it is understandable that Goode & Bean considered their specimen a new species. A fact which probably also influenced Goode & Bean's decision is that the two specimens were caught at localities far from each other, viz. *A. gelatinosus* in the Western Pacific and *A.mollis* in the Gulf of Mexico.

Below is given a redescription of both species, and the reasons why *A.mollis* and *A.gelatinosus* are now considered synonymous are also discussed.

Comparison between the holotypes of *A. gelatinosus* and *A. mollis:*

When comparing the illustrations of the two species (Günther 1887, pl. XXVI and Goode & Bean 1896, pl. LXXXV) they look very different, but this is mainly explained by the incorrectness of the *A. mollis* figure. Thus, according to the description, the dorsal fin issues almost above the posterior edge of the operculum, while in the illustration the first ray is situated much more anteriorly. Also the depth of the body is incorrectly illustrated being much too large. It appears from the description although it was not mentioned directly that the tail of *A.mollis* was broken, but the figure shows an intact caudal part.

A comparison between the descriptions given by Günther (1878 and 1887) and that of Goode & Bean (1886) reveals disagreement in a few char-

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[1] In the original description Goode & Bean indicated St. CCXXI, but this was later corrected by Eschmeyer (1965).

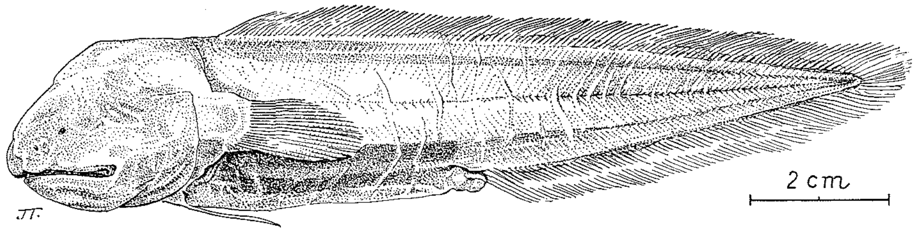


Fig. 1. *Aphyonus gelatinosus* Günther, 1878, SL 121 mm. USNM 202159.

Table 3. Meristic and morphometric characters of *Aphyonus* spp.

	A. gelatinosus			*A. brevidorsalis* Holotype
	A. gelatinosus Holotype	*A. mollis* Holotype	USNM 202159	
Standard length[1]	132	82+?	121	71
Meristic characters				
Dorsal fin	116	110+?	106	72
Caudal fin	7	—	6+?	7
Anal fin	68	66+?	65	58
Ventral fin[2]	1-1	1-1	1-1	1-1
Pectoral fin[2]	17-17	18-18	18-18	17-17
Gill rakers on anterior arch[2]	1/3/10-1/3/9[3]	1/4/9-1/3/10[3]	1/3/9-1/3/9[3]	1/9/4-1/9/4[3]
Branchiostegal rays[2]	8-	8-8	8-	8-8
Vertebrae (incl. urostyle)	33+51	31+53+?	33+51	32+39
Ant. anal-ray below dorsal-ray No.	46	42	42	20
Ant. anal-ray below vertebra No.	38	36	37	35
Ant. dorsal-ray above vertebra No.	8	9	10	22
Morphometric characters as % of standard length				
Head	25.5	24.5—?	25.0	27.0
Depth at ant. end of dorsal fin	16.5	16.5—?	17.5	21.0
Snout	8.4	8.5—?	8.7	9.3
Upper jaw	14.5	14.0—?	13.0	13.0
Postorbital	16.5	15.5—?	15.5	17.5
Preventral	22.0	19.5—?	20.0	22.5
Preanal	56	52 —?	54	59
Predorsal	29.5	28.0—?	29.0	43.5
Distance from base of ventral fins to anterior anal-ray	35.5	33.0—?	35.5	36.5
Base of the anterior 10 dorsal-rays	5.0	4.8—?	5.1	6.1
Base of the anterior 10 anal-rays	6.1	7.7—?	6.8	7.7

1. The measurements were taken from the upper jaw symphysis as the tip of the swollen snout is too inaccurate a point.
2. Right and left side, respectively.
3. The first number indicates the poorly developed gill rakers on the upper branch, the second number the amount of long rakers, and the last number the short rakers on the lower branch.

acters. In the paragraphs below the characters of *A. gelatinosus* are mentioned first, followed by those of *A. mollis*. Comments based on the present re-examinations are given in brackets:

1. Teeth on dentaries and vomer. According to the description 1878 teeth were also present on the palatines while the description 1887 stated "Palatine teeth none". – Teeth on vomer, palatines, mandible, and maxillary. – (The same three bones were found to be dentigerous in the two holotypes: Premaxillaries, vomer, and dentaries).
2. No gill laminae on the fourth arch. – Gill laminae present on the fourth arch. – (Gill laminae found on the fourth arch of both holotypes).
3. Skin loose (GÜNTHER 1878) and skin covering the muscular parts not loose (GÜNTHER 1887). – Skin not loose. – (Relatively good agreement between *A. mollis* and GÜNTHER's description 1887. However, almost 100 years of preservation most probably affected the condition of the skin).

When adding the evidence of agreement in the meristic and morphometric characters (cf. Table 3) to the above three points there seems to be no doubt that *A. gelatinosus* and *A. mollis* are synonymous. According to the rule of priority, *mollis* should be regarded as a junior synonym of *gelatinosus*.

Condition of the material:

Only the type of *A. mollis* is not quite intact since the tip of the tail is broken. In the original description the length is given as 85 + x mm without stating how the measurement was taken, while, when re-examining the type, the length was found to be 82 mm, measured from the upper jaw symphysis.

Diagnosis and relationship:
See the key p. 14 and the discussion p. 20.

Description:
Table 3 shows very little variation in the meristic characters. However, the difference in the vertebral and dorsal fin-ray counts would have been more pronounced had the tail of the *A. mollis* type been intact. All vertebral counts are based on radiographs. All morphometric characters show a very small variation although the divergences become slightly greater when the cutting of the tail is considered. (With the tail complete all the figures in Table 3 would have been smaller). The body is much compressed, and the head is broad. The loose skin is transparent. The anterior ray of the dorsal fin is placed a little in front of the pectoral base. The rays are of almost the same length in all the vertical fins. The anal fin issues closer to the caudal base than to the snout (the preanal length forms 52-56 % of the standard length). The pectoral peduncle is connected to the body with a thick skin. The ratio between the maximum height and the length of the pectoral peduncle is 0.7 approx. The number of pectoral fin-rays are 17-18 (not 33 as mentioned by GÜNTHER (1887)). The ventrals are placed close together well in front of the pectorals. The snout is swollen, slightly protruding over the lower jaw. Owing to the swollen skin the head profile is variable. The nostrils of the holotype of *A. mollis* and of the "Oregon" specimen were examined with an air-jet. The two nostrils are placed close together midway between the eye and the upper jaw. Both are provided with a rather high rim. The mouth opening is rather big with the upper jaw forming about 60 % of the length of the head ending well behind the eye. The gill slits are very long. The gill membranes are free of the isthmus. The eyes are placed below the skin. The black-pigmented part of the eyes is very small and difficult to see in the type of *A. gelatinosus*. The musculi infracarinales mediales are easily seen in the type of *A. gelatinosus* and in the "Oregon" specimen. The ratio between the length and the width of the middle "fields" forms 0.3 approx. In the type of *A. mollis* it is difficult to see the form of the single "fields", but they are definitely wider than long. The large otoliths from the type of *A. mollis* are 4 mm long and those from the *A. gelatinosus* type 6.5 mm, all measured on a radiograph.

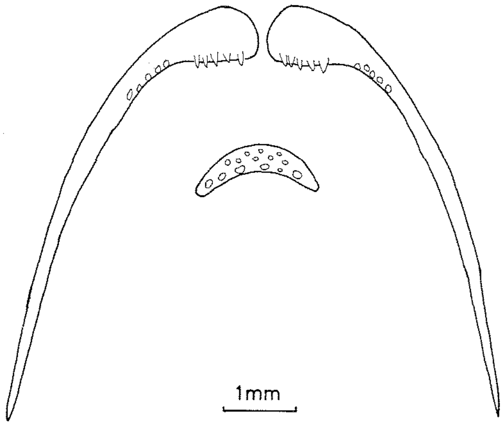


Fig. 2. Dentition of vomer and premaxillaries of the holotype of *A. mollis* (= *A. gelatinosus*).

Lateral line system. An air-jet showed a number of small papillae along the midline of the body, on the lower jaw and a few on the rest of the head. The holotype of *A. gelatinosus* was not examined by this method.

Dentition. In spite of the divergences in the original description of *A. gelatinosus* and *A. mollis* a re-examination showed that both holotypes and the "Oregon" specimen have the same bones provided with teeth: Premaxillaries, vomer, and dentaries. The premaxillaries are much broadened anteriorly and only provided with a few teeth, all placed in the anterior fourth (Fig. 2). About five relatively large conical teeth are placed medially and more laterally another five smaller teeth are found. In the "Oregon" specimen there is medially an inner row of six large teeth and a number of smaller teeth arranged in an irregular outer row. The vomer has six to eight large teeth, of which the median ones are larger than the lateral ones. The front row consists of 6-8 small teeth. The dentaries (cf. Fig. 7) are provided with many irregularly arranged teeth in the broad anterior part. The following part of the bone has 1-2 rows and the posterior half has monoserial teeth. The teeth are conical; about one-third is twice the size of the remaining ones, mixed with each other. In the "Oregon" specimen, the teeth in the posterior half of the dentaries are almost of the same size, being relatively long and pointed.

Vertebral column. All information derives from radiographs. There are 31-33 precaudal and 51-53 caudal vertebrae. The thin, pointed neural

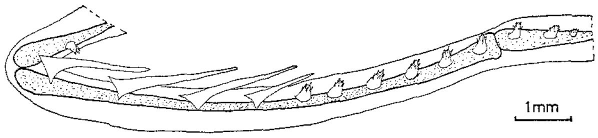


Fig. 3. Anterior, right gill arch of the holotype of *A. mollis* (= *A. gelatinosus*).

arches and spines decrease gradually in length and are rather depressed posteriorly. The anterior neural spine is equal in length to the following spines. Ventrally directed processes are not found on the anterior three precaudal vertebrae, but they are all well developed on the remaining precaudal vertebrae. It cannot be stated whether these processes are formed by the parapophyses and/or the pleural ribs. The transition between the precaudal and the caudal vertebrae is like that in *A. brevidorsalis* (Fig. 9). The vertebral centra are rectangular in a lateral view. The ratio between the length and the height of the last precaudal vertebral centrum is 0.5 approx., and the ratio in the 20th caudal vertebral centrum is 0.8-0.9. The elongate pectoral radials much resemble those of *Calamopteryx goslinei* Böhlke & Cohen, 1966. The ossification is much better in the type of *A. gelatinosus* (SL 132 mm) than in the type of *A. mollis* (SL 82 + ?). There are two large hypural plates in the caudal skeleton.

Gill cavity. Fig. 3 shows the anterior, right gill arch from the type of *A. mollis*. The gill laminae are not shown. There is one small raker on the epibranchiale, four long and six small rakers on the ceratobranchiale and three small ones on the hypobranchiale. There are only three long rakers on the left, anterior arch. All the remaining arches have exclusively short rakers. Except for the anterior arch the rakers in the inner rows are equal in length to those in the outer rows. All rakers are dentigerous except for the 3-4 long ones on the anterior arch. There are no rakers on the fifth arch. Below is given a survey of the number of rakers in the outer row from both sides, including all three specimens:

1st gill arch with 1/3-4 (long) + 9-10 (short) rakers
2nd gill arch with 1/0 (long) + 11-13 (short) rakers
3rd gill arch with 0-1/0 (long) + 10-13 (short) rakers
4th gill arch with 0-1/0 (long) + 9-11 (short) rakers

The gill laminae are well developed, but the appendages on the main stem are smaller than those from *A. brevidorsalis*. There are 40 laminae approx. on the anterior gill arch. Only few, rather short laminae are present on the fourth arch. Two pseudobranchial filaments are found dorsally in each gill cavity in the "Oregon" specimen. Two of the upper pharyngeal plates are provided with small, pointed teeth. Lower pharyngeal tooth-plates could not be observed.

Colour. The two old specimens are light yellow in their present condition, and apparently they have not faded much since Günther (1878, p. 22) stated "Transparent, colourless, like a *Leptocephalus*" and Goode & Bean (1886, p. 163) "Texture of body rather firm, not transparent, whitish". The peritoneum is provided with fine brown mottles and the small eyes are black. The "Oregon" specimen, caught in 1964, has a dark brown peritoneum, the testicular sacks are light brown, and each gill lamina is provided with a brown line on the main stem.

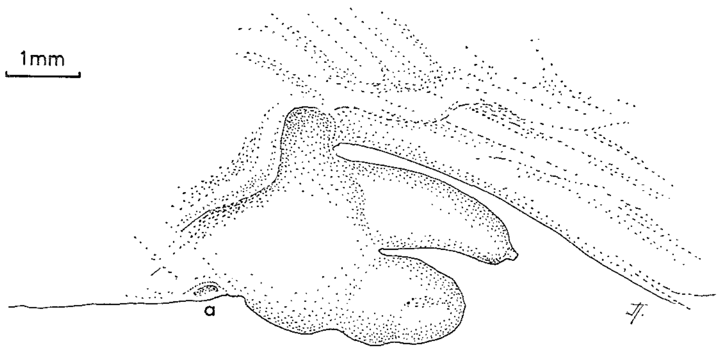
Viscera. The following description is based on the type of *A. mollis* and the "Oregon" specimen. – The inside of the thick-walled stomach is provided with approx. six longitudinally running ridges. The anterior fourth of the intestine is relatively wide and has the interior surface very much enlarged by folds. The remaining part of the intestine is very long and thin. The distance from the posterior part of the stomach to the anus is only one-third of the total length of the intestine. The small liver ends somewhat in front of the posterior part of the stomach.

Gonads:

Females. The type of *A. gelatinosus* has very distended ovaries (22 mm long and about 6 mm wide, oval in cross-section). According to Peter J. Whitehead, who kindly examined one of the ovaries, it held about 800 yellow or yellowish-orange eggs with a diameter of 1 mm approx. They contain numerous yolk-grains. Scattered between the large eggs were several whitish eggs with a diameter of 0.2-0.3 mm. No embryos could be seen. The gonads of the type of *A. mollis* are 16 mm long and 0.5 mm wide. They contain numerous eggs of varying size. The maximum diameter is 0.2-0.3 mm. Owing to the poor fixation it was not possible to measure and count the eggs from the ovaries. The copulatory apparatus consists of a urogenital sinus only. There seems to be a very small pair of soft appendages in the holotype of *A. gelatinosus*, but it may only be torn skin.

Male. The testes of the "Oregon" specimen are 22 mm long and 4 mm thick. A common testicular sack envelops both testes. Part of one of the testes was sectioned. It showed great quantities of spermatophores in the testicular duct. The maximum length

Fig. 4. Anal opening (a) and male copulatory apparatus of *A. gelatinosus,* SL 121 mm. USNM 202159.



is 40-50 μ, and in most cases the spermatozoa are arranged in the capsule with the heads in the same direction. The testicular tissue contains many spermatids and spermatozoa besides a few spermatophores. The copulatory apparatus (Fig. 4) consists of a long penis and a medially placed clasper ventrally to the penis. A urogenital sinus is not developed.

Reproduction and biology:

MARSHALL (1960, p. 111) mentioned that *A.gelatinosus* most probably is oviparous, judging from the many eggs in the ovaries of the holotype. However, the presence of a penis and spermatophores in the "Oregon" specimen strongly indicates that *A. gelatinosus* is a viviparous species like the other aphyonids. Each ovary of the holotype of *A.gelatinosus* contains about 800 eggs with a diameter of c. 1 mm besides several much smaller eggs, so apparently at least large specimens produce big clutches. The softness, the poor ossification and other neotenic characters suggest a pelagic occurrence while the rather well developed gill rakers, the many eggs and a relatively shallow depth of the stations indicate a benthic occurrence (cf. p. 79). MARSHALL (1954, p. 243) mentioned that in blind brotulids the loss of sight is correlated with powerful development of the lateral line system of the head. This is true for many brotulids, but I do not consider *A. gelatinosus* a good example since its lateral line system is not especially well developed. Later (p. 249) MARSHALL wrote that the size and number of olfactory lamellae are much inferior to those of the eel. However, it should be kept in mind that the nasal organs of the eels are some of the best developed among all fishes.

Distribution:

Fig. 5 shows the localities in the Western Pacific and in the Gulf of Mexico. Judging from the distance between the localities it seems reasonable to assume that *A.gelatinosus* has a circumtropical occurrence. The depths at the three localities vary from 914-2560 m. As shown above *A.gelatinosus* has characters typical both for a pelagic and a benthic occurrence.

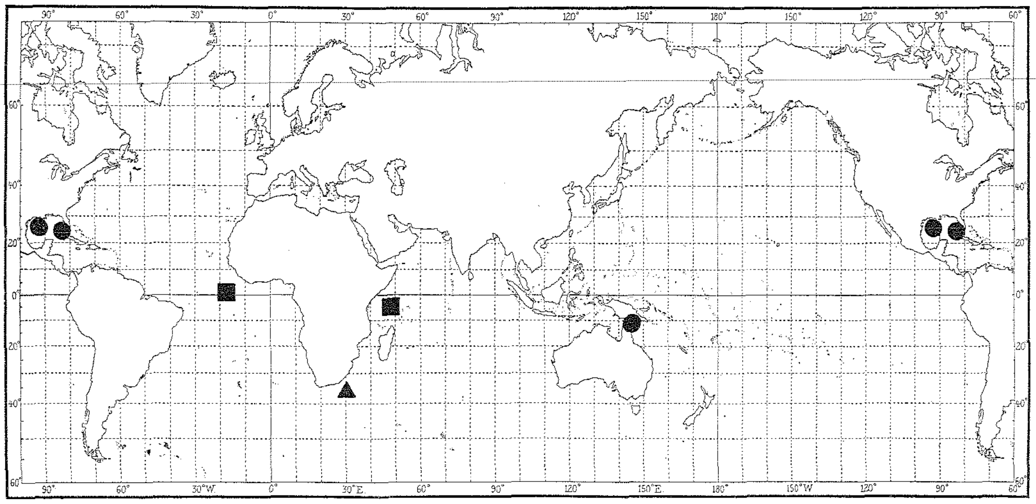


Fig. 5. Records of *Aphyonus gelatinosus* (●), *Aphyonus brevidorsalis* (▲), *Nybelinia erikssoni* (■).

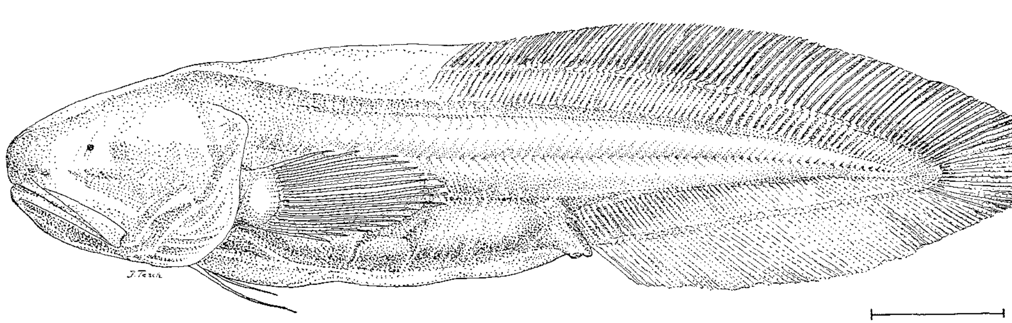


Fig. 6. Holotype of *Aphyonus brevidorsalis* n. sp., SL 71 mm.

Aphyonus brevidorsalis n. sp.

Fig. 6

Aphyonus: Bruun 1953, fig. on p. 168.
Aphyonus: Grey 1956, p. 92.
Aphyonus sp.: Nielsen, Jespersen & Munk 1968, p. 247.

Material examined (1 specimen):

Holotype (SL 71 mm, ♂); "Galathea" St. 194, off Durban (34°09′S, 30°45′E); 4360 m; shrimp otter trawl. 7. Febr. 1951. ZMUC P77452.

Diagnosis and relationship:

A. brevidorsalis differs from *A. gelatinosus* in several characters. Some of these are mentioned below with those of *A. gelatinosus* in brackets: Number of dorsal rays 72 (106-116), anal rays 58 (65-68), caudal vertebrae 39 (51-53), and elongated gill rakers on the anterior arch 9 (3-4) (cf. Figs. 3 and 10). The long gill rakers on the anterior arch are dentigerous (the long rakers are edentate). Four rakers on the fifth gill arch (no rakers on the fifth arch). Origin of dorsal fin over the tip of the pectoral fin (anterior dorsal fin-ray somewhat in front of the pectoral base). Depth of body 21.0 % of the standard length (16.5-17.5 %). No otoliths visible on radiographs (otoliths present). The copulatory apparatus consists of a pair of claspers and a short penis (one medially placed clasper and a well developed penis).

The specific name refers to the short dorsal fin.

A. brevidorsalis differs from a number of the key-characters of *Aphyonus* mentioned in Norman's key to the oceanic genera of Brotulidae (1939, p. 80). (Norman's characters are given in brackets): 1. The pigmented eyes visible (no externally visible eyes). – 2. Operculum with a delicate bifurcated spine (no spines). – 3. Origin of the dorsal fin over the tip of the pectorals (more or less above base of pectoral). – 4. Vent placed posterior to the middle of the total length (never far in front of the middle of the total length). – 5. Pectoral base slightly prolonged (pectorals normal).

Description:

All the more important meristic and morphometric characters are given in Table 3. The body is compressed, and the head is almost twice as broad as the body. The dorsal part of the head is flat. The caudal part of the body is short and rounded. The pterygophores of the dorsal and anal fins are very prominent, visible through the thin, overlying tissues. The dorsal fin issues above the tip of the pectorals. The anterior anal fin-ray is much closer to the caudal base than to the snout (the preanal length forms 59 % of the standard length). The pectoral peduncle is somewhat prolonged, formed as an axe. The length of the peduncle equals the base of the pectoral fin. The single-rayed ventral fins are placed well in front of the pectoral base. The head as well as the body are covered with a very loose, transparent skin. The snout is slightly protruding. The nostrils are placed closer to the upper lip than to the eye (Fig. 6). The upper jaw ends somewhat behind the very small eye, which is provided with black pigment and placed rather deep in the head. However, the eye is easily seen through the transparent skin. A poorly developed, bifurcated spine is found dorsally on the operculum, covered by the skin. The distinct musculi infracarinales mediales are very broad. The ratio between the length and the width of one of the middle "fields" represents about 0.2. The radiographs show no trace of otoliths.

Lateral line system. Some very small lateral line papillae are found along the midline of the body and on the head. Owing to the torn skin the rows on the head cannot be reconstructed.

Dentition. There are only three dentigerous bones in the mouth cavity (Figs. 7 and 8). The

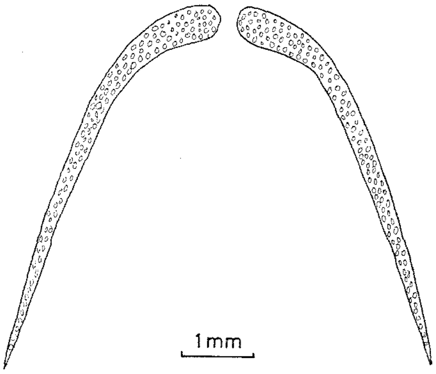


Fig. 7. Dentition of dentaries of the holotype of *A. brevidorsalis.*

premaxillaries, which are rather broad at the symphysis, are provided with teeth in the anterior third only. Some of the teeth were probably lost, judging from the unequal dentition of the two halves. The pattern and size of the teeth correspond to what is found in *A.gelatinosus,* viz. a few larger teeth on the broad part and the smaller ones placed more laterally. No separate teeth were observed in the vomer as apparently they are grown together, forming an irregular tooth-plate. The dentaries are provided with many close-set, rather blunt teeth, placed in 6-7 irregular rows anteriorly and in 1-2 rows posteriorly. In contrast to *A.gelatinosus* all the teeth on the dentaries are of almost the same size.

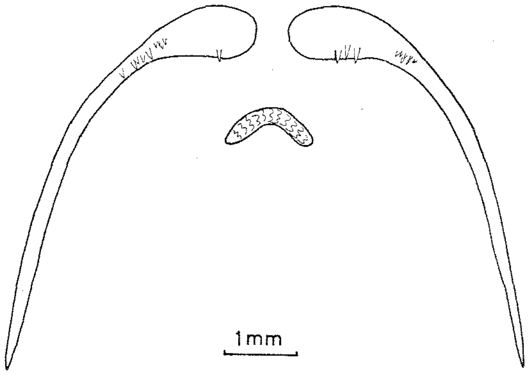


Fig. 8. Dentition of vomer and premaxillaries of the holotype of *A. brevidorsalis.*

Vertebral column. The following particulars are based on radiographs only, a method by which it may be impossible to detect, e.g., the ribs in poorly ossified specimens like the present one. There are 32 precaudal and 39 caudal vertebrae. The thin, pointed neural arches and spines gradually decrease in length, and become more depressed towards the caudal tip. The anterior spine is of the same length as the following neural spines. Parapophyses and ribs apparently are not present on the anterior 11 vertebrae. It is not possible to see where the parapophyses start to form the haemal arches. There is a distinct transition between the precaudal and the caudal vertebrae (Fig. 9). The vertebral centra are almost rectangular in lateral view. The ratio between the length and the height of the last precaudal vertebral centrum is 0.5 approx., and the ratio in the 20th caudal vertebral centrum is 0.8. The radiographs show numerous thin lines on the centra which seem to be parts better ossified than the rest of the centra. The pectoral radials are similar to those of *A.gelatinosus.* No details of the caudal skeleton can be seen on the radiographs.

Gill cavity. The anterior, right gill arch is shown in Fig. 10. (The gill laminae are excluded). On the lower branch there are nine more or less elongated rakers, which gradually decrease in length ventrally, and four short ones all provided with small teeth. Only one raker is present on the epibranchiale. There are no rakers in the outer row on the hypobranchiale, but one in the inner row. The anterior, left arch has an equal number of well developed rakers as the right, but there is one raker in the outer and two in the inner row on the hypobranchiale. The rakers in the inner row are equal

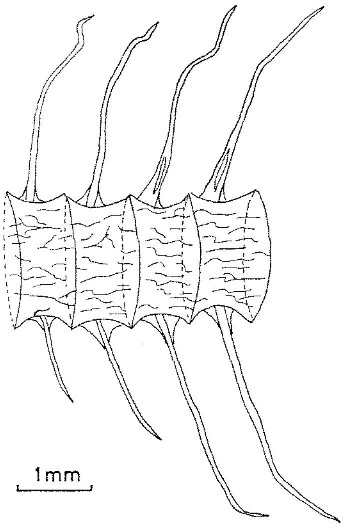


Fig. 9. Transition between precaudal and caudal vertebrae in the holotype of *A. brevidorsalis.*

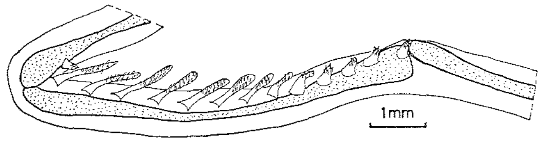


Fig. 10. Anterior, right gill arch of the holotype of *A. brevidorsalis.*

in size to those in the outer row on the 2nd-4th gill arches. All rakers are dentigerous. Below is given a survey of the number of rakers from both sides of the holotype:

1st gill arch with 1/13-14 rakers
2nd gill arch with 1/13-14 rakers
3rd gill arch with 1/11-12 rakers
4th gill arch with 1/10-12 rakers
5th gill arch with 1/3 rakers

The main stem of the gill laminae is provided with a number of plate-like appendages, which considerably enlarge the respiratory surface. There are 40 gill laminae approx. on the anterior arches placed on the upper and the lower branch. No gill laminae are present on the 4th and 5th arches. The laminae are very short, about the length of the smallest gill raker. The dorsal part of the branchial cavities is not intact so it can not be stated whether pseudobranchs are developed. The pharyngeal plates are very small. Only two of the upper ones are provided with teeth.

Colour. Except for the black eyes and a few brown spots dorsally in the abdominal cavity the specimen is coloured by the yellowish muscular tissues as the skin is quite transparent.

Viscera. The rather thick-walled oesophagus and stomach are about 15 mm long and 2 mm in diameter. The anterior 15-20 mm of the intestine is 5 mm approx. in diameter, very thin-walled and provided with an irregular pattern of folds which enlarge the inner intestinal surface. In the present condition the intestine is much torn. Fig. 11 shows, among other things, a much dilated anal opening, due to the fact that part of the intestine was hanging outside the anus during fixation. The small liver ends at the anterior part of the intestine.

Gonads and reproduction:

Sections of one of the gonads (7 mm long and 2-3 mm broad) showed that it was a testis. The dorsal sperm duct contained numerous spermatophores. Most often the heads of the spermatozoa were located at one end of the capsule. The spermatogenic tissue contained both spermatophores and young developmental stages. The average length of the spermatophores was c. 45 μ (Nielsen, Jespersen & Munk 1968, pl. XXIII fig. 2). The copulatory apparatus consists of a thick-walled urogenital sinus, a pair of claspers, and a very short penis at the distal end of the sinus. Fig. 11 shows the copulatory apparatus in ventral view, the cavity therefore is excluded. Female specimens of *A. brevidorsalis* are unknown, but the presence of spermatophores and a penis suggest internal fertilization.

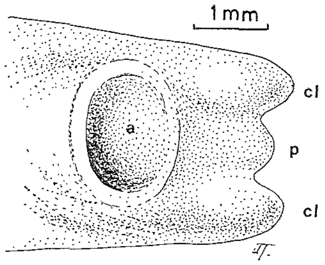


Fig. 11. Ventral view of anal opening (a) and male copulatory apparatus (cl: clasper, p: penis) of the holotype of *A. brevidorsalis*.

Biology:

The trawl in which the present specimen was caught fished typical bottom fishes (Ipnopidae and Macrouridae) as well as pelagic fishes such as Sternoptychidae, Gonostomatidae, and Myctophidae. The only stomach contents found were fragments of small indeterminable crustaceans.

Distribution:

Only known from the type locality off Durban, South Africa, (Fig. 5), over a depth of 4360 m. As regards the vertical distribution see p. 19.

Nybelinia **n. gen.**

Type species by monotypy *Barathronus erikssoni* Nybelin, 1957, p. 308. The holotype of *B. erikssoni* was caught close to the equator just east of the Mid-Atlantic Ridge.

Nybelin (1957, p. 309) found some differences between his specimen and the earlier described *Barathronus* spp., but considered them of specific value only. He also found that his new species approached *Sciadonus* and *Leucochlamys* (cf. p. 62 and p. 69, respectively) owing to the rather slender body and the great preanal length. Nybelin's reasons for referring *erikssoni* to the genus *Barathronus* were the agreement in the shape of the mouth cleft ("very oblique") and the pectoral fin-base ("although somewhat spatulate in *erikssoni*").

By courtesy of my colleagues I was able to compare the holotypes of all the species referred to the genus *Barathronus*. This made me establish a new genus for the species *erikssoni*. A specimen caught north of Madagascar by the Galathea Expedition proved to be conspecific with Nybelin's specimen.

Diagnosis:

An aphyonid fish with a compressed body and a broad and high head. The caudal part of the fish only represents 35-40 % of the standard length. The eyes are placed somewhat under the skin and have very little pigment. The upward directed mouth cleft forms an angle of about 45° with the horizontal plane. The dentaries, premaxillaries and vomer are dentigerous, but without fangs. The anterior gill arch is provided with seven rather long, dentigerous rakers and 17-18 shorter ones. Pseudobranchs are not developed. The pectoral peduncle is a little longer than wide. There are 86 dorsal, eight caudal, 52-53 anal and 23-25 pectoral fin-rays. The small ventral fins are provided with one ray each. There are 40 precaudal and 36-38 caudal vertebrae. The neural and haemal spines are rather weak. The precaudal vertebrae are without ventrally directed processes. The copulatory apparatus of the female is provided with two claspers and a median fold. The male has a urogenital sinus ending in a penis-like appendage and no claspers.

This new genus is named after Professor ORVAR NYBELIN, Gothenburg, who kindly placed his material at my disposal.

Relationships:

Below is mentioned some characters which are differently developed in *Nybelinia* and in the most closely related genus, *Barathronus* Goode & Bean, 1886 (those of the latter in brackets): Rectangular vertebral centra (sand-glass shaped vertebral centra in ripe specimens). Precaudal vertebrae 40 (31-37). No ribs and parapophyses (both ribs and parapophyses present). Caudal fin with eight rays (10, very rarely nine). About 25 dentigerous gill rakers on the anterior arch, seven of which are somewhat prolonged (24-33 long, thin rakers). No fang-like teeth (fangs on the vomer, palatines, and premaxillaries). Gill laminae few and short (numerous, rather long gill laminae). The copulatory apparatus is differently developed in the males as well as in the females of the two genera.

Nybelinia and *Meteoria* are compared on p. 58.

Nybelinia eriksssoni (Nybelin, 1957)

Fig. 12

Barathronus erikssoni Nybelin, 1957, p. 308, pl. VII, figs. 1, 5 and 7.
– –: MARSHALL 1960, p. 111.
– –: MUNK 1965, p. 27.
– –: MUNK 1966, p. 37.
– –: NIELSEN, JESPERSEN & MUNK 1968, p. 242.

Material (2 specimens):

Holotype (SL 75 mm, ♀); Swedish Deep-Sea Exped. St. 342 (01°03′N, 18°40′W – 00°58′N, 18°27′W); 5250-5300 m; trawl. 16. July 1948. NHMG Pi. ex. 1743.

1 specimen (SL 70 mm, ♂); "Galathea" St. 234 (5°25′S, 47°09′E); 4820 m; herring otter trawl; globigerina ooze. 10. Mar. 1951. ZMUC P77455.

Both specimens are very well preserved.

Diagnosis:

With the characters of the genus (see above).

Description:

The meristic and morphometric characters of the two specimens show much similarity (Table 4). In the original description of *B. erikssoni* the "Length of the body" was 78 mm, while measuring the standard length in accordance with HUBBS & LAGLER (1958) gave 75 mm. The left, anterior gill arch of the holotype is lost. The head is large being higher than the maximum body depth. The body is thin and rather slender. All the viscera, most of the vertebrae and muscles and many details in the head skeleton are visible in transparency. The dorsal fin issues well behind the tip of the pectorals. The anterior ray of the anal fin is much closer to the caudal fin than to the tip of the snout; (the preanal length forms 62-64 % of the standard length). The poorly developed ventral fins, each with one ray only, are placed below the posterior part of the operculum. The pectorals are provided with a peduncle the width of which forms 0.8 of the length. The lower jaw is somewhat protruding. The maxillary is

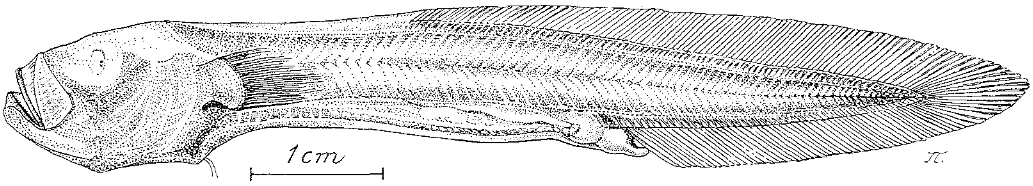


Fig. 12. *Nybelinia erikssoni* (Nybelin, 1957), SL 70 mm. ZMUC P77455.

Table 4. Meristic and morphometric characters of *N. erikssoni.*

	Holotype Pi. ex. 1743	"Galathea" St. 234 P 77455
Standard length	75	70
Meristic characters		
Dorsal fin	86	86
Caudal fin	8	8
Anal fin	52	53
Ventral fin	1-1	1-1
Pectoral fin[1]	24-25	24-23
Branchiostegal rays[1]	9-	9-9
Gill rakers on anterior arch[1]	3/1/21-	3/1/20-3/1/21
Vertebrae (incl. urostyle)	40+38	40+36
Anterior anal-ray below dorsal-ray No.	31	34
Anterior anal-ray below vertebra No.	41	41
Anterior dorsal-ray above vertebra No.	21	22
Morphometric characters as % of standard length		
Head	20.5	20.0
Upper jaw	10.0	10.0
Diameter of pigmented eye-ring	1.6	1.7
Interorbital	—	3.6
Preventral	20.0	20.5
Preanal	62	64
Predorsal	40.0	41.5
Distance from base of ventral fins to anterior anal-ray	44.5	45.0
Base of anterior 10 dorsal-rays	6.7	6.0
Base of anterior 10 anal-rays	7.2	7.1

1. Right and left side, respectively.

vertically expanded posteriorly. It ends below the anterior edge of the eye. The upward directed mouth cleft forms an angle of 45° approx. with the horizontal plane. The nostrils are indistinct in the "Galathea" specimen, but in the holotype they are placed close together with the posterior nostril closer to the lip than to the eye. There are no rims around the circular openings. The indistinct eyes are situated beneath the skin. The diameter of the centrally placed, pigmented part of the eye is only about 0.2 mm. This small pigmented spot is placed in the middle of the eye and is formed by proliferated cells from the retinal pigmented epithelium (Munk 1966, p. 37). A very narrow, black ring (a little more than 1 mm in diameter) made of the reduced iris, surrounds the black, central spot. A lens seems to be absent. According to Nybelin (1957, p. 309) "... the weak pigmentation of the eye is caused by reduction during ontogenetic development as the embryos have rather well pigmented eyes". This also appears from a comparison between Figs. 12 and 19. The eye of *Barathronus affinis* Brauer, 1906 was described by Brauer (1908, p. 161), and, according to Munk (1966, p. 37), the eyes of *N. erikssoni* and *B. affinis* are very much alike. The musculi infracarinales mediales (cf. p. 9) are very distinct in both specimens, but the dimensions of the darkbrown muscular "fields" do not agree. The ratio between the length and the width of the middle "fields" is 1.5 in the holotype (♀) and 0.6 in the "Galathea" specimen (♂). This might be a sexual difference. Otoliths are not seen on the radiographs.

Lateral line system. The lateralis system is more or less distinctly developed, best on the holotype. Posteriorly on the body there is a row of small papillae in the midline; above the anus it bends upward, running closer to the dorsal edge. The papillae are here larger than the more posterior ones. A few larger ones are also situated close to the pectoral fin. Papillae are found in a relative small number all over the head, but owing to the loose and partly torn skin no rows of papillae can be distinguished on the head.

Dentition. All the teeth are small and pointed.

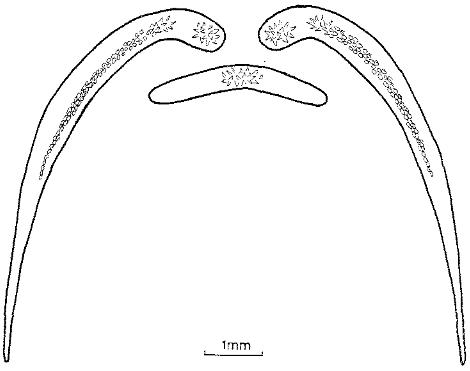


Fig. 13. Dentition of vomer and premaxillaries of the holotype of *N. erikssoni.*

There are no teeth in the upper jaw symphysis. Fig. 13 shows the tooth-pattern of the premaxillaries and the vomer. Closest to the symphysis is an oval patch consisting of 10-15 conical teeth partly separated from the rest of the premaxillary teeth. The remaining part of the premaxillaries has four irregular tooth-rows anteriorly, gradually decreasing to only one row more posteriorly, while the last part is edentate. The outer row contains the longest teeth. The inner rows of teeth are recurvated. Only a very small median area of the vomer is dentigerous, with 10-15 teeth in a patch in the holotype, while the "Galathea" specimen has 8-10 teeth. There are no teeth on the palatines. The lower jaw symphysis is dentigerous. The dentaries are provided with about four irregular tooth-rows anteriorly, decreasing to only one row more posteriorly. The last third is edentate. Relatively long and small teeth are placed among each other in the dentaries. Generally, the teeth are longer than in the premaxillaries.

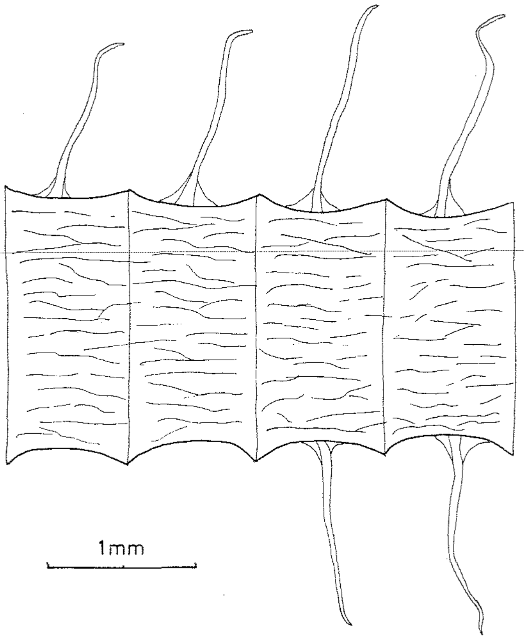


Fig. 14. Transition between precaudal and caudal vertebrae of *N. erikssoni,* SL 70 mm. ZMUC P77455.

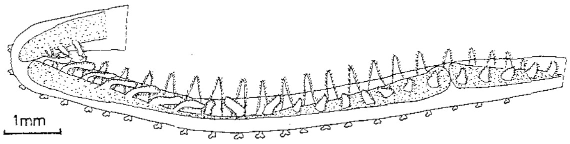


Fig. 15. Anterior, right gill arch of the holotype of *N. erikssoni.*

Vertebral column. The radiographs of the "Galathea" specimen came out much better than those of the holotype, so the information below is based mainly on the former. There are 40 precaudal and 36-38 caudal vertebrae. The anterior neural arch and spine is of the same length as the second arch and spine. The 3rd-5th spines become rapidly shorter, and from the 6th spine the length decreases gradually to the caudal fin. The radiographs show no trace at all of parapophyses and ribs. The first vertebra with a haemal spine is placed just above the anterior anal fin-ray. Both neural and haemal spines are very long and thin, often with the pointed tip bent. The transition between the precaudal and caudal vertebrae is distinct (Fig. 14). The ratio between the length and the height of the posterior precaudal vertebral centrum is 0.5 approx. and the ratio in the 20th caudal vertebral centrum is 0.7 approx. Two large hypural plates are developed.

Gill cavity. Fig. 15 shows the right, anterior gill arch of the holotype. The outer row of gill rakers consists of three rather small, but slender rakers on the epibranchiale, one rather long raker in the angle between the epi- and ceratobranchiale, 16 rakers on the latter bone, six of which are relatively long and bent, and five rakers on the hypobranchiale. All the gill rakers in the inner row are nearly of the same size as the corresponding ones in the outer row on the 2nd-4th arches. In Fig. 15 many of the outer rakers appear to be too short which is due to the fact that they were drawn seen partly from above. All rakers bear several small denticles. None of the 2nd-4th gill arches have prolonged rakers, but, on the other hand, only a few of the most dorsal and ventral rakers are so poorly developed that they only form small knobs. Below is given a survey of the number of rakers on all the five arches based on both specimens (distinction is made between the cerato- and hypobranchial rakers for the anterior arch):

1st gill arch with 3/1/6 (long)+9-10 (short)/5 rakers
2nd gill arch with 2-3/21 short rakers
3rd gill arch with 2/19 short rakers
4th gill arch with 0-1/16-17 short rakers
5th gill arch with 11-12 short rakers

The gill laminae are very poorly developed, and each arch is only provided with a small number (20-25 laminae on each of the first and second arches). Pseudobranchs and lower pharyngeal teeth are not developed. The teeth in the upper pharyngeal plates are minute.

Colour. The only black-pigmented parts are the eyes and the peritoneum which dorsally is provided with numerous spots. The holotype is otherwise mostly violet-brown, but whitish where the muscular tissue is very thin. The "Galathea" specimen is generally more transparent, and the musculature is yellow-brown.

Viscera. The oesophagus and stomach are thick-walled and rather narrow. The intestine-wall is so thin that the contents are visible. The diameter of the anterior part of the intestine is twice that of the stomach. The intestine is roughly one-third longer than the distance from the pyloric part of the stomach to the anus. A less transparent rectal part is indicated by a constriction in the holotype. The liver is small and ends just in front of the anterior part of the intestine.

Gonads:

Female. By examining the holotype in transparency it became evident that the specimen was a female with well developed embryos. A more thorough examination of the ovaries (length 13 mm) showed that they contained light-brown, rather small eggs and dark-brown, somewhat larger eggs and a total of five, free embryos. These three components were mixed together in the ovaries. Apparently, the ovaries were not completely filled out. Probably only the dark eggs were fertilized. The two ovaries contained the following amount of eggs and embryos (in brackets is mentioned the number from the right and left ovary, respectively): Light-brown eggs 779 (325 and 454) varying in diameter from 0.1-0.4 mm approx., darker eggs 62 (25 and 37) with a diameter, varying from 0.2-0.7 mm and 5 (2 and 3) embryos 6.5-9 mm long. Fig. 16 shows the number and diameter of the eggs from both ovaries. The posterior fifth of the ovaries are grown together. The copulatory apparatus which consists of a pair of claspers and a median fold is shown in Fig. 17. The area round the anus is thickened.

Male. The 13 mm long, much distended gonads of the "Galathea" specimen are testes. Sections of a part from the left testis showed that the very voluminous testicular duct is filled with sperma-

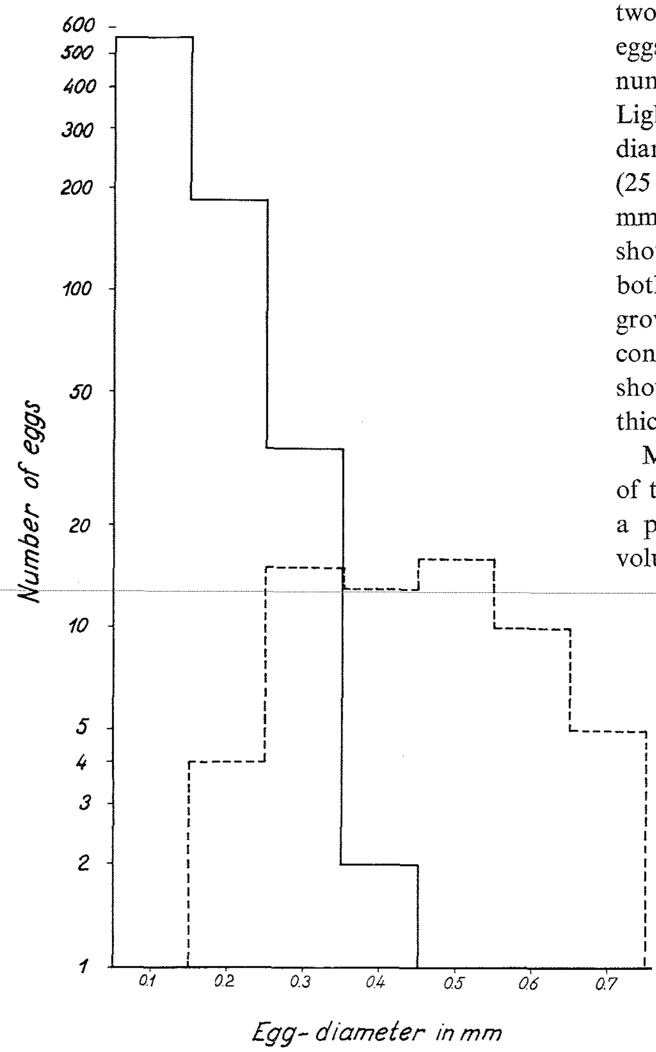
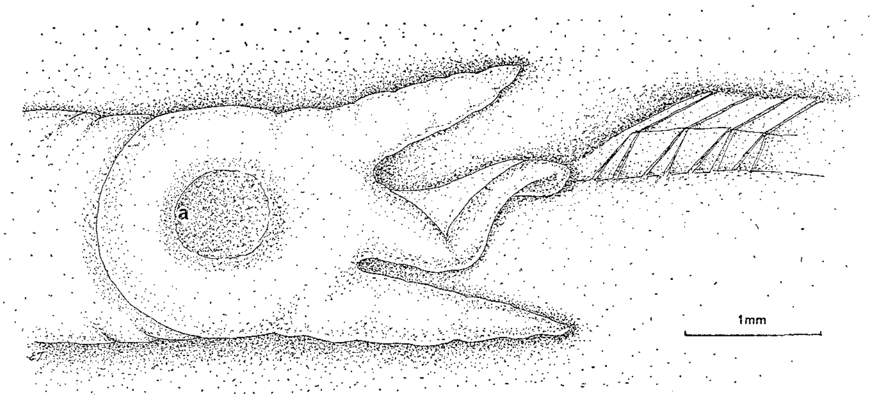


Fig. 16. Number and diameter of eggs, measured to nearest tenth of mm, from both ovaries of the holotype of *N. erikssoni*. The full-drawn diagram represents the light-brown eggs and the broken-line diagram the dark-brown eggs. The graphs are drawn on semilogarithmic paper.

Fig. 17. Anal opening (a) and female copulatory apparatus of the holotype of *N. erikssoni*, SL 75 mm.



tophores. The maximum length of these oval capsules is about 70 μ. In most cases the spermatozoa were placed with the heads in the same direction. The testicular tissue contained bundles of spermatozoa as well as younger developmental stages (see also NIELSEN, JESPERSEN & MUNK 1968, p. 247). Also the testes were grown together posteriorly. The common excretory duct was only a few mm long. The copulatory apparatus consists of a large, thick urogenital sinus which ends in a penis-like appendage. Medially was found a short papilla, almost hidden by the urogenital sinus. Claspers were not developed (Fig. 18).

Reproduction and biology:

Judging from the large, free and well developed embryos (Fig. 19) it is obvious that *N. erikssoni* is viviparous. The ovaries were not fully expanded, so the presence of only few embryos might indicate that the female was caught at the termination of a period of delivery. The number of dark eggs most probably indicates the size of the clutch (c. 60). The testes contained many spermatophores which shows that the male was ready for spawning. The many neotenic features indicate a pelagic occurrence (cf. 79). The stomach contents were of no help when trying to decide whether *N. erikssoni* is pelagic or benthic, since the "Galathea" specimen only held a few, small, indeterminable remains of crustaceans, and the digestive canal of the holotype was empty.

Distribution:

Fig. 5 shows the localities of the two specimens of *N. erikssoni*. The extremely good condition of the two specimens suggests that they were caught during the hauling up of the trawl. Both on the Swedish and the Danish expeditions the trawl contained pelagic as well as bottom living animals at the two stations in question. Owing to the pelagic occurrence it is not surprising that the species is distributed both in the Atlantic and in the Indian Oceans.

Description of an embryo:

A number of five embryos were found in the two ovaries. All of them lie more or less stretched out. The very small number of free embryos indicates that they may be the remains of a clutch already brought forth. This means that Fig. 19, illustrating a 7.5 mm long embryo, most probably is fairly similar to a larval *N. erikssoni*. No aphyonid larvae are known, and also among the Brotulidae there are extremely few larvae which have been referred with certainty to an adult species (NIELSEN 1966, p. 93). Since in this case there is no doubt about the identity of the "larva", a description is given below (the five embryos varied in length from 6.5-9 mm):

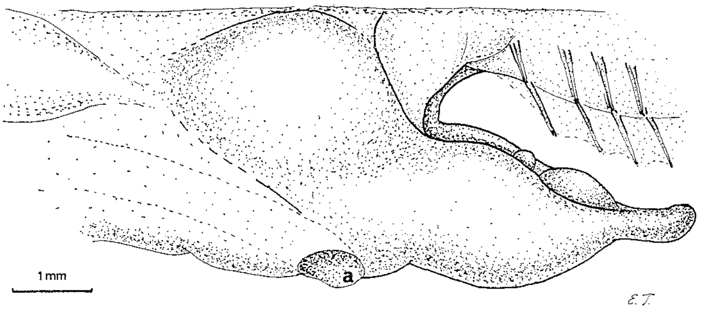


Fig. 18. Anal opening (a) and male copulatory apparatus of *N. erikssoni*, SL 70 mm. ZMUC P77455.

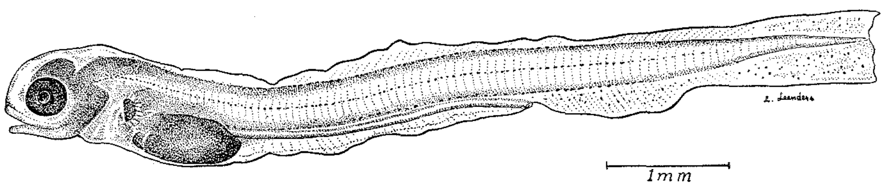


Fig. 19. Embryo of *Nybelinia erikssoni* (length 7.5 mm) from the holotype.

Standard length 7.5 mm. The horizontal diameter of the pigmented eye forms 4 % of the SL (diameter of pigmented eye-ring 1.6-1.7 % in the adult). Snout to anus represent 52 % of SL (snout to anal fin 65 % in the adult). There is a united dorsal, caudal and anal fin-fold with a few of the fin-rays discernible. The ventral fins can not be seen, but the pectorals are distinct although it is impossible to count the rays. The vertebrae are short and high. The intestine is long and straight. The large, brown area in the abdominal cavity most probably is the rest of the inner yolk sack. There are rows of pigment along the dorsal and ventral edges, along the midline and scattered over the dorsal and anal fin-fold. Pigment is also found at the base of the pectoral fin-rays and on the dorsal part of the head. The eye-ball is dark brown, and the lens yellow like the rest of the body tissues.

Barathronus Goode & Bean, 1886

Barathronus Goode & Bean, 1886, p. 164, type species *Barathronus bicolor* by monotypy.

Alexeterion Vaillant, 1888, p. 282, type species *Alexeterion parfaiti* by monotypy.

Remarks on *Alexeterion:*

Alexeterion was described by VAILLANT (1888) on basis of the holotype of *A.parfaiti.* The reason why he did not compare it to *Barathronus* most certainly is that he had no knowledge of this genus, described only two years earlier. The holotype of *A.parfaiti* was in a poor condition, but from the collection in Monaco ROULE (1915) described a well preserved specimen (SL 100 mm) as *A.parfaiti.* Strange enough, he did not consider the difference in number of dorsal and anal fin-rays as being of specific value; dorsal 48 *vs.* 70 and anal 40 *vs.* 63 rays in the holotype and Monaco specimen, respectively. A re-examination of the holotype shows that it actually has a much greater number of rays than stated by VAILLANT, which is in agreement with the Monaco specimen. ROULE now gave a new description of *Alexeterion* mainly based on the latter specimen. His generic diagnosis differed from VAILLANT's diagnosis in the following characters: Ventral fins, lateral line and vomerine teeth present. My re-examination of the holotype shows the presence of both ventral fins and a few lateral line papillae on the posterior part of the body, and the vomer has marks which might derive from broken fangs. ROULE found so great likeness between *Barathronus* and *Alexeterion* that he considered the latter a junior synonym of *Barathronus.* – NYBELIN (1957, pp. 313-14) described a 25 mm long aphyonid specimen, but since it was a juvenile he did not give it a name. He compared it to all known Aphyonidae and ended with *Barathronus parfaiti* which, according to VAILLANT's description, has about the same number of fin-rays. Consequently, NYBELIN suggested that his specimen probably is a juvenile *B. parfaiti* (cf. p. 53). Owing to the difference between *B. parfaiti* and the other *Barathronus* spp. in number of fin-rays he said "I think it probable that this species when better known, will be removed from the latter genus and constitute a genus of its own, in which case the genus name *Alexeterion* would be valid again". As mentioned above, I found a much higher number of fin-rays in the dorsal and anal fin than did VAILLANT, which involves that NYBELIN's reason for revalidating *Alexeterion* is not correct.

Diagnosis:

See also the generic key (p. 12). Rather compressed fishes with a heavy head, an oblique mouth and a caudal part, forming c. 50 % of the standard length. The nostrils are placed close together midway between the upper lip and the eyes. The eyes are placed deep in the head. Only a narrow ring and a central spot are black pigmented. Small teeth are found on the vomer, premaxillaries and dentaries. Fangs in a number of 1-2 are present in each side of the vomer, occasionally 1-2 on the palatines and about five posteriorly in the premaxillaries. The anterior gill arch is provided with 24-33 rakers most of which are long and thin. A pseudobranch consisting of 2-3 filaments and a dorsally placed thymus-like spot are present on either side. Some of the meristic characters are shown in Tables 5-13. Ventral fins, each with one long ray. Pectoral fins

Frequency distribution for some of the meristic characters of *Barathronus* spp.:

Table 5. Dorsal fin-rays.

	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
B. affinis	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
B. bicolor	.	1	2	6	6	5	1	3	4	4	2	5	.	.	1	.	.	.
B. bruuni	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
B. diaphanus ..	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
B. parfaiti	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
B. specimen ..	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.

Table 6. Anal fin-rays.

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
B. affinis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
B. bicolor	.	.	3	6	2	6	1	12	8	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B. bruuni	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
B. diaphanus ..	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B. parfaiti	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
B. specimen ..	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 7. Total vertebrae (incl. urostyle).

	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
B. affinis	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
B. bicolor	2	5	12	16	2	2	.	.	.	.	.	.	.	.	.	.	.
B. bruuni	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
B. diaphanus ..	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B. parfaiti	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.
B. specimen ..	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.

Table 8. Precaudal vertebrae.

	31	32	33	34	35	36	37
B. affinis	.	.	.	1	.	.	.
B. bicolor	1	5	17	18	1	.	.
B. bruuni	.	.	.	.	.	1	.
B. diaphanus ..	.	1	3	.	.	.	.
B. parfaiti	.	.	.	1	.	.	1
B. specimen ..	.	1	.	.	.	.	.

Table 9. Caudal vertebrae (incl. urostyle).

	37	38	39	40	41	42	43	44	45	46	47	48	49	50
B. affinis	.	.	.	.	.	.	.	1	.	.	.	.	.	.
B. bicolor	.	9	21	6	3	.	.	.	.	.	.	.	.	.
B. bruuni	.	.	.	.	.	.	.	.	.	.	.	.	.	1
B. diaphanus ..	1	2	.	.	.	.	.	.	.	.	.	.	.	.
B. parfaiti	.	.	.	.	.	.	.	.	.	.	2	.	.	.
B. specimen ..	.	.	.	.	.	1	.	.	.	.	.	.	.	.

Table 10. Gill rakers on anterior arch (average between right and left side).

	24	25	26	27	28	29	30	31	32	33
B. affinis	1	.	.	.	.	.	.	.	.	.
B. bicolor	.	.	.	.	.	10	17	7	6	.
B. bruuni	.	.	.	.	.	.	.	.	.	1
B. diaphanus ..	.	.	.	.	.	.	2	1	.	.
B. parfaiti	.	.	.	.	.	1	1	.	.	.
B. specimen ..	.	.	.	.	.	.	.	1	.	.

Table 11. Anterior anal ray below dorsal ray number.

	10	11	12	13	14	15	16	17	18	19	20
B. affinis	.	.	.	.	1	.	.	.	.	.	.
B. bicolor	.	.	.	.	.	1	.	13	13	12	2
B. bruuni	1	.	.	.	.	.	.	.	.	.	.
B. diaphanus ..	.	.	.	.	1	1	1	.	.	.	.
B. parfaiti	.	.	1	.	.	.	.	.	.	.	.
B. specimen ..	.	.	.	1	.	.	.	.	.	.	.

Table 12. Anterior anal ray below vertebra number.

	31	32	33	34	35	36	37
B. affinis	.	.	.	1	.	.	.
B. bicolor	.	1	4	24	13	.	.
B. bruuni	.	.	.	.	.	.	1
B. diaphanus ..	1	1	2	.	.	.	.
B. parfaiti	.	.	.	.	1	1	.
B. specimen ..	1	.	.	.	.	.	.

Table 13. Anterior dorsal ray above vertebra number.

	23	24	25	26	27	28	29	30	31
B. affinis	.	.	.	.	1	.	.	.	.
B. bicolor	1	7	15	18	.	.	.	.	.
B. bruuni	.	.	.	.	.	.	.	.	1
B. diaphanus ..	1	1	1	.	.	.	.	.	.
B. parfaiti	.	.	.	.	.	.	1	.	.
B. specimen ..	.	.	1	.	.	.	.	.	.

with 21-25 rays. The pectoral peduncle is not prolonged. Caudal fin with ten rays in 43 specimens and with nine rays in two specimens. Small lateral line papillae are found along the midline of the body and on the head. The male copulatory apparatus is provided with a urogenital sinus and a penis. Paired claspers are not found. A few females have a pair of very small claspers. There are 31-37 precaudal vertebrae, of which the anterior bears the longest neural arch and spine. The two anterior vertebrae have no ventrally directed processes. The following six have thin pleural ribs, and the rest of the precaudal vertebrae are provided with parapophyses. The vertebral centra in adult specimens are sand-glass shaped while in juveniles they are rectangular in lateral view. The caudal skeleton of two alizarin-stained specimens was examined (cf. Figs. 26 and 27). The pectoral fins are supported by five radials, while all the ophidioids examined by GOSLINE (1968, p. 25) have four radials.

Relationship:

Barathronus differs from all other aphyonid genera by not showing many neotenic characters, e.g., do adult specimens have sand-glass shaped vertebral centra. The closest related genus seems to be *Nybelinia* (cf. p. 22).

Biology:

BRAUER (1906, p. 347) wrote, that in spite of the fact that *Barathronus* lives in ooze (benthically) it is found both in the Atlantic and Indian Oceans. However, all other authors who have discussed the biology of *Barathronus* have concluded that it is a pelagic genus, most of them referring to a juvenile specimen of *B. parfaiti* (cf. p. 53). NYBELIN (1957, pp. 281 and 310) used the following criteria for listing *Barathronus* as a pelagic genus: Semitransparent fishes with an upward directed mouth and reduction of the black pigment in the eyes in the adult stage. However, none of these characters are typical of pelagic fishes.

The vertical distribution of the only well known species, *B. bicolor,* is discussed on p. 44, and it seems most probable that at least the adults of this species occur on the bottom. Larvae of *B. bicolor* are not known. No adult *Barathronus* specimens have been caught at depths greater than c. 1850 m, while the three known juveniles were taken at stations at depths varying from c. 2900-c. 5000 m. One of the juveniles, *B. bruuni,* was caught in a trawl which was hauled from a depth of c. 1700 m to the surface with c. 4800 m to the bottom. This strongly indicates that the juveniles occur (bathy)pelagically and the adults on the bottom at bathyal depths.

The fact that all catches of adult specimens were made close to the shore also indicates that *Barathronus* has a bathyal occurrence.

The stomach contents gave no information of the vertical distribution of *Barathronus,* as the only macroscopical remains were parts of unidentifiable copepods.

A thorough examination of the gonads of *B. bicolor* is described on p. 39. It showed that the number of fertilized eggs was great, which necessitates a rich supply of food, and that spermatophores were not observed in the ovaries, in contrast to other aphyonid genera. There is no distinct spawning season.

Distribution:

Figs. 33 and 35 show that *Barathronus* is found in tropical and subtropical zones of the Atlantic and Indian Oceans. The only Pacific locality is off Japan.

Species:

Five species of *Barathronus* are described in this paper. In addition, one specimen has not been referred to species, but is described as a "*Barathronus* specimen" (p. 57). Nielsen, Jespersen & Munk (1968, p. 247 footnote) mentioned that the West Atlantic *Barathronus* material probably consists of more than one species due to different length of the penis. However, it is shown elsewhere (cf. p. 42) that the penis-length apparently is dependent of the developmental stage of the testes. No. 14 in the list of material (Nielsen et al. 1968, p. 242), listed as *Barathronus* sp., belongs to *B.parfaiti*. Chan (1965, p. 51) listed a *Barathronus* sp. which he the following year described as a new genus and species of the family Brotulidae, *Barbuliceps tuberculatus* Chan, 1966. *Barathronus erikssoni* Nybelin, 1957, in this paper is referred to a new genus (p. 22).

B.bicolor and *diaphanus* are closely related, and also *B.affinis, bruuni* and *parfaiti* apparently form a group (cf. Tables 5-13). Only *B.bicolor* is represented by a large material (42 specimens). *B.diaphanus* is known in four and the remaining three species in 1-2 specimens each. Consequently, the natural variation of the four species is unknown so it is difficult to decide whether some of the species ought to be synonomized.

The following key might prove to be useless when more material is available. Only by dividing the key into an Atlantic Ocean and an Indian Ocean part is it possible to make an unambiguous, but artificial key, as in this way the two species-groups are split up. Furthermore, a now lost *Barathronus* specimen has been caught off South Africa (p. 34) which makes the abovementioned geographical division of the key inadequate.

Key to the species of *Barathronus*

I. Less than 60 anal fin-rays; not more than 75 vertebrae
  a. Most often teeth on palatines; testicular excretory duct shorter than ripe testes (Atlantic Ocean) .... *bicolor* Goode & Bean, 1886
  b. No teeth on palatines; testicular excretory duct longer than ripe testes (Indian Ocean) .... *diaphanus* Brauer, 1906
II. More than 65 anal fin-rays; not less than 78 vertebrae
  a. 24 rakers on anterior gill arch (Indian Ocean) .... *affinis* Brauer, 1906
  b. 29-33 rakers on anterior gill arch
    1. Predorsal 43.5 % of the SL (Indian Ocean) .... *bruuni* n.sp.
    2. Predorsal 51 % of the SL (Atlantic Ocean) .... *parfaiti* (Vaillant, 1888)

Barathronus bicolor Goode & Bean, 1886

Fig. 20

Barathronus bicolor Goode & Bean, 1886, p. 164.
– –: Goode & Bean 1896, p. 341, fig. 298.
– –: Jordan & Evermann 1898, p. 2524.
– –: Brauer 1906, pp. 305 and 406.
– –: Gilchrist 1906, p. 158.
– –: Roule 1915, p. 58 and 1916, p. 18.
– –: Thompson 1916, p. 107.
– –: Roule 1917, p. 73.
– –: Barnard 1927, p. 884.
– –: Smith 1953, p. 361, fig. 1013.
Barathronus bicolor Marshall 1954, p. 244.
– –: Nybelin 1957, p. 310.
– –: Grey 1959, p. 344, fig. 57.
– –: Norman 1966, p. 497.
– –: Nielsen, Jespersen & Munk 1968, p. 247.

Material examined (42 specimens):[1]

Holotype (SL 118 mm, ♂); "Blake" St. 163 (16°03′10″N, 61°52′20″W); 1406 m; dredge; ooze, sand. 20. Jan. 1878. MCZ 28077.

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[1] All depths are converted from fathoms into metres, which explains the apparently very exact soundings.

1 specimen (SL 58 mm, ♀); "Blake" St. 230 (13°13′20″N, 61°18′45″W); 848 m; dredge; fine sand. 20. Febr. 1879. USNM 47628.

1 specimen (SL 103 mm, ♂); Dry Tortugas, Florida, (24°40′N, 82°50′W); coll. W. H. LONGLEY. Field No. 62. 19. July 1932. USNM 116855.

2 specimens (SL c. 90-108 mm, 2 ♀♀); "Oregon", north-eastern part of Gulf of Mexico; 366-549 m; 1956. CNHM 65805.

3 specimens (SL 81-97 mm, 3 ♀♀); "Oregon" St. 1908 (12°33′N, 82°20′W); 640 m; 40′ flat trawl. 11. Sept. 1957. CNHM 64581.

1 specimen (SL 104 mm, ♀); "Oregon" St. 2637 (17°37′N, 63°36′W); 512 m; 40′ flat trawl; sand, mud. 30. Sept. 1959. British Museum 1961.9.7.1.

2 specimens (SL 66-74 mm, 2 ♀♀); "Oregon" St. 2824 (29°07.5′N, 88°04′W); 668-722 m; 40′ balloon trawl. 17. July 1960. USNM 202109.

1 specimen (SL 118 mm, ♂); "Oregon" St. 3217 (29°19′N, 87°33′W); 494-585 m; 60/80′ semi-balloon trawl. 9. Febr. 1961. USNM 202108.

1 specimen (SL 97 mm, ♀); "Silver Bay" St. 3516 (24°24′N, 80°00′W); 732-860 m; 40′-2 seam trawl w/2″ M. 9. Nov. 1961. UMML 24227.

1 specimen (SL 92 mm, ♂); "Oregon" St. 3654 (29°08.5′N, 88°00.5′W); 732-750 m; 40′ flat trawl; bottom temp. 8°C. 25. July 1962. USNM 202107.

2 specimens (SL 104-113 mm, ♂+♀); "Oregon" St. 3655 (29°10.5′N, 87°56′W); 640-695 m; 40′ flat trawl. 26. July 1962. USNM 202115.

1 specimen (SL 100 mm, ♂); "Oregon" St. 3656 (29°07.5′N, 87°58′W); 823-914 m; 40′ flat trawl; bottom temp. 6°C. 26. July 1962. USNM 202117.

1 specimen (SL 75 mm, ♂); "Oregon" St. 3660 (29°10′N, 87°57′W); 658-732 m; 40′ flat trawl. 27. July 1962. USNM 202118.

1 specimen (SL 140 mm, ♀); "Oregon" St. 3681 (29°15′N, 87°47′W); 411 m; 130′ flat trawl. 8. Aug. 1962. USNM 202114.

4 specimens (SL 85-103 mm, 3 ♂♂+♀); "Oregon" St. 4145 (24°25′N, 83°29′W); 549 m; 40′ flat trawl; bottom temp. 7.8°C. 14. Dec. 1962. USNM 202116.

2 specimens (SL 60-98 mm, 2 ♂♂); "Oregon" St. 4149 (29°12′N, 87°48′W); 732 m; 40′ flat trawl. 17. Dec. 1962. USNM 202110.

1 specimen (SL 100 mm, ♂); "Oregon" St. 4150 (29°12′N, 87°57′W); 549 m; 40′ flat trawl. 17. Dec. 1962. USNM 202111.

4 specimens (SL 63-72 mm, 3 ♂♂+♀); "Gerda" St. G-131 (24°11′N, 80°57′W); 786-878 m; try-net. 21. June 1963. UMML 12345.

1 specimen (SL 103 mm, ♀); "Oregon" St. 4413 (11°53′N, 69°25′W); 640 m; 40′ flat trawl; bottom temp. 7.8°C. 3. Oct. 1963. MCZ 45999.

1 specimen (SL 106 mm, ♀); "Oregon" St. 4413 – same locality data. USNM 202113.

2 specimens (SL 88-98 mm, 2 ♂♂); "Oregon" St. 4414 (11°54′N, 69°23′W); 732 m; 40′ flat trawl; bottom temp. 6.8°C. 3. Oct. 1963. USNM 202105.

1 specimen (SL 87 mm, ♀); "Oregon" St. 4571 (23°04′N, 86°37′W); 732 m; 10′ beam trawl; bottom temp. 7.5°C. 7. Dec. 1963. USNM 202112.

1 specimen (SL 100 mm, ♂); "Oregon" St. 4580 (29°06′N, 88°06′W); 732 m; 40′ shrimp trawl; bottom temp. 7.2°C. 11. Dec. 1963. USNM 202106.

1 specimen (SL 91 mm, ♂); "Oregon" St. 4730 (27°37.5′N, 92°23.5′W); 732 m; 40′ flat shrimp trawl; bottom temp. 6.7°C. 27. Febr. 1964. ZMUC P77462.

1 specimen (SL 93 mm, ♂); "Oregon" St. 4814 (24°49′N, 96°27′W); 914 m; 40′ shrimp trawl; bottom temp. 5°C. 12. Apr. 1964. ZMUC P77463.

4 specimens (SL 97-113 mm, 4 ♂♂); "Oregon", north-eastern part of Gulf of Mexico; 366-549 m. UMML 7800.

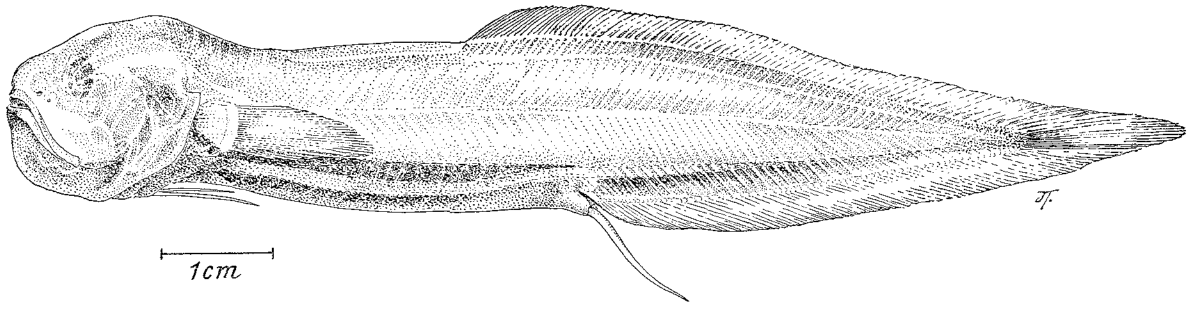


Fig. 20. *Barathronus bicolor* Goode & Bean, 1886, SL 91 mm. ZMUC P77462.

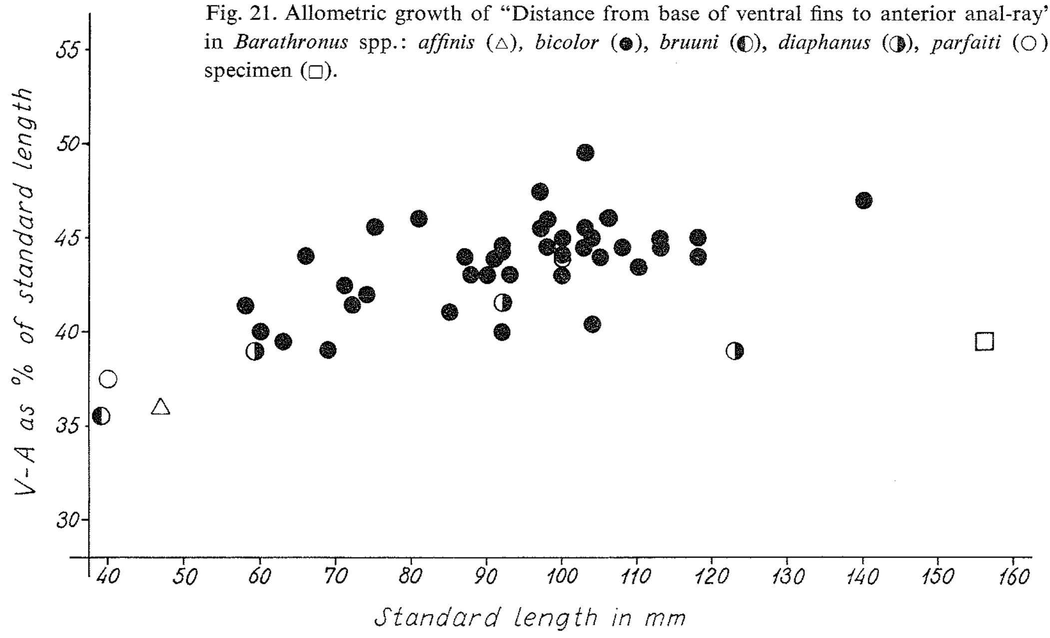


Fig. 21. Allometric growth of "Distance from base of ventral fins to anterior anal-ray" in *Barathronus* spp.: *affinis* (△), *bicolor* (●), *bruuni* (◐), *diaphanus* (◑), *parfaiti* (○), specimen (□).

Table 14. Meristic and morphometric characters of *B. bicolor*.

	Variation	Average	Holotype
Standard length in mm	58-140 [42]		118
Meristic characters			
Dorsal fin	65-78 [40]	70.4	69
Caudal fin	9-10 [36]	9.9	10
Anal fin	52-59 [40]	55.9	57
Ventral fin[1]	1/1 [42]	1/1	1/1
Pectoral fin[1]	22-25 [40] / 22-25 [38]	23.5/23.2	23/23
Gill rakers on anterior arch[1]	28-33 [39] / 29-32 [35]	30/30	30/30
Branchiostegal rays[1]	7-8 [16] / 7-8 [16]	7.9/7.9	—
Vertebrae (incl. urostyle)........	70-75 [39]	72.4	73
Precaudal vertebrae	31-35 [42]	33.3	33
Caudal vertebrae	38-41 [39]	39.0	40
Ant. anal-ray below dorsal ray No.	15-20 [41]	18.0	15
Ant. anal-ray below vertebra No.	32-35 [42]	34.2	34
Ant. dorsal-ray above vertebra No.	23-26 [41]	25.2	25
Morphometric characters as % of standard length			
Head	18.5-22.5 [40]	20.0	18.5
Upper jaw	10.0-12.5 [40]	11.0	10.5
Preanal.......................	53-60 [40]	57	53
Predorsal	43.5-50 [40]	46.0	45.0
Distance from base of ventral fins to anterior anal-ray	39.0-49.5 [40]	44.0	44.0
Base of anterior 10 dorsal-rays ..	4.3-6.8 [38]	5.7	6.8
Base of anterior 10 anal-rays ...	6.0-8.3 [39]	7.2	6.8

Explanation to Table 14:
The numbers between brackets give the number of specimens examined.
1. Right and left side, respectively.

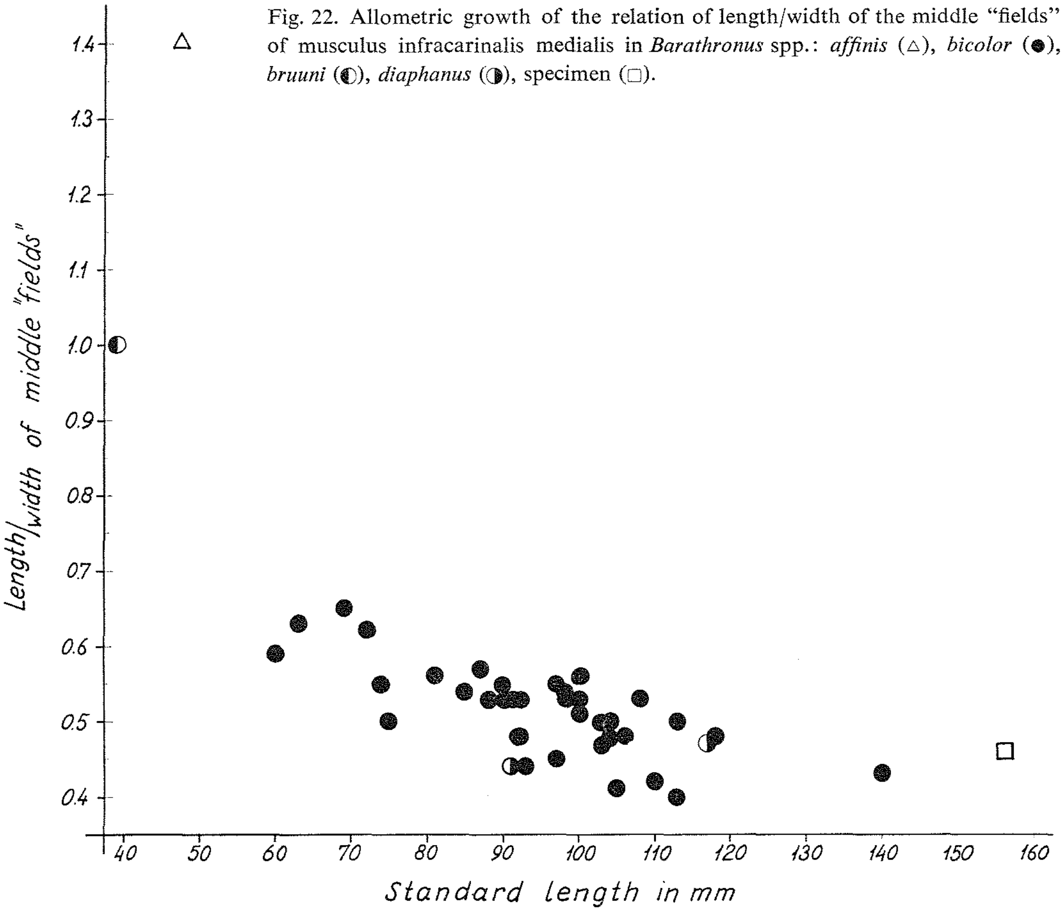


Fig. 22. Allometric growth of the relation of length/width of the middle "fields" of musculus infracarinalis medialis in *Barathronus* spp.: *affinis* (△), *bicolor* (●), *bruuni* (◐), *diaphanus* (◑), specimen (□).

A few additional specimens are listed in the literature. GILCHRIST (1906, p. 158) mentioned a c. 120 mm long female caught off Cape Point at a depth of 1207 m, but the specimen has later been lost. Owing to the short description it is not possible to check the identification, so this specimen is not considered here. GREY (1959, p. 344) described three specimens from an unknown "Oregon" station in the Gulf of Mexico, but the larger of these (total length 123 mm), a cleared and stained specimen, is in so poor a condition, that it is impossible to mail.

Condition of the material:

Except for five specimens all the material has been preserved in less than ten years, so the bulk of it is in a good condition.

Diagnosis and relationship:

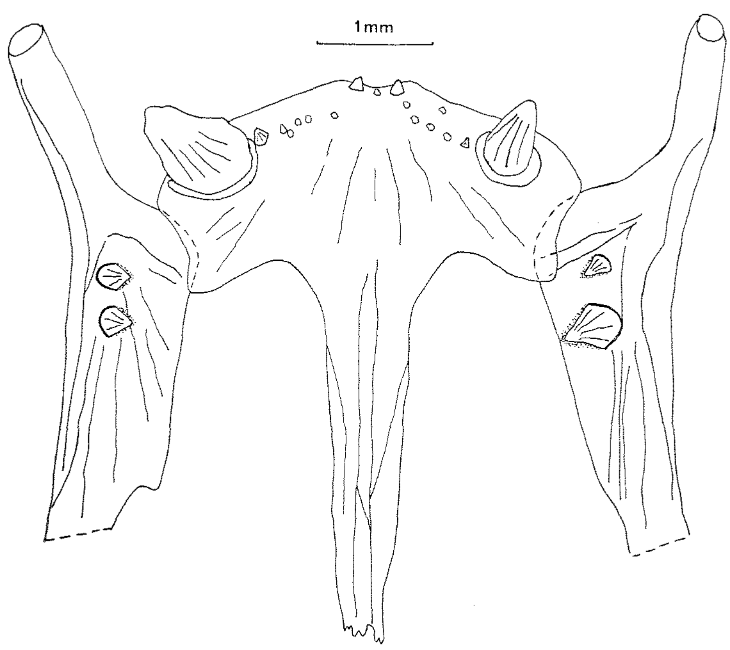
The most closely related species is *B. diaphanus*. A comparison between *bicolor* and *diaphanus* is made on p. 45. When more material of *diaphanus* is available the difference between the two species might be completely levelled out.

Description:

Meristic characters. Table 14 shows the meristic characters of the holotype and the variation and average for the total number of *B. bicolor* examined. Table 5-13 give furthermore the frequency distribution for nine of the meristic characters which in most cases makes a detailed discussion superfluous. Only two of the 36 specimens with an intact caudal fin had a ray-number different from ten, namely nine. The "Gill rakers on anterior arch" gives the total amount of long and short rakers from both the dorsal and the ventral branch of the arch. The six last-mentioned of the meristic characters are all based on radiographs. Considering the number of specimens examined, the variation is rather small.

Morphometric characters. The first four characters in Table 14 show only a slight variation. The two last-mentioned, with a rather high variation, have a tendency to an allometric growth (the graphs are not shown) and Fig. 21 demonstrates a quite clear allometric growth for the "Distance from base of ventral fins to anterior anal-ray". Besides those characters mentioned in Table 14 a few ad-

Fig. 23. Dentition of vomer and palatines of *B. bicolor*, SL 88 mm. USNM 202105. The anterior part of the parasphenoid is seen.



ditional ones were examined. The ratio between the length and width of the middle muscular "fields" of the musculi infracarinales mediales shows an allometric growth (Fig. 22). The penis-length expressed as percentage of the standard length is illustrated in Fig. 31 (further explanation p. 42). The ratio between the distance from the caudal end of the testes to the proximal part of the penis and the length of the testes is mentioned p. 42.

General description. The caudal part of the body is compressed, the anterior part oval in cross-section, and the head is rather heavy, being higher and broader than the anterior part of the body. The scaleless skin is very loose. The mouth opening is almost vertical with a somewhat protruding lower jaw. The eyes are placed deep in the head and are poorly pigmented. In some specimens there is no pigment at all. The eyes of *B. bicolor* have not been examined histologically, but apparently they are similar to the eyes of *B. affinis* (cf. p. 49) and *Nybelinia erikssoni* (cf. p. 24). The nostrils are placed midway between the eye and the upper jaw. A gross examination of the olfactory organs did not show any lamellae. A histological examination kindly made by Birgit Theisen, showed that the organs, at least in the specimen examined (USNM 202115 – SL 104 mm – ♂), were of a simple structure formed as a single elevation without lamellae. Otoliths were seen on the radiographs of 36 of the 42 specimens examined. The dorsal fin issues a little anterior to the midpoint of the body (average predorsal length is 46 % of the standard length). The anal fin originates below the 18th dorsal fin-ray on average. The ventral fins, each consisting of a single ray, are placed well in front of the pectoral fins. The latter fins insert midway between the dorsal and the ventral edge of the body.

Lateral line system. Owing to the loose skin it is difficult to find the lateral line papillae and to follow the rows of papillae. All specimens examined have a row of very small papillae on either side of the body, almost from the caudal base along the midline to the gill opening. There is a relatively distinct preoperculo-mandibular row, the infraorbital row is more diffuse, and the supraorbital row is hardly developed.

Dentition. Four bones are dentigerous: the premaxillare, dentale, vomer, and the palatinum. The three former are provided with small knobformed teeth arranged in irregular rows, and the three latter with a variable number of fangs. The long, thin fangs are apt to break, but it is rather easy to find the remaining base of a broken tooth. Thus the variation of the number of fangs are not only due to mechanical influence from, i. a., the gear, but is probably mainly caused by the natural variation.

Table 15. Frequency distribution of the number of fangs in the palatines of *Barathronus* spp.

	0+0	1+0	1+1	2+0	2+1	2+2
B. bicolor	11	7	11	5	5	3
Remaining four species .	8	.	.	.	.	.

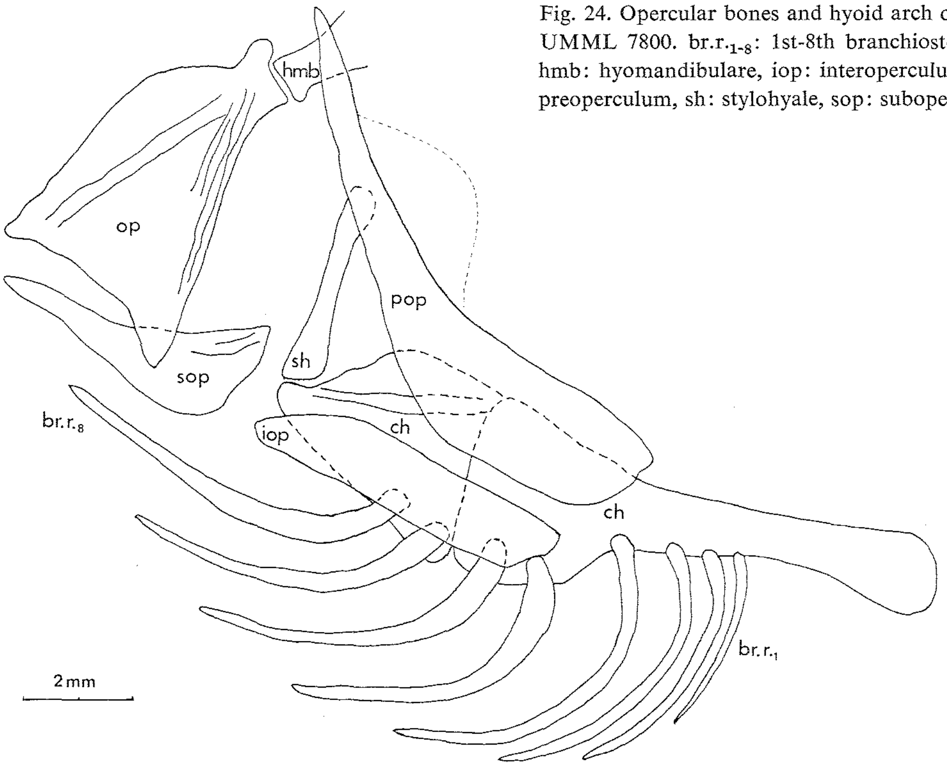


Fig. 24. Opercular bones and hyoid arch of *B. bicolor,* SL 110 mm. UMML 7800. br.r.$_{1-8}$: 1st-8th branchiostegal ray, ch: ceratohyale, hmb: hyomandibulare, iop: interoperculum, op: operculum, pop: preoperculum, sh: stylohyale, sop: suboperculum.

A stump of a tooth is counted as a tooth in the tables below.

Palatinum: As seen from Table 15 the number of fangs in each palatinum varies from 0-2. No smaller teeth are observed in this bone. In specimens with two fangs the anterior is most often placed parallel to the palatinum, and the second fang is erect. The palatine teeth are always placed on the anteriormost part of the bone (Fig. 23).

Vomer: In most cases the vomer is provided with two laterally placed fangs (Table 16). Between the fangs a number of small, blunt teeth placed in 2-3 irregular rows (Fig. 23) occur. If there is more than one fang in each side, the median ones are always the shorter.

Dentale: The anterior third of the lower jaw is provided with small, closely placed teeth. Posteriorly they form one row only, gradually increasing anteriorly where there are about five irregular rows. The symphysis is edentate. The posterior $\frac{1}{2}$-$\frac{2}{3}$ of the dentaries have a varying number of larger teeth (fangs), with a maximum of six in each side.

Premaxillare: The posterior $\frac{1}{3}$-$\frac{1}{2}$ of each premaxillare and the symphysis are edentate. The anterior $\frac{1}{2}$-$\frac{2}{3}$ is provided with teeth of the same size and arrangement as the small ones in the dentaries.

Osteology. All data of osteological characters are based on two specimens, a 110 mm long specimen from UMML (Cat. No. 7800) and an 88 mm long specimen from USNM (Cat. No. 202105), cleared and stained according to the method described by CLOTHIER (1950). Besides, radiographs both from a lateral and a dorsal view were taken of all the 42 specimens.

Fig. 24 and also Pl. I Fig. 4 show the opercular bones and the hyoid arch. The preoperculum has an anteriorly directed thin bony membrane and the operculum is provided with two ridges, forming a V. All branchiostegal rays are slender. The two dorsal ones fasten on the upper part, and the six ventral ones to the lower part of the divided ceratohyale. – Pl. I Fig. 4 furthermore shows that the pectoral fins are supported by five radials, an unusual number for an ophidioid fish. A similar amount of radials were found in the other stained specimen and in the radiographs of five specimens – the only ones with distinct radials. – A small supramaxillary bone is seen on both stained specimens.

Table 16. Frequency distribution of the number of fangs in the vomer of *Barathronus* spp.

	1+0	1+1	2+1	2+2	3+1	4+1
B. bicolor	1	28	5	5	2	1
Remaining four species .	1	4	2	1	.	.

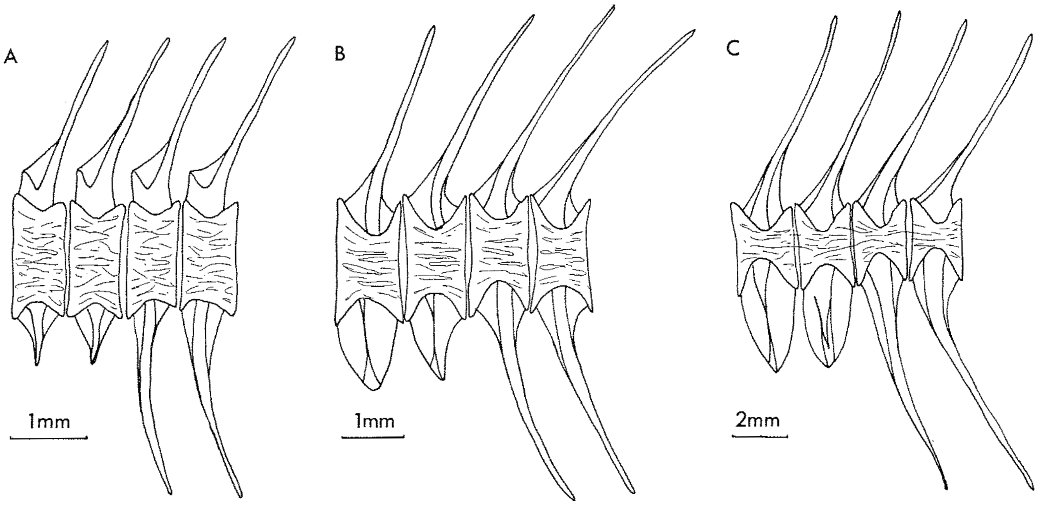


Fig. 25. Changes in the form of the vertebral centra in the transitional zone between precaudal and caudal vertebrae in *B. bicolor*. A: SL 58 mm (USNM 47628), B: SL 87 mm (USNM 202112), C: SL 140 mm (USNM 202114).

Vertebral column: The 31-35 precaudal and 38-41 caudal vertebrae are all rather well ossified. The anterior four neural spines are the longest, then they gradually get shorter. The 1st-2nd spines are rather erect, the 3rd-9th spines are more retrorse, the following again less retrorse, and the most posterior ones are much depressed. The haemal arches and spines are similar in form and size to the corresponding neural ones. The 3rd-7th vertebrae are provided with a pair of long, thin pleural ribs, which apparently fasten directly to the vertebral centra, as no parapophyses can be seen. All the

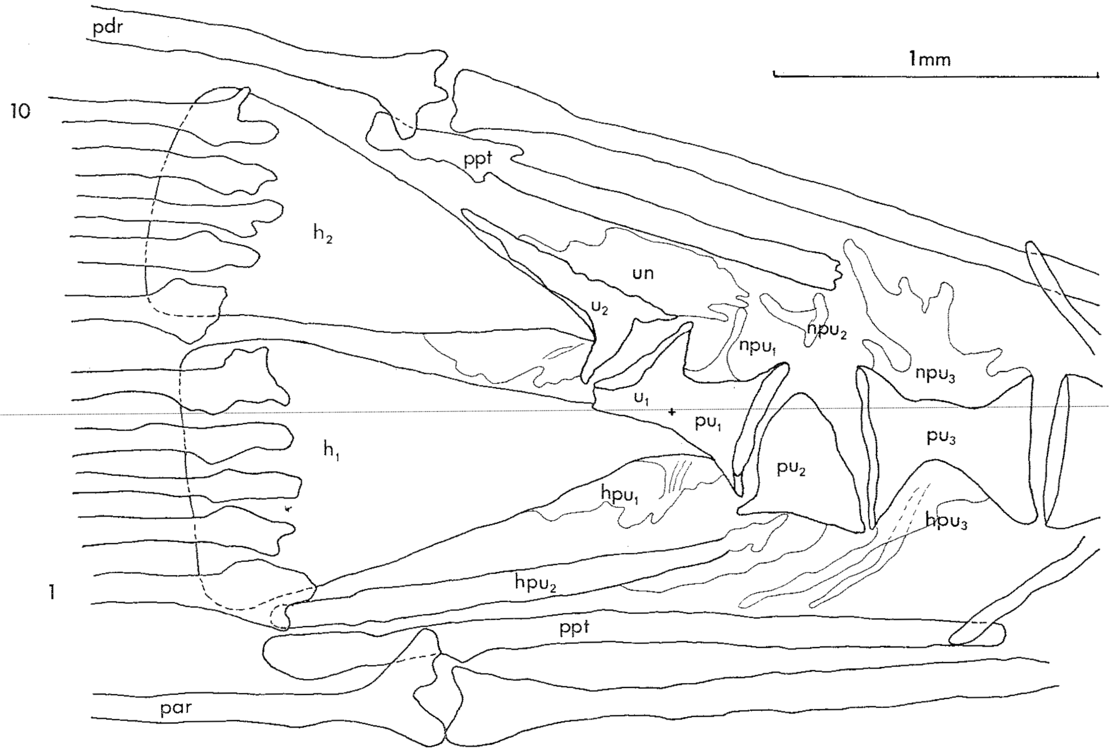


Fig. 26. Alizarin stained caudal skeleton of *B. bicolor*, SL 110 mm. UMML 7800. h_{1-2}: hypural plates, hpu_{1-3}: haemal arch and spine of 1st-3rd preural vertebra, npu_{1-3}: neural arch and spine of 1st-3rd preural vertebra, par: posterior anal fin-ray, pdr: posterior dorsal fin-ray, ppt: posterior pterygophore, pu_{1-3}: 1st-3rd preural vertebra, u_{1-2}: 1st-2nd ural vertebra, un: uroneural, 1-10: caudal fin-rays.

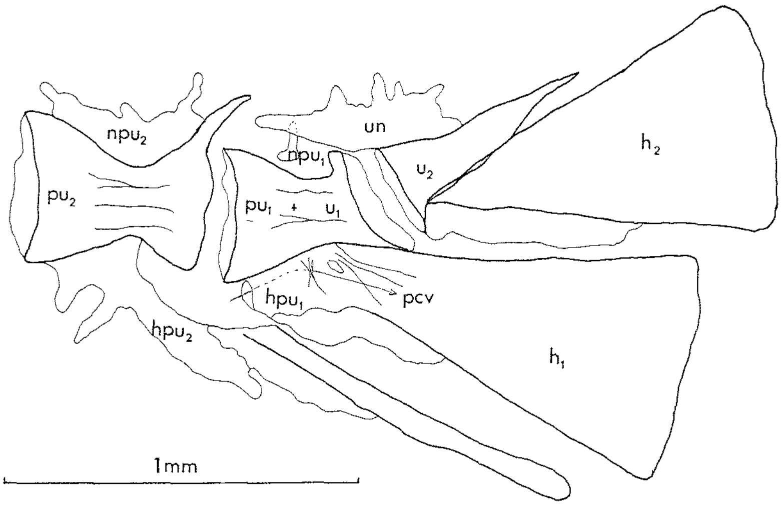


Fig. 27. Alizarin stained caudal skeleton of *B. bicolor*, SL 88 mm. USNM 202105. pcv: piercing of caudal vein. For other abbreviations see Fig. 26.

remaining precaudal vertebrae have parapophyses. The transition between the precaudal and the caudal vertebrae is distinct (Fig. 25). If specimens of different standard lengths are compared the form of the vertebral centra, e.g., from the transition zone (Fig. 25), changes from being almost rectangular in a lateral view in the small specimen to sandglass shaped in the larger specimen. The ratio between length and height of the last precaudal vertebral centrum is about 0.5 in the small and 0.7 in the large specimen. If the 20th caudal vertebral centrum is measured the ratio between length and height is found to be almost similar in the three specimens examined, but the shape changes in the same way as shown in Fig. 25.

Caudal skeleton: The examination of the caudal skeleton is based on the two cleared and stained specimens. The larger which is in a very good condition is shown in Fig. 26, but owing to the abnormal development of the second preural vertebra (pu_2) also the less well preserved caudal skeleton of the smaller specimen is illustrated (Fig. 27). The following caudal elements were found: Two ural vertebrae. The anterior of these is grown together with the last caudal vertebra (= first preural vertebra) which is the last vertebra with a haemal arch pierced by the caudal vein. The hole for the caudal vein is only seen in Fig. 27. – One pair of uroneurals. – Two hypural plates which consist of more than one hypural element each. – Ten principal caudal finrays. There are no epichordal and hypochordal dermal rays, and epural elements are not developed. The second preural vertebra (Fig. 26) has a very small and free neural process, while the haemal process is well developed. The centrum is abnormally small. However, a normal development of the second preural vertebra can be seen in Fig. 27 which also shows the piercing of the haemal arch of pu_1 (arrow, and the abbreviation pcv). The posterior five neural arches and the third and fourth haemal arch are open, i.e., the process from the right and that from the left side are not grown together.

Gill cavity. Fig. 28 shows the right, anterior gill arch from USNM 202118. There are six rakers on the epibranchiale, one raker in the angle between the epi-and ceratobranchiale, 17 rakers on the latter bone, and six rakers on the hypobranchiale. Normally, only the anterior gill arch is provided with long rakers. The only exception is a 108 mm long specimen (CNHM 65805) in which a long raker is developed in the angle on the right, second arch.

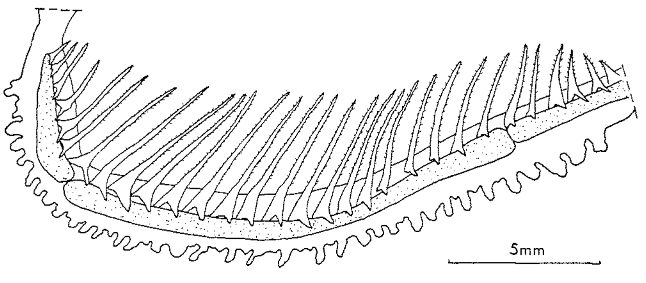


Fig. 28. Anterior, right gill arch of *B. bicolor*, SL 75 mm. USNM 202118.

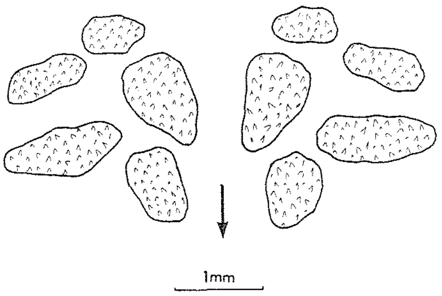


Fig. 29. Upper pharyngeal tooth-plates of *B. bicolor*, SL 88 mm. USNM 202105. The arrow points anteriorly.

The number of rakers on the anterior arch varies on the epibranchiale from 5-7 and from 23-28 on the ventral branch of the arch. There are 2-3 rakers on the epibranchiale of the second to fourth arches, and none on that of the fifth arch. Except for the anterior arch, in which the rakers in the inner row are much shorter than those in the outer row, the rakers in the two rows of an arch are of the same size. All rakers are provided with numerous small teeth. Below is given a survey of the amount of rakers in the outer row from both sides. The number of gill arches examined is stated in brackets:

1st gill arch with 28-33 rakers (74)
2nd gill arch with 22-24 rakers (12)
3rd gill arch with 18-22 rakers (12)
4th gill arch with 16-18 rakers (12)
5th gill arch with 12-15 rakers (12)

The anterior arch is provided with 35-40 gill laminae, each formed as a feather with a main stem and several short side branches. At the base of each is a pair of short laminae, about $\frac{1}{4}$ the length of the long laminae which again are $\frac{1}{3}$-$\frac{1}{4}$ the length of the prolonged gill rakers. The short laminae are distinctly developed only on the anterior arch. In many specimens the laminae are shorter on the anterior than on the following arches.

Dorsally in each gill cavity an oval, yellow body, 1-2 mm in diameter is found. This is most probably the thymus, and as in the two benthic, deep-living brotulid genera, *Acanthonus* Günther, 1878 and *Typhlonus* Günther, 1878 (cf. NIELSEN 1965, pp. 38 and 45), also the thymus in *B. bicolor* apparently does not undergo any involution when the specimen becomes mature, which is in contrast to most other teleosts examined (HAMMAR 1909).

The upper pharyngeal tooth-plates (five on either side) are shown in Fig. 29. Lower pharyngeal plates are apparently not developed.

The basihyal is provided with a group of small teeth.

Colour. The peritoneum is usually very dark, but in a few cases light brown. The yellowish musculi infracarinales mediales divide the peritoneum into three dark longitudinally running stripes. GREY (1959, p.344) in her description of three specimens wrote that they differed from the holotype in lacking the black lateral streak, only the belly being black. However, this difference is most certainly due to bleaching, as the same feature is observed in all old material. A few specimens have no pigment at all on the head and on the body. However, most of them are pigmented on the dorsal part in front of the dorsal fin and on the head, especially on the lower jaw. A small part of the material also has pigment on the dorsal fin-rays. A single specimen has a series of dark spots in the midline on either side. The oral cavity is pigmented in some specimens. The larger the specimen is the darker is the digestive canal. The black or brown iris is more or less distinct, depending on the size of the specimen, as the eyes gradually sink into the head with the growth. In some cases the iris appears as a broken ring or is absent. The area inside the iris is brownish.

Viscera. The short oesophagus and the stomach are black and thick-walled. There is a strong constriction between the stomach and the intestine. The intestine is thin-walled and semi-transparent. The anterior part is much wider than the stomach. The long intestine forms three coils. In five of the 42 specimens there is a constriction on the intestine near the anus indicating a rectal part. The small liver is yellow. The gall-bladder is large and transparent. The urinary bladder is black-pigmented in most specimens, but occasionally is without pigment.

Gonads:

The material consists of 17 females and 25 males. A gross as well as a histological examination was made of the gonads. Two males and one female were examined and discussed by NIELSEN, JESPERSEN & MUNK (1968).

Females. Seventeen females were examined, ranging in standard length from 58-140 mm. The five smaller specimens, 58-81 mm, were unripe, with long, thin ovaries and a transparent ovarial sack. The 12 remaining females, 87-140 mm, were all provided with ovaries which held numerous large eggs and sometimes also free embryos. Pl. I Fig. 2 shows the ovaries with the unpaired section (=

Table 17. Month of capture for ripe and unripe (in brackets) specimens of *B. bicolor.*

	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	?
♀♀	–	(1)	–	–	–	(1)	1(2)	1	3(1)	2	1	2	2
♂♂	1	2	–	1	–	(3)	4(1)	–	–	2	–	6(1)	4

excretory duct). The ovarial sack is always somewhat pigmented. The eggs in the ripe specimens were found also in the unpaired section, making it difficult to see the transition between the ovaries and the duct. Table 17 shows that ripe females were found only in the period July-December. However, this should not be interpreted as being the spawning season for *B. bicolor,* as Table 17 also shows that only two small (SL 58-72 mm) females were caught during the first six months of the year. Four of the females (a-d below) were examined histologically (8 and 10 μ sections). Two were unripe specimens (SL 72 and 74 mm) and the two other had relatively well developed ovaries (SL 87 and 104 mm).

a. The entire left ovary of the smallest specimen was sectioned (Ser. No. 57). It contained very few and small, unfertilized eggs filled with yolk granules. The larger eggs, 80-90 μ, were found in a number of less than ten in each section. The ovarian tissue is only poorly developed, and the ovarian duct is very voluminous (Pl. II Fig. 1). No spermatozoa were observed. Occasionally, diverticles from the dorsal duct penetrate the ovarian tissue, much resembling this feature in the unripe *Parabrotula* Zugmayer, 1911 and *Leucobrotula* Koefoed, 1952 (Nielsen 1968). Also the apparent division of the 9 mm long ovaries into 15-20 small sections and the high epithelium between the duct and the ovarian tissue are similar to the two abovementioned genera.

b. The caudal 2 mm of both ovaries and the cranial 2 mm of the unpaired section of the 74 mm long female were sectioned (Ser. No. 60). The unpaired section contains a few eggs and spermatozoa, but is not provided with a reservoir. The ovarian tissue is rather undeveloped and contains few eggs all of which are unfertilized. The maximum diameter is about 150 μ, but only a few of this size are found in each section. The very large ovarian ducts contain enormous quantities of spermatozoa (Pl. II Fig. 2). No spermatophores or remains of capsules are seen. This specimen too is provided with a high epithelium and penetrations of the duct into the ovarian tissue (see above).

c. From the 87 mm long female the caudal part of the ovaries and the cranial part of the unpaired duct were sectioned (Ser. No. 63). The duct contained a few eggs and spermatozoa. A reservoir is not seen, at least not in the cranial 2 mm, which was sectioned. The ovaries held many small and a few larger eggs. Apparently none of the eggs were fertilized. The maximum egg-diameter is about 350 μ, and normally not more than 3-4 of the larger eggs are seen in each ovary per section (Pl. II Fig. 3). The ovarian ducts are very narrow, as most of the volume is occupied by the ovarian tissue, in which numerous spermatozoa are seen. In some of the sections spermatozoa were found embedded in the ovarian epithelium. No spermatophores or remains of capsules were observed.

d. The cranial 10 mm of the left ovary from a 104 mm long specimen was sectioned (Ser. No. 41). The ovarian duct is very narrow. There were many eggs of varying size with a maximum diameter of c. 675 μ. Some of the larger ones contained an embryo, but no free embryos were present in this specimen (Pl. II Fig. 4). Many spermatozoa were found, both in the duct and in the ovarian tissue, some with their heads embedded in the ovarian epithelium. No spermatophores or remains of capsules were observed.

It is possible to form an idea of the changes in the ovarian structure on basis of the four examined females which apparently represent four different developmental stages (a-d) of which "a" is the youngest and "d" the oldest. Specimens with still more developed ovaries, containing free embryos, were also represented in the material, but were not examined histologically. The standard length of the specimens examined increases from 72 mm to 104 mm, corresponding to stages "a"-"d". The maximum egg-diameter of the four stages (a-d) was 80-90, c. 150, c. 350, and c. 675 μ, respectively. "a" did not contain spermatozoa at all. "b" had numerous spermatozoa in the ovarian ducts and in the unpaired section, but none were observed in the ovarian tissue. "c" had spermatozoa in the ovarian tissue and in several sections spermatozoa were found with their heads in close contact with the ovarian epithelium, but apparently no eggs were fertilized. "d" contained several fertilized eggs, but was otherwise similar to stage "c". The diverticles of the ovarian ducts into the ovarian tissue and the presence of high epithelium were observed only in stages "a" and "b". All females longer than c. 100 mm are at stage "d" or further, which indicates that when a female has become mature it continuously produces young.

Ovary contents: The left ovaries of the specimens from "Oregon" Sts. 4145 and 3655, respectively 103 mm and 113 mm long, were removed, and the eggs and embryos counted and measured according to the method described on p. 9. The ovary of the former specimen measured 21 mm and its volume was approx. $\frac{1}{3}$ cm^3 and that of the latter 22 mm and $\frac{1}{4}$ cm^3. Fig. 30 shows the number and size of the eggs. Those with a diameter of less than 0.1 mm were not included owing to uncertain measurements, but the number of these small eggs is definitely lower than that of the 0.5-0.6 mm eggs in the 103 mm specimen, while the number of these two egg-sizes is more equal in the larger specimen. Eggs with a diameter of 0.4-0.8 mm have a relatively dark part in the middle. It is difficult to see whether they are fertilized or not. From a 104 mm long specimen ("Oregon" St. 2637) the cranial part of one of the ovaries was sectioned (Ser. No. 41). The caudal part of the ovary contained eggs varying in diameter from less than 0.1 - about 1 mm. A gross examination shows that eggs with a diameter of 0.4-0.8 mm are quite similar to those found in the ovaries of the 103 and 113 mm long specimens mentioned above. By comparing sectioned and intact eggs of equal size from the 104 mm long female (Ser. No. 41) it can be seen whether eggs of a certain appearance and size contain embryos. On the basis of this comparison it is possible, with a reasonable degree of certainty, to decide whether the eggs forming the high peaks of the two graphs on Fig. 30 are fertilized or not. Eggs containing embryos from the 104 mm long specimen never have a dark centre, and the embryo is easily seen both in sectioned and intact eggs. Since all the large eggs from the 103 and 113 mm long females possess a centrally placed dark part it seems reasonable to assume that they are not fertilized. The sections show that the dark centre is the nucleus.

Fig. 30 indicates that the next clutch in both specimens contains about 600 eggs in each ovary. It is therefore surprising that the two ovaries examined contained only three and 23 free embryos (Fig. 32). The three embryos are all c. 6 mm long, and the length of the 23 embryos varied from 4-5.5 mm. In both cases there is no indication that the ovaries were newly emptied of embryos, as the ovaries were distended. Probably not all the large eggs shown in the graphs (Fig. 30) become fertilized, or only a small part of the fertilized eggs carry through development. Most of the 23 free embryos in the 113 mm long female were found in the cranial fourth of the ovary which might indicate that they are remains of the last clutch.

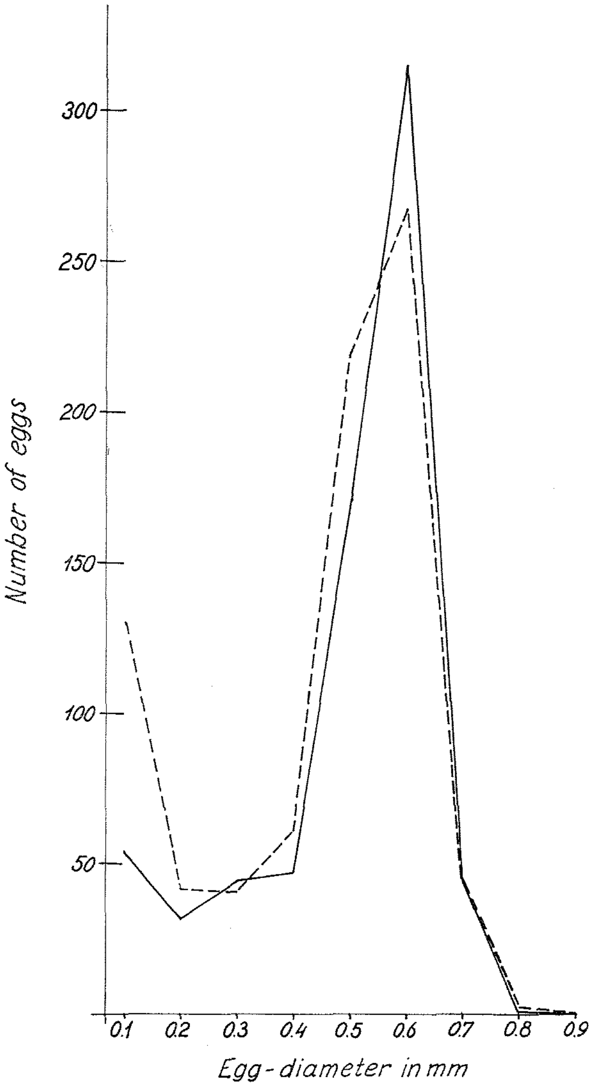


Fig. 30. Number and diameter of the eggs from one ovary of *B. bicolor*. (—), SL 103 mm, USNM 202116. (---), SL 113 mm, USNM 202115.

Males. The material comprised 25 males, varying in standard length from 60-118 mm. Five specimens, 60-75 mm, had thin transparent, unripe testes, while the testes of the ripe specimens were thick and yellow. The 19 ripe specimens varied in length from 85-118 mm; (a 103 mm long specimen was eviscerated). Pl. I Fig. 1 shows that the transition be-

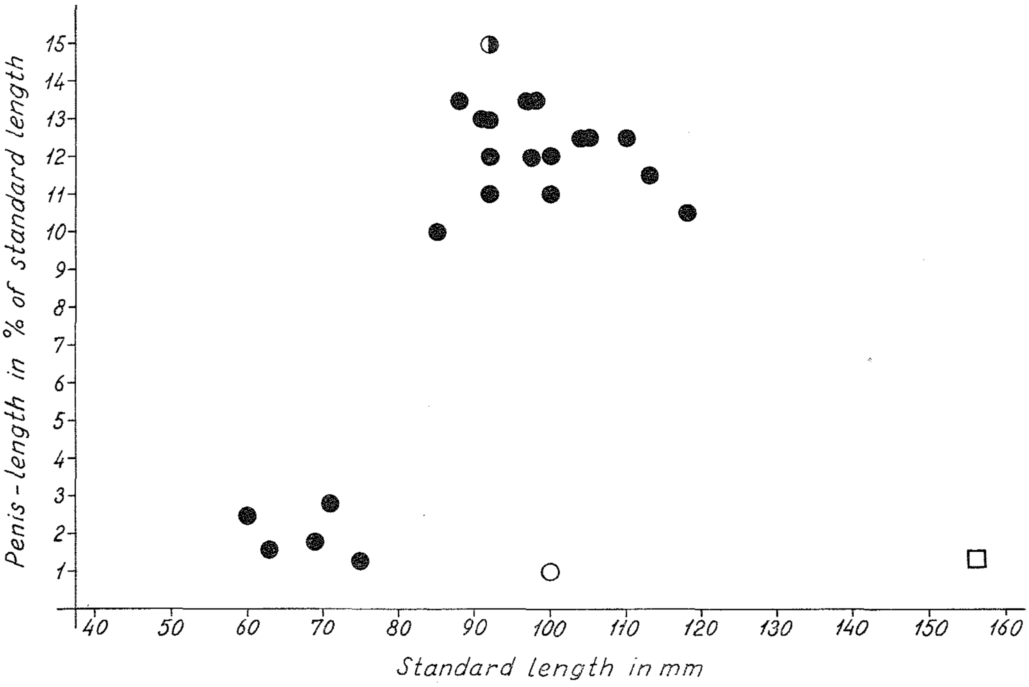


Fig. 31. The length of the penis expressed as % of the standard length in *Barathronus* spp. Those with a length of 1-3 % all have unripe testes, while the others have ripe testes. *bicolor* (●), *diaphanus* (◑), *parfaiti* (○), specimen (□).

tween the testes and the unpaired section (= excretory duct) is easily recognizable in ripe specimens in contrast to the females. The unpaired section does not issue at the caudal tip of the testes, but somewhat more anteriorly. Thereby the testes form two blind ends posterior to the origin of the duct. The ratio between the distance from the caudal end of the testes to the base of the penis and the length of the testes varied from 0.3-0.7 with an average of 0.45; (this is one of the characters by which *B. bicolor* differs from *B. diaphanus).* The variation apparently is not dependent of the degree of ripeness of the testes.

Table 17 shows that ripe males are met with practically all the year round, so the species apparently has no delimited mating season.

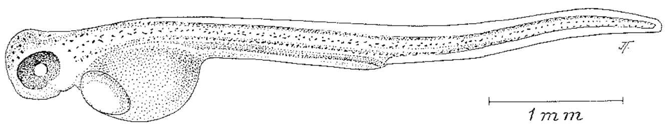
Fig. 31 shows the penis-length expressed as percentage of the standard length. The *B. bicolor* specimens fall into two well separated groups. However, it appeared that all the five small specimens in the group with a short penis had poorly developed testes, while the long penis was correlated with ripe testes. Judging from the present material, the males ripen at a length of 85-90 mm approx.

The testes or part of these of six specimens were examined histologically. The following data are the standard length, the date of capture, and the section serial number:

69 mm – 21. June (Ser. No. 58),
91 mm – 27. Febr. (Ser. No. 39),
92 mm – 14. Dec. (Ser. No. 62),
93 mm – 12. Apr. (Ser. No. 38),
98 mm – 3. Oct. (Ser. No. 61),
104 mm – 26. July (Ser. No. 59).

The first-mentioned specimen belongs to the group with a short penis. The 7.5 mm long, semi-transparent testes are only 0.5-1 mm thick. The testicular ducts which are very narrow hold at a maximum c. 10 spermatophores in each section. The testicular tissues contain a few spermatophores, some bundles of not-encapsuled spermatozoa, but younger developmental stages of spermatozoa were dominating (Pl. III Fig. 1). The sections of the remaining five specimens which are all provided with a long penis and thick, not-transparent testes do not differ much. All hold numerous spermatophores both in the dorsal ducts and in the unpaired section. A spermatophore-reservoir formed by the unpaired section is found in the two specimens from which this part was sectioned. The smaller specimens have relatively much testicular tissue with traces of active spermatogenesis and few spermatophores, while 90 % of the area of each section of the 104 mm long specimen consist of spermatophores. Pl. III Fig. 2 shows a testicular section from a 92 mm long specimen.

Fig. 32. A 5 mm long embryo of *B. bicolor*, SL 113 mm. USNM 202115.



The majority of the spermatophores have the spermatozoa placed with the heads at one end only. The maximum length of the spermatophores varies from c. 55 μ to c. 100 μ, but there is no correlation between the length of the fish and that of the spermatophore.

Copulatory apparatus:

The males are provided with a urogenital sinus which forms a tube with an oval-shaped incision on its backside. The penis, which is very long in ripe specimens, is grown together with the front side of the urogenital sinus. Claspers are not developed.

The only trace of a copulatory apparatus in the females is a pair of c. 0.5 mm long claspers placed caudo-laterally to the genital opening. They were observed only in a few specimens.

GARMAN (1899, pl. 39 fig. 5) illustrated the "genital cage and papilla" of *Barathronus bicolor* without further comments. Judging from the well developed urogenital sinus and the apparent lack of a penis the figure most probably derives from an unripe male.

Embryos:

All the 4-6 mm long embryos from the two ovaries examined (see above) are uniform (Fig. 32). The eyes of the embryo (5 mm) shown on Fig. 32 form 7.0 % of the SL while the more indistinct eyes of the female (113 mm) form 3.4 %. The small mouth is placed on the ventral side of the head. Each specimen is provided with a yolk-sack, 1 mm in diameter approx. There is a thin intestine, and the anus is placed more posteriorly than in the adult specimens. A continuous fin-fold issues over the middle of the yolk-sack, incloses the caudal fin, and ends at the anus. There are several black pigment-spots on the head and body.

Biology and reproduction:

B. bicolor is the only species of the Aphyonidae of which the material is sufficiently large to give some information about its biology. Sections of the gonads show that *B. bicolor* is dioecious and viviparous. In contrast to species of other aphyonid genera spermatophores never occur in the ovaries although they are numerous in all the males examined. The spermatophore-capsule most certainly dissolves as soon as the spermatophore has been transferred into the female, since only free spermatozoa and not even remains of spermatophores were observed in the most caudal part of the excretory duct. Free spermatozoa were observed in five out of six females, and in the two larger specimens spermatozoa were found with their heads embedded in the ovarian epithelium. This might be a way to prolong the life of the spermatozoa so that the female may store the spermatozoa if mating takes place before the eggs are ready for fertilization, or it may be an instance of superfoetation, i.e., spermatozoa from one mating keep alive and fertilize more than one clutch of eggs (cf. p. 82). It is difficult to estimate the number of larvae in each clutch (cf. p. 41).

As seen from the discussion of the vertical distribution (below) adult specimens of *B. bicolor* most certainly occur benthically. Furthermore, only few of the neotenic characters mentioned on p. 80, which are typical of deep-pelagic species, are found in *B. bicolor*. The bottom temperature, measured at nine stations varied from 5-8 °C.

An examination of the gonads shows that there is no seasonal spawning period although the animals live at depths which are subjected to a yearly change in physical characters as well as in the amount of food available. On the other hand, judging from the ovary contents, the newly born larvae are at least c. 10 mm long, and therefore less dependent on a plankton maximum than smaller, slowly moving larvae. The restricted area of distribution indicates that the duration of the larval life is very short.

The macroscopic stomach content was unidentifiable except in one specimen which held four copepods with a length of c. 4 mm. However, they are in such a poor condition that no safe data can be given of the biology of *B. bicolor* on basis of the stomach contents.

The well developed gill rakers indicate that it is possible for the fishes to withhold small food items, and the rather large teeth enable them to grab bigger prey as well.

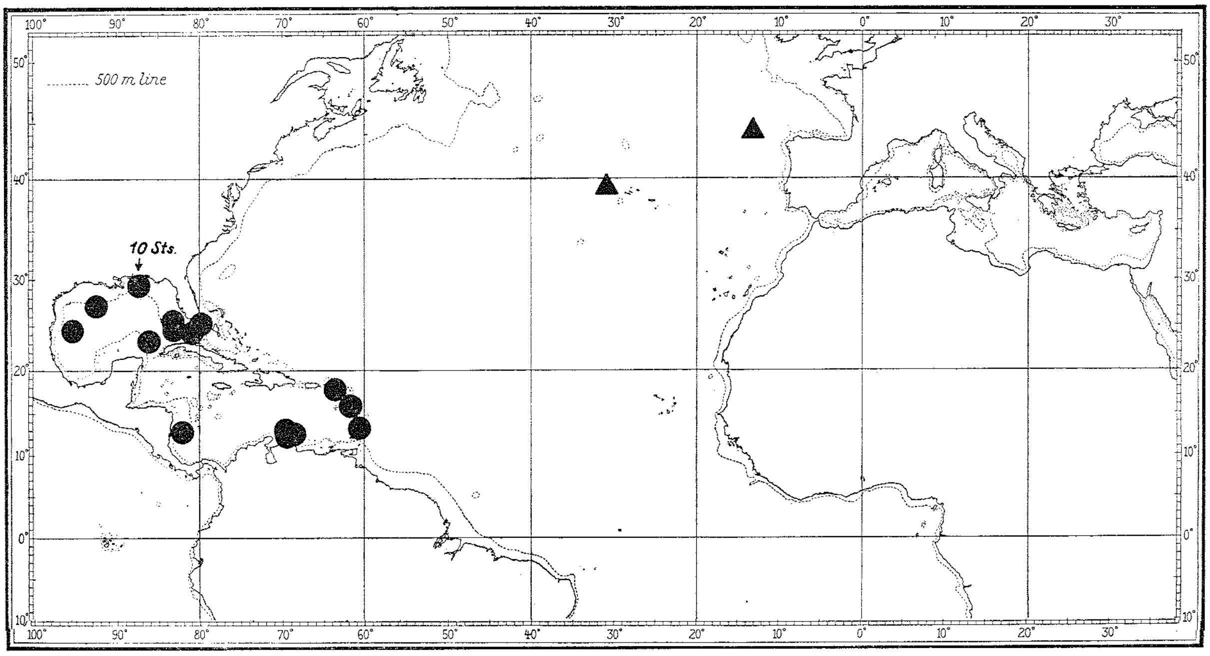


Fig. 33. Records of *B. bicolor* (●) and *B. parfaiti* (▲).

Distribution:

Horizontal. All specimens known were caught in a very limited area, the Gulf of Mexico and in the Caribbean Sea (Fig. 33). The doubtful specimen from South Africa (cf. p. 34) is omitted. Despite the number of stations made in the neighbouring parts of the Atlantic Ocean, none of the present species were caught, and Fig. 33 therefore probably gives a true picture of the distribution of *B. bicolor*.

Vertical. Except for the holotype, which was caught at a depth of 1406 m, the depths of the remaining 24 stations vary from 366-914 m. In two cases the depths are indicated as 366-549 m (200-300 fath.) while the station number is unknown. When these two uncertain stations are excluded the depths of the remaining stations vary from 494-914 m (= 270-500 fath.). Eighteen of these are "Oregon" stations. Below is shown the number of bottom trawl-hauls at certain depths-intervals. The data derive from the "Oregon" stationlists, Sts. 1-1429 (SPRINGER & BULLIS 1956), Sts. 1430-3174 (BULLIS & THOMPSON 1965) and Sts. 3175-4831 (H. R. BULLIS, JR. personal communication):

477 hauls at 366-485 m (200-265 fath.) – all negative.
176 hauls at 494-914 m (270-500 fath.) – 18 positive (33 specimens).
62 hauls at 933-3658 m (510-2000 fath.) – all negative.

At 24 stations pelagic trawls worked deeper than 366 m (200 fath.), at a maximum down to 3895 m (2130 fath.), all with a negative result. This strongly indicates that *B. bicolor* lives on the bottom between a depth of 400-500 and 900-1000 m (bathyally). The station-data from the Blake Expedition are too unsafe (ESCHMEYER 1965) to give any reliable information of the depth of the type locality (1406 m).

Barathronus diaphanus Brauer, 1906
Pl. IV Fig. 2

Barathronus diaphanus Brauer, 1906, pp. 305-6, pl. 14 fig. 6.
– –: LLOYD 1909, p. 166.
– –: WEBER 1913, pp. 551-2.
– –: BEAUFORT & CHAPMAN 1951, p. 406, fig. 61.

Material examined (4 specimens):

Holotype (SL 117 mm, ♀); Deutsche Tiefsee Exped. "Valdivia" St. 259 (2°58.8′N, 47°6.1′E); 1289 m; trawl; bottom temperature 6.3°C. 28. Mar. 1899. ZMB 17699.

1 specimen (SL 59 mm, ♀); "Siboga" St. 300 (10°48.6′S, 123°23.1′E); 918 m; trawl. 30. Jan. 1900. ZMA 104.467.

1 specimen (SL 65-70 mm, ♀); "Investigator" St. 310 (13°29′30″N, 95°29′E); 1756 m; Agassiz trawl; bottom temperature 4.8°C. 5. Nov. 1902. ZSIC 1050/1.

1 specimen (SL 92 mm, ♂); R/V "Cape St. Mary" cruise 1/64 St. 26 (19°40′N, 115°30′E); 732-796 m; mud; Agassiz trawl. 7. Jan. 1964. FRSH.

Condition of the material:

The fixation of the holotype is so hard that the specimen has become rather brittle. This involves that the viscera could not be examined without damaging the specimen. – The "Siboga" specimen also is not well preserved, being rather soft. Furthermore, the posterior tip of the body is lacking. According to WEBER (1913, p. 551), the standard length was 59 mm which means that the caudal fin and 1 mm of the body have been lost, provided that the standard length was measured in the same way. Unfortunately, WEBER did not give any information about the number of rays in the dorsal and anal fins. It is estimated that 1 mm of the posterior part of the specimen holds three dorsal and anal rays and two vertebrae and the urostyle. These elements are added to the characters in Table 18, except for the dorsal fin-rays of which three were loosely attached to the fish, apparently representing the rays belonging to the lost part. – The "Investigator" specimen had lost the head, and most of the posterior part of the body as well. The remaining part of the fish is brittle. The length was estimated in the following way. All the precaudal vertebrae remain, measuring 29 mm in length. In the three other *B. diaphanus* specimens the ratio between the length of the precaudal vertebrae and the standard length is 0.4-0.45, which involves that the length of the "Investigator" specimen is 65-70 mm. There is a mistake in LLOYD's (1909, p. 166) description of this specimen. He wrote that the "Valdivia" obtained the same species from the Indian Ocean near the Chagos group at a depth of 2919 m. However, this is the type locality for *B. affinis* and not for *B. diaphanus*. Since the present condition of the specimen prevents a re-identification, it can not be decided whether LLOYD accidentally cited the wrong locality or the wrong specific name. – The specimen from Hongkong is in an excellent condition as it has been preserved about 60 years less than the three other specimens.

Diagnosis and relationships:

B. diaphanus differs distinctly from the two other Indian Ocean species *(affinis* and *bruuni)* and from the Eastatlantic *parfaiti* in most of the meristic characters (see frequency distribution in Tables 5-13). The most closely related species is the Westatlantic *B. bicolor*, but the tables show that *diaphanus* tends to have lower counts. *B. diaphanus* has no palatine teeth in contrast to most of the *B. bicolor* specimens. The ratio between the length of the testicular excretory duct, measured to the base of the penis, and the length of the testes of ripe specimen(s) is 1.1 in *diaphanus*, but only 0.3-0.7 in *bicolor* (measured in 19 specimens). The penis is relatively long (Fig. 34) and thick in *diaphanus*.

Description:

Many of the meristic and morphometric characters are given in Table 18 and in the general remarks on the genus *Barathronus*.

The dorsal and anal fin-ray count is somewhat higher in the "Cape St. Mary" specimen, but the difference is not greater than the intraspecific variation of *B. bicolor* (Tables 5-13). The most pronounced difference is found in the number of rakers on the posterior gill arches (cf. the "Gill cavity" below). The morphometric characters show very little variation. There is a surprisingly small likeness between the holotype in its present condition and the drawing published by BRAUER (1906, pl. 14 fig. 6). The difference can hardly be explained by the drying up of the specimen.

The dorsal profile of the heavy head is most oblique in the holotype in which the head apparently was fixed in a bent position (Pl. IV Fig. 2). The skin is loose and transparent. The ratio between the length and the width of the middle "fields" of the musculus infracarinalis medialis is c. 0.5; (this muscle is hardly visible in the "Siboga" specimen). The dorsal fin originates in front of the midpoint (predorsal 43.5-46.0 % of the SL). The anal fin arises behind the midpoint (preanal 55-57 % of the SL) below the 14th-16th dorsal fin-ray. Only the eyes of the "Cape St. Mary" specimen are visible. They are apparently built in the same way as in the other species of *Barathronus*, but the interorbital is very narrow compared to the diameter of the "eye ring", measuring 1 mm and 4 mm, respectively. Both nostrils are provided with a low rim. They are placed like those of *B. bicolor*. The mouth cleft forms an angle of about 45° with the horizontal plane. The upper jaw ends below the eye. Circular otoliths are found in all three specimens.

Lateral line system. All the specimens have a row of small papillae along the midline of the body. The skin of the head is rather torn, so only the mandibular row of papillae could be seen.

Dentition. The posterior third of the dentary is

Table 18. Meristic and morphometric characters of *Barathronus diaphanus* and *B.* specimen.

	B. diaphanus[2]			*B.* specimen[3]
	"Valdivia" St. 259	"Siboga" St. 300	"Cape St. Mary" St. 26	"Albatross" St. D-5065
Standard length in mm	117	58 + 1	92	156
Meristic characters				
Dorsal fin	65	64	69	75
Caudal fin	10	—	10	10
Anal fin	50	48 + 3	57	59
Ventral fin[1]	1-1	1-1	1-1	1-1
Pectoral fin[1]	-22	-22	23-22	25-25
Gill rakers on anterior arch[1]	6/1/25-5/1/24	6/1/23-6/1/23	6/1/24-5/1/22	6/1/24-6/1/23
Vertebrae (incl. urostyle)	33 + 38	33 + (34 + 3)	32 + 38	32 + 42
Anterior anal-ray below dorsal-ray No.	15	14	16	13
Anterior anal-ray below vertebra No.	32	33	33	31
Anterior dorsal-ray above vertebra No.	25	24	23	25
Morphometric characters as % of standard length				
Head	19.0	20.5	19.0	19.0
Upper jaw	11.0	12.0	11.0	11.0
Preventral	15.5	18.5	16.5	15.5
Preanal	55	56	57	51
Predorsal	46.0	44.0	43.5	45.0
Distance from base of ventral fins to ant. anal-ray	39.0	39.0	41.0	39.0
Base of anterior 10 dorsal rays	6.4	7.0	6.9	5.6
Base of anterior 10 anal-rays	8.0	7.8	—	7.4

1. Right and left side, respectively.
2. The only characters obtainable from the "Investigator" specimens are: Number of precaudal vertebrae 33. Anterior anal-ray placed below vertebra No. 31.
3. Cf. p. 57.

edentate, the middle part is provided with 2-4 large fangs, and the anterior part bears irregular rows of small, close-set teeth. Also the symphysis is dentigerous. The vomer of the "Siboga" specimen has two fangs laterally in each side and very small teeth medially. The inner fangs are the shorter. The two other specimens have only one fang in each side. The premaxillary has no teeth on the posterior third and in the symphysis. The anterior third has numerous small teeth placed in irregular rows, gradually decreasing to a single row on the middle third of the premaxillary. The palatinum, the tongue and the basibranchials bear no teeth.

Vertebral column. All information is based on radiographs. The 32-33 precaudal and 37-38 caudal vertebrae are all well ossified and placed with small interspaces. The form and length of the neural and haemal arches and spines are very similar to those in *Barathronus bicolor*. The 3rd-8th vertebrae are provided with long, thin pleural ribs of which the anterior are the longest. The rest of the precaudal vertebrae have rather short, thick parapophyses like those in *B. bicolor*. The ratio between the length and the height of the last precaudal vertebral centrum is c. 0.5, actually 0.45 for the two smaller and 0.55 for the two larger specimens. The same ratio for the 20th caudal vertebral centrum is very close to 1 in all specimens. The transition between the precaudal and the caudal vertebrae is like that shown in Fig. 25. All vertebrae are more or less sand-glass shaped. Two large hypural plates are the only details of the caudal skeleton obtainable from the radiographs.

Gill cavity. The form of the long rakers in the outer row of the anterior gill arch is similar to that in *B. bicolor* (Fig. 28). There are 5-6 rakers on the epibranchiale, one in the angle between the epi- and ceratobranchiale, 17-19 on the latter bone and six on the hypobranchiale. All rakers are dentigerous. The rakers in the outer and inner rows of the 2nd-4th arches are of the same size.

The number of rakers on the 3rd-5th arches varies somewhat in the present specimens; (no rakers remain in the "Investigator" specimen). Therefore, the counts (outer row) from each of the three other specimens are given in Table 19.

Table 19. Number of gill rakers in *B. diaphanus.*

	"Valdivia"	"Cape St. Mary"	"Siboga"
Standard length in mm..............	117	92	59
No. of rakers on the 1st gill arch	5-6/1/24-25	5-6/1/22-24	6/1/23
No. of rakers on the 2nd gill arch	21-22	21-22	21
No. of rakers on the 3rd gill arch	21	17	18
No. of rakers on the 4th gill arch	19-20	16	16-17
No. of rakers on the 5th gill arch	14-15	14	10-11

The difference in the standard lengths might explain the above variation in the gill raker counts.

The gill laminae are of a feather-like composition. There are 2-3 pseudobranchial laminae in each side. The holotype has a distinct yellow spot (= the thymus) dorsally in each gill cavity.

The pattern of the five, dentigerous pharyngeal plates is similar to that of *B. bicolor* (Fig. 29).

Colour. The holotype and the "Siboga" specimen are almost uniformly yellowish owing to the long period of preservation. The latter specimen has the eyes and the area around the mouth slightly pigmented. The specimen from "Cape St. Mary" has only been preserved for four years. It has a black streak in the midline on either side, especially on the anterior part of the body, and also much pigment between the dorsal fin and the nape. The peritoneum is dark brown. The eyes are provided with a black ring surrounding a centrally placed black spot. It thereby resembles the colouration of *B. bruuni.*

Viscera. The following information is based on the "Cape St. Mary" specimen only, as the other specimens are in a poor condition.

The thick-walled oesophagus and stomach are dark brown. The intestine is very long, measuring c. 60 mm, while the distance from the posterior part of the stomach to the anus is only c. 30 mm. A constriction separates a more thin-walled and wider rectal part. The liver is small. The urinary bladder is c. 10 mm long.

Gonads:

Females. The holotype and the "Investigator" specimen have well developed ovaries. The maximum diameter of the eggs is about 800 µ. All the larger eggs are fertilized. The much distended ovaries of the holotype are c. 25 mm long. The ovaries of the "Siboga" specimen are thin and 11 mm long. Sections (Ser. No. 68) show that the maximum egg-diameter is c. 30 µ. None of the eggs are fertilized, and spermatozoa were not found in the ovaries. No trace of a copulatory apparatus is seen in any of the three females, but, on the other hand, they are in such a poor condition that small papillae cannot be distinguished.

Males. The testes of the single male are 10 mm long and distended. The excretory duct, which apparently is filled with spermatophores, is slightly longer than the testes (c. 11 mm). A small part of the right testis was sectioned (Ser. No. 54), showing a number of spermatophores 40-50 µ long, the heads being orientated in one direction. In addition, many earlier developmental stages from the spermatogenesis were found. Fig. 34 shows the copulatory apparatus, consisting of a urogenital sinus and a long penis, which is grown together with the sinus ventrally.

Biology and reproduction:

The presence of fertilized eggs in the ovaries shows that *B. diaphanus* is viviparous. Furthermore, the male is provided with spermatophores and a

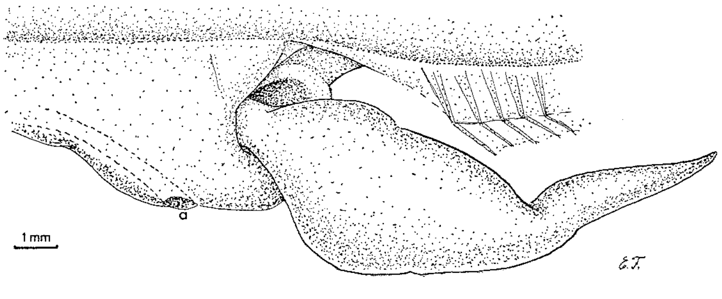


Fig. 34. Anal opening (a) and male copulatory apparatus of *B. diaphanus,* SL 92 mm. FRSH.

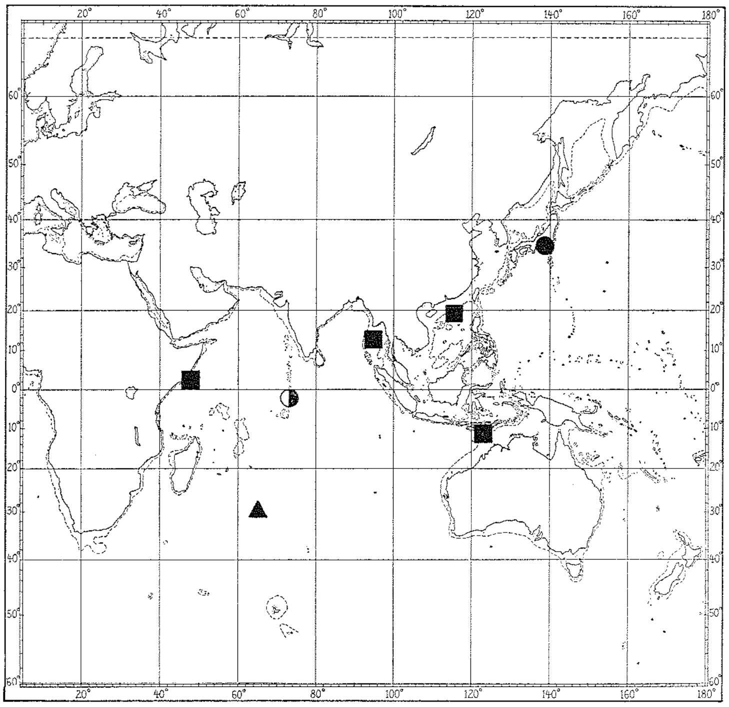


Fig. 35. Records of *B. affinis* (◑), *bruuni* (▲), *diaphanus* (■), *B.* specimen (●).

well developed penis. The four specimens occurred most probably bathyally.

Distribution:

All the four known specimens were caught in bottom trawl hauls at depths varying from 732-1756 m, i.e., bathyally. None of the trawls were provided with a closing device, so it can not be excluded that the specimens were taken pelagically. Fig. 35 shows that *B. diaphanus* is found in the Indian Ocean only and very close to coastal areas.

Barathronus affinis Brauer, 1906
Pl. III Fig. 3

Barathronus affinis Brauer, 1906, p. 306.
– –: Brauer 1908, pp. 161-64, pl. 35, figs. 11-13, textfig. 3.
– –: Grey 1956, p. 221.
– –: Munk 1966, p. 37, fig. 22.

Material examined (1 specimen):

Holotype (SL 47 mm, ♀); Deutsche Tiefsee Exped. "Valdivia" St. 220 (1°57′S, 73°19′1″E); 2919 m; trawl; bottom temperature 1.8°C. 21. Febr. 1899. ZMB 17700.

Condition of the material:

In order to study the anatomy of the eye, Brauer removed the left half of the head. Also the skin of the abdominal part and the pectoral fin were removed from the left side. The rest of the specimen is rather well preserved.

Diagnosis and relationships:

The most closely related species are *B. bruuni* and *B. parfaiti*. With reference to the diagnosis of *B. bruuni* (p. 51) a comparison was made between these two species in which some of the characters of specific value are mentioned. See also the characters in the key on p. 31, Tables 5-13 and the remarks under *B. parfaiti* (p. 53).

Description:

Many of the meristic and morphometric characters are given in Table 20. See also the generic diagnosis p. 28.

Only the right part of the head remains. It is higher and broader than the body. The body is compressed, and the caudal part is short (preanal 50 % of the SL). The transparent skin is rather loose. The musculus infracarinalis medialis is distinct. The ratio between the length and the width of the middle muscular "fields" is 1.4 (Fig. 22). Also the musculus infracarinalis posterioris is clearly seen. The dorsal fin arises somewhat in front of the midpoint of the fish (predorsal 44 % of the SL). The anal fin originates below the 14th dorsal fin-ray. The ventral fin consists of a single, rather long ray inserted below the middle part of

Table 20. Meristic and morphometric characters of *B. affinis* and *bruuni*.

	B. affinis	*B. bruuni*
	Holotype	Holotype
Standard length in mm	47	39
Meristic characters		
Dorsal fin	77	81
Caudal fin	10	10
Anal fin	67	73
Ventral fin[1]	1-1	1-1
Pectoral fin[1]	—	25-25
Gill rakers on anterior arch[1]	4/1/19-	6/1/26-6/1/26
Vertebrae (incl. urostyle)	34 + 44	36 + 50
Anterior anal-ray below dorsal-ray No.	14	10
Anterior anal-ray below vertebra No.	34	37
Anterior dorsal-ray above vertebra No.	27	31
Morphometric characters as % of standard length		
Head	17.0	19.0
Upper jaw	9.6	10.5
Preventral	15.0	14.0
Preanal	50	48.5
Predorsal	44.0	43.5
Distance from base of ventral fins to anterior anal-ray	36.0	37.5
Base of anterior 10 dorsal-rays	6.2	3.9
Base of anterior 10 anal-rays	7.7	6.4

[1] Right and left side, respectively.

the gill cover. All the pectoral fin-rays are broken at the base. The peduncle is a little longer than broad. The length forms 6.0 % of the SL. The eye is placed so deep in the head that it can not be observed directly. (Only BRAUER's dissection of the head makes it possible to see the eye). There is a central, pigmented spot (approx. 0.1 mm in diameter) and a very narrow, dark ring with a diameter of c. 0.6 mm. (See also the description of the eyes of *Nybelinia erikssoni* on p. 24). The anterior nostril is placed midway between the eye and the tip of the snout, and the posterior midway between the eye and the anterior nostril. Both nostrils have a very low rim. The mouth cleft forms an angle of about 45° with the horizontal plane. The upper jaw ends posterior to the eye. The circular otolith is 1 mm in diameter (Pl. III Fig. 4).

Lateral line system. Since the skin is torn only few lateral line papillae were found. There are 10-12 papillae along the midline of the caudal part of the body. The length is less than 0.1 mm. Besides these, a few scattered papillae were seen on the lower jaw.

Dentition. Only the dentigerous bones of the right side of the mouth remain. Near the symphysis the anterior third of the dentary has many, small, close-set teeth arranged in about three irregular rows. A few of the teeth are larger and more fang-like than the rest. More laterally there are 1-2 rows of small teeth. The middle third of the dentary holds four large fangs which gradually become longer posteriorly. The most posterior tooth is about ten times as long as one of the small symphysis teeth. The posterior third of the dentary is edentate. The right side of the vomer has one large fang laterally and a few small teeth more medially. The premaxillary tooth-pattern is formed almost as that of the dentary except for the fangs which are much longer in the latter bone. The palatine, the tongue and the basibranchials are edentate.

Vertebral column. All the information below derive from radiographs. There are 34 precaudal and 44 caudal vertebrae, all with rather poorly ossified centra. Large unossified parts of the chorda are found between the centra, and the middle part of each centrum is less ossified than the periphery. The anterior five neural spines are relatively long and thick (the first is the longest). From the 6th they gradually become shorter and more retrorse. The haemal spines are equal to the corresponding

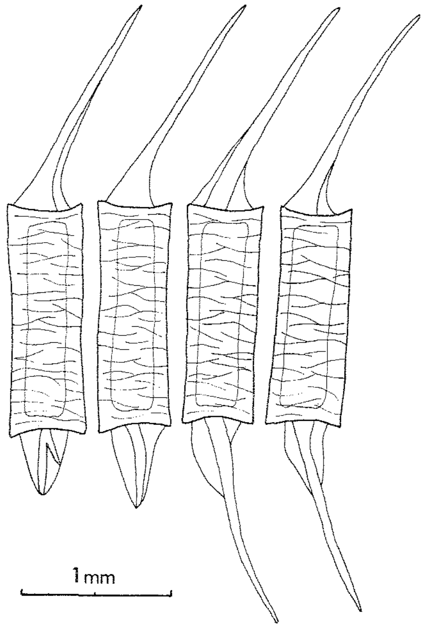


Fig. 36. Transition between precaudal and caudal vertebrae in the holotype of *B. affinis*, SL 47 mm.

neural spines in length and shape. Both the neural and haemal spines have a pointed tip. The ventrally directed processes on the precaudal vertebrae are not well ossified, judging from the radiographs. There seems to be a pair of thin pleural ribs on the 3rd-5th vertebrae and some shorter and thicker processes, parapophyses?, approx. from the 10th to the last precaudal vertebra, increasing in length posteriorly. (Processes on the 6th to approx. the 10th vertebra might be present, but are not visible on the radiographs). Radiographs taken from a dorsal view also do not show any ribs. The transition between the precaudal and the caudal vertebrae is very distinct (Fig. 36).

This form of the vertebral centra is only found in a few additional *Barathronus* specimens *(B. affinis* and *B. parfaiti)* which all are juveniles. The rectangular shape, viewed laterally, combined with the small standard length and the poorly developed gonads indicate that also the present specimen is in a juvenile stage. The ratio between the length and the height of the last precaudal vertebral centrum is 0.3, while it is 0.5 for the 20th caudal vertebral centrum. Fig. 25 shows that the centra undergo a change in form from sub-rectangular to sand-glass shaped during ontogeny. No details of the caudal skeleton were obtainable.

Gill cavity. Only from the right gill chamber is any information available. The anterior arch is shaped as that of *Barathronus bicolor* (Fig. 28). The outer row of rakers on the anterior arch holds four, long epibranchial rakers, one long raker in the angle between the epi- and ceratobranchiale, 15 long rakers on the ceratobranchiale, and four short ones on the hypobranchiale. There is a decreasing number of rakers on the 2nd-5th arch. The shape and size of the rakers in the inner row of the 2nd-4th arches are like that of the rakers in the outer row of the corresponding arches. All rakers are dentigerous. The length of the gill laminae is equal to one of the short rakers. Below is given a survey of the number of rakers in the outer rows from the right side:

1st gill arch with	4/1/15+4	rakers
2nd gill arch with	17	rakers
3rd gill arch with	16	rakers
4th gill arch with	12	rakers
5th gill arch with	9	rakers

There are two pseudobranchs, but apparently no yellow "body" (= thymus). The number of toothed upper pharyngeal plates can not be stated.

Colour. Except for the black lenses the specimen is uniformly coloured in varieties of yellow and brown. According to BRAUER's description, the preserved specimen was uniformly white-yellowish.

Viscera. The relatively thick-walled oesophagus and stomach are 7.5 mm long. The anterior part of the thin-walled intestine is much wider than the pyloric part of the stomach. There are three coils on the intestine which is 22 mm long. The distance from the posterior part of the stomach to the anus is 8 mm. The posterior third of the intestine is wider than the median part. The liver ends just posterior to the most anterior part of the intestine. The almost transparent urinary bladder is 1 mm long approx.

Gonads:

The paired gonads are 9 mm long, and each of them is 0.4 mm wide. Sections (Ser. No. 46) showed the presence of few, small eggs with a maximum diameter of about 100 μ. No spermatophores or free spermatozoa were observed. A copulatory apparatus is not developed, but the skin surrounding the urogenital openings is not well preserved.

Biology and reproduction:

The only known specimen, a female, has so poorly developed gonads (egg-diameter 100 μ) that even if interior fertilization does take place, as in other *Barathronus* spp., embryos could not be expected at this developmental stage. As mentioned

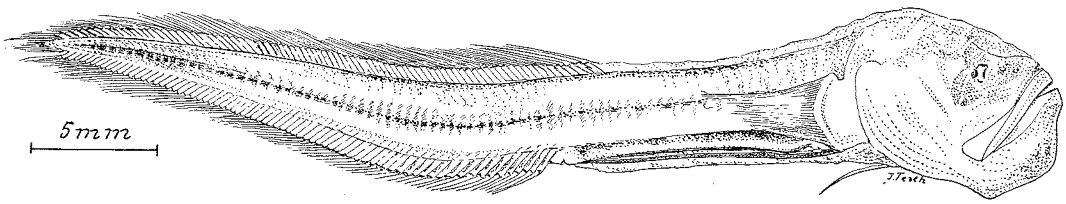


Fig. 37. Holotype of *B. bruuni* n. sp., SL 39 mm. USNM 202104.

under the "Vertebral column", this specimen is most probably a juvenile.

BRAUER (1908, p. 161) listed *B. affinis* as a bottom-fish, which cannot be verified. The stomach contents hold mostly indeterminable remains of crustaceans, and the only other fish in the trawl was the pelagic *Cyclothone microdon* Günther, 1878. The holotype of the related species, *B. bruuni,* also a juvenile, was caught pelagically, which might also apply to *B. affinis*. The temperature was 1.8°C at the bottom (2919 m).

Distribution:

Known only from the type locality off Chagos Archipelago in the Indian Ocean (Fig. 35).

Barathronus bruuni n. sp.
Fig. 37

Material examined (1 specimen):

Holotype[1] (SL 39 mm, ♀); IIOE "Anton Bruun" Cruise 6, St. 351 B (29°45'S, 64°58'E); pelagically, c. 1700 m; Isaacs-Kidd midwater trawl. 4825 m to the bottom. 28. June 1964. USNM 202104.

Diagnosis and relationships:

The most closely related species are *B. affinis* and *B. parfaiti* (p. 53). See Tables 5-13. Table 20 (p. 49) shows some of the characters of *B. affinis* and *B. bruuni*. It is difficult to say whether the difference between the two specimens is due to intra- or interspecific variation, since only the holotype of each species is known. However, I find it justifiable to use the *B. bicolor* material (42 specimens) as an indication of an expected intraspecific variation within the genus *Barathronus.*

Below are listed those meristic characters which vary more than do the *B. bicolor* specimens *(B. bruuni* is mentioned first, *B. affinis* between brackets): Number of caudal vertebrae 50 (44), total number of vertebrae 86 (78), total number of gill rakers on the anterior arch 33 (24), anterior dorsal fin-ray situated above vertebra number 31 (27).

Since the two specimens are of about equal length (39-47 mm) also differences in the morphometric characters may be used in the diagnosis: The base of the anterior ten dorsal and anal fin-rays forms 3.9 and 6.4 % of the standard length respectively (6.2 and 7.7 %). The ratio between the length and the width of the middle "fields" of the musculus infracarinalis medialis is 1.0 (1.4). This latter character shows an allometric growth, at least in *B. bicolor* (Fig. 22), which makes the difference in this character more pronounced since the holotype of *B. bruuni* is the smaller of the two specimens. The length of the intestine forms 14 % of the standard length (25 %). The dentition of the dentaries is different in the two species (cf. the respective descriptions).

The species is named after the R/V "Anton Bruun".

Description:

Some of the meristic and morphometric characters are shown in Table 20 (p. 49). See also the generic diagnosis.

The head is much broader and higher than the body. The body is not so compressed as that of *B. affinis,* being almost circular in section. The caudal part of the body is the longer (preanal length 48.5 % of the SL). The transparent skin is firm. The musculi infracarinales mediales are somewhat indistinct, owing to the pigmented peritoneum. The ratio between the length and the width of the middle muscular "fields" is 1.0 (Fig. 22). The dorsal fin origins in front of the midpoint (predorsal length 43.5 % of the SL). The anal fin arises below the 10th dorsal fin-ray. The ventral fins are placed not far behind a vertical line through the eyes. The pectoral fins are large. The peduncle is a little broader than long. The length forms c. 4 % of the SL. The eyes are placed rather deep in the head, but owing to the transparency of the overlying tissues the black-pigmented parts are easily seen. They much resemble *B. affinis,* but the centrally placed

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[1] The specimen is in an excellent condition.

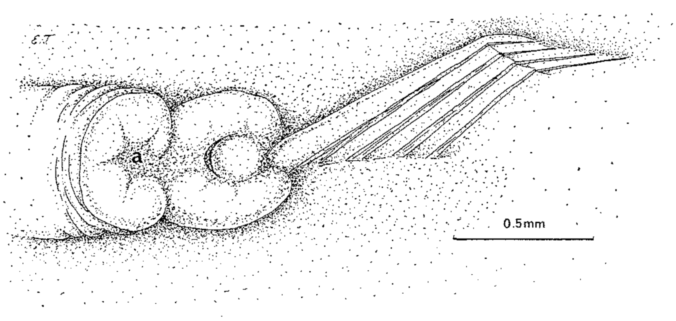

Fig. 38. Ventral view of anal opening (a) and copulatory apparatus of the holotype of *B. bruuni.*

spot as well as the surrounding, narrow ring are much larger in *B. bruuni,* being 0.5 and 1 mm respectively. The position of the nostrils is shown on Fig. 37. The mouth cleft forms an angle of about 60° with the horizontal plane. The upper jaw ends below the eye. The otoliths are visible through the roof of the skull.

Lateral line system. A few, very small lateral line papillae are present along the midline of the caudal part of the body and on the head.

Dentition. The anterior part of the dentary is provided with 1-2 irregular rows of pointed, rather large teeth. Also the symphysis is dentigerous. The posterior half has c. ten uniserially placed fangs 2-3 times the length of the more anterior dentary teeth. The vomer has one large fang laterally in either side and one fang almost medially. Between the fangs are numerous small, flat teeth in irregular rows. The teeth on the premaxillary are all more or less of the same size and shape as those of the dentary, arranged in one row on the anterior third, in 1-2 rows in the middle third and again uniserially in the posterior third of the premaxillary. The lower jaw symphysis is edentate. The palatinum, the tongue and the basibranchials are not provided with teeth.

Vertebral column. There is much similarity between the "Vertebral column" of *B. affinis* and *B. bruuni,* so only a few characters are mentioned here.

All the following information is based on radiographs. There are 36 precaudal and 50 caudal vertebrae. The ossification is even slighter than in *B. affinis,* and it is very difficult to distinguish the ventrally directed processes of the precaudal vertebrae. The vertebral centra are placed close to each other, with very small interspaces. The transition between the precaudal and caudal vertebrae is distinct. The ratio between the length and the height of the last precaudal vertebral centrum is 0.2 and it is 0.4 for the 20th caudal vertebral centrum. The smaller standard length of the holotype of *B. bruuni* might explain why the above ratio is less than that for *B. affinis.* The radiographs give no details of the caudal skeleton, but when examined in transparent light two large hypural plates are seen like those on Fig. 26.

Gill cavity. The "Gill cavity" of this species is very similar to that of *B. affinis* (cf. p. 50). In the following only those characters by which the two species differ are mentioned. As seen from the survey below, showing the number of rakers in the outer rows from both sides, there are definitely more rakers in *B. bruuni* than in *B. affinis:*

1st gill arch with 6/1/26 rakers
2nd gill arch with 23 rakers
3rd gill arch with 21-22 rakers
4th gill arch with 18-19 rakers
5th gill arch with 13-14 rakers

There are three pseudobranchial laminae in each side. No thymus could be seen. All the five pharyngeal plates are provided with teeth.

Colour. The background colour of the fish is yellowish. Anteriorly, the body is provided with a distinct, brown streak in the midline on each side. Diffuse brown pigmentation is found on the sides of the fish with a concentration between the dorsal fin and the nape. The peritoneum is much pigmented. The caudal part of the fish is almost without pigment. Very small and scattered pigment-spots are present all over the head, where the only heavy pigmented parts are the eyes.

Viscera. The oesophagus and the stomach are 6 mm long and much more thick-walled than the intestine. The anterior part of the intestine is wider than the stomach. The intestine, measuring c. 10 mm, is almost straight with only one coil. The distance from the posterior part of the stomach to the anus is 8 mm. There is no constriction on the intestine indicating a rectal part. The liver ends just in front of the anterior part of the intestine. None of the viscera are pigmented.

Gonads:

The length of the thin, white, paired gonads is 6 mm. A portion of the middle part was sectioned (Ser. No. 66) and proved to be ovaries. The unripe eggs are c. 20 μ in diameter, and only 4-5 are seen in each section. None of the eggs are fertilized and spermatophores or free spermatozoa were not observed. Considering that the only known specimen is a female, the copulatory apparatus (Fig. 38) is built in a peculiar way, consisting of a small, medially placed papilla surrounded by a low rim. This is the only known *Barathronus* female with a centrally placed papilla which makes the copulatory apparatus rather similar to that of an unripe *Barathronus* male.

Biology:

The form of the vertebral centra and the poorly developed ovaries show that this specimen is a juvenile. This is the only known specimen of *Barathronus* which occurred pelagically, as it was caught with a midwater trawl at a depth of c. 1700 m over a depth of 4825 m.

Distribution:

Known only from the type locality south east of Madagascar (Fig. 35).

Barathronus parfaiti (Vaillant, 1888)

Pl. IV Fig. 1

Alexeterion parfaiti Vaillant, 1888, pp. 283-84, pl. XXV fig. 2.
– –: Goode & Bean 1896, p. 343, fig. 300.
– –: Brauer 1906, p. 407.
Barathronus parfaiti: Roule 1915, pp. 57-58.
– –: Roule 1916, pp. 18-19.
– –: Roule 1919, pp. 73-74, pl. II fig. 4.
– –: Roule 1934, pp. 194-95, pl. XI and the fig. on p. 195.
– –: Legendre 1934, p. 406, fig. 52 (= *Oculospinus* cf. *brevis* Koefoed, 1927).
– –: Fowler 1936, p. 1071.
– –: Nybelin 1954, pp. 65-66 (= part. *B.parfaiti* and part. *Oculospinus* cf. *brevis).*
– –: Grey 1956, pp. 221-22 (= part. *B.parfaiti* and part. *Oculospinus* cf. *brevis).*
Gen. et spec. indet.: Nybelin 1957, probably a juvenile *parfaiti*?, pp. 313-14, pl. VII figs. 4 and 11 (= *Meteoria erythrops* cf. p. 58).
Barathronus parfaiti: Marshall 1960, p. 111 (= *Oculospinus* cf. *brevis).*
Barathronus parfaiti: Nielsen 1966, p. 95.
Barathronus sp.: Nielsen, Jespersen & Munk 1968, p. 247 (= *B.parfaiti* (Vaillant, 1888)).

Material examined (2 specimens)[1]:

Holotype (SL 40 mm); "Talisman" haul 137[2], between France and the Azores; 4975-5005 m; whitish mud; small trawl; bottom temp. 2.7°C. 1883. MNHN 86-554.

1 specimen (SL 100 mm, ♂); "Princesse-Alice" St. 698, Azores (39°11′N, 30°44′40″W); 1846 m; sandy mud; trawl. 18. July 1896. MOM.

Condition of the material:

The holotype is in a very poor condition, being very soft and poorly fixed, almost completely eviscerated and much curled up. Vaillant (1888, p. 284) wrote "Le dénumbrement des rayons est assez difficile vu la petitesse et l'état de conservation de l'individu" and his illustration of the holotype is most probably a reconstruction.

The Monaco specimen is well preserved except for the caudal fin which is broken at the base. The figure published by Roule (1919) agrees with the specimen itself except for the "Preventral" and the "Depth at the origin of the dorsal fin" which are too long in the figure. The peculiar pattern just in front of the anus is skin-folds.

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[1] As shown in Table 21 two additional specimens have been referred to *B.parfaiti*. However, the one from Concarneau is a postlarval *Oculospinus* cf. *brevis* Koefoed, 1927 (cf. p. 57) and the Gothenburg specimen is here identified as *Meteoria erythrops* (cf. p. 58).

[2] As already mentioned by Grey (1956, p. 110), the list of the "Talisman" stations in Smith (1889, p. 980) and also in Annales Hydrografiques (1883) differs very much from Vaillant's station data (1888). Smith gave the following data for what he calls "Serial number 137": Azores (38°37′N, 28°21′W); 1258 m; grey mud; bottom temp. 11.5°C.; 15. Aug. 1883. A handwritten copy of the "Talisman" station list, made in 1917 by E.L. Bouvier, Paris, is kept in the Zoological Museum, Copenhagen. This list adds some data to those given by Vaillant (1888, p. 58). The position and date of St. 137 was: 44°29′N-44°21′N, 15°52′W-15°53′W of Paris (= 13°32′W-13°33′W of Greenwich); 27. Aug. 1883. – M.L. Bauchot (personal communication) has checked the divergency concerning the data for St. 137 and sent me a copy of Annales Hydrografiques (1883). By comparing Bouvier's list with the data from Annales Hydrografiques, Smith, and Vaillant it appeared that Vaillant and Bouvier used "Numéro du dragage" while Smith used "Serial number" which explains the disagreement mentioned by Grey. In this particular case "Numéro du dragage 137" corresponds to "Serial number 152".

Table 21. Meristic and morphometric characters of *B. parfaiti.*

	Holotype[2] Paris	ROULE (1915) Monaco	LEGENDRE (1934) Concarneau = *Oculospinus* cf. *brevis*	NYBELIN (1957) Gothenburg = *Meteoria erythrops*
Standard length in mm	40	100	27	25
Meristic characters				
Dorsal fin	80-85	71	97	48
Caudal fin	10	10	9	>5
Anal fin	60-65	66	79	34
Ventral fin[1]	1-1	1-1	—	0
Pectoral fin[1]	21-21	24-25	c. 30	13-13
Gill rakers on anterior arch[1]	6/1/22-6/1/23	6/1/22-6/1/22	2/10-2/10	c. 10
Vertebrae (incl. urostyle)	37 + 47	34 + 47	—	38 + 30
Branchiostegal rays[1]	—	8	—	7-8
Anterior anal-ray below dorsal-ray No.	c. 15	12	25	15
Anterior anal-ray below vertebra No.	36	35	—	39
Anterior dorsal-ray above vertebra No.	25-30	29	—	28
Morphometric characters as % of standard length				
Head	20.0	21.5	—	—
Upper jaw	—	11.0	—	—
Preventral	—	18.0	—	—
Preanal	—	59	—	—
Predorsal	—	51	—	—
Distance from base of ventral fins to anterior anal-ray	37.5	44.0	—	—
Base of anterior 10 dorsal rays	—	5.8	—	—
Base of anterior 10 anal-rays	—	6.7	—	—

1. Right and left side, respectively.
2. When the characters of *B. parfaiti* are compared to those in table 1 (NIELSEN 1966) of the same specimen, a few differences are found, e.g., 10 *vs.* 8 caudal fin-rays, 1-1 ventral fin-rays *vs.* ventral fin-rays not seen, and 37 *vs.* 39 precaudal vertebrae. This is partly due to better radiographs and partly to the use of a compressed air-jet in the present examination. Because of the approximate indication of many of the meristic characters only a few of these are included in the frequency distribution (Tables 5-13).

Diagnosis and relationships:

Tables 5-13 show that *B. parfaiti* differs from the other Atlantic species, *B. bicolor,* in the number of anal fin-rays, caudal vertebrae, position of the anterior anal fin-ray in relation to the dorsal fin and in the position of the anterior dorsal fin-ray in relation to the vertebrae. NYBELIN (1957, p. 314) re-examined the Monaco specimen and found that it differed greatly from *A. parfaiti,* being closely related to *B. bicolor,* which is correct if the specimen is compared to VAILLANT's description of *B. parfaiti.* The most closely related species are *B. affinis* and *bruuni* from the Indian Ocean. Tables 5-13 show that *parfaiti* most often takes up an intermediate position between these two species. Also the morphometric characters differ but this might be due to an allometric growth as, e.g., the "Distance from base of the ventral fins to the anterior anal-ray" (Fig. 21). Examination of the "Predorsal length" in the *B. bicolor* material shows no allometric growth at all, so difference in this character might be of specific value (51 % in *parfaiti vs.* 43.5-44 % in the two Indian Ocean species). When more material of *B. parfaiti, affinis* and *bruuni* becomes available, it might be most correct to lump them all together into one species, but as long as only four specimens are known, of different size, and two of them even in a poor condition, I find it reasonable to regard them as separate species.

Table 21 only gives a few morphometric characters of the three small specimens, as those from the Gothenburg specimen are given in Table 22 (p. 59) and the remaining two are in so poor condition as to be useless.

Description:

The following description is mainly based on the Monaco specimen. Most of the meristic and morphometric characters are given in Table 21. See also the generic and specific diagnosises.

The meristic characters differ much in one character only, viz. the number of dorsal fin-rays, but not more than the intraspecific variation in the *B. bicolor* material (cf. Table 14). There is quite a difference between VAILLANT's fin-ray counts and those from the re-examination, e.g., dorsal fin-rays 48 *vs.* 80-85, anal fin-rays 40 *vs.* 60-65 and caudal fin-rays 0 *vs.* 1-1. VAILLANT (1888, p. 284) gave some morphometric characters, e.g., depth of body 16 %, head 16 %, snout 7 %, diameter of eye 1.2 % and interorbital width 9.5 % of the length.

The head is broad and high and the body is compressed with a rather short caudal part. The transparent skin is loose. The musculus infracarinalis medialis (p. 9) is very distinct and also the anterior part of the musculus infracarinalis posterioris can be seen. Midway between the ventral and anal fins the muscular "fields" are a little more short than wide (the ratio is 0.9). Another distinct muscle runs from the base of the ventral fins to the base of the pectorals. This muscle probably is the musculus infracarinalis anterioris. The dorsal fin originates close to the midpoint of the fish. The anal fin arises below the 12th dorsal fin-ray. Each of the ventral fins consists of a single, but well developed ray which ends below the middle of the pectoral fin. They are inserted below the posterior edge of the preoperculum. The pectoral peduncle is rather short and axe-formed. The ratio between the length and the maximal height (distally) of the pectoral peduncle is 0.9. The length forms 5.0 % of the standard length. The head is grooved, and the mouth cleft is almost vertical. The eyes are indistinct and apparently are built in the same way as the eyes of *Barathronus affinis* Brauer, 1906 and *Nybelinia erikssoni* (Nybelin, 1957) (cf. p. 24). They consist of a very narrow, subcircular, black ring, 4 mm in diameter approx. Inside the ring, but deeper in the head, is a tiny, black spot with a diameter of 0.5 mm. The nostrils are placed rather close to each other midway between the upper lip and the eyes. Both are provided with a low rim. Otoliths are not seen on the radiographs.

Lateral line system. The holotype has only a few papillae left on the posterior part of the body, so the description below is based solely on the Monaco specimen. There is one row consisting of 12-14 papillae in the lateral midline of the caudal part of the body. Just posterior to the anus the row forks. The ventral branch holds 8-10 papillae. Near the tip of the pectoral fin it ascends and reaches the dorsal branch a little posterior to the gill slit. The dorsal branch ascends from the midline and runs close to the dorsal edge from the origin of the dorsal fin to above the gill slit. It consists of 20-25 papillae arranged in a very irregular row. The two anterior papillae are somewhat prolonged, while the other papillae measure 0.2 mm approx. The sensory canals on the head are very indistinct. Four supratemporal papillae seem to be present. The preoperculo-mandibular canal consists of 3-4 papillae on the preoperculum and 12 prolonged papillae on the mandible. Owing to the condition of the skin it is impossible to reconstruct the supra- and infraorbital canals.

Dentition. The premaxillary teeth are all very small and pointed. Anteriorly there are 3-4 rows, gradually decreasing to only one row. The posterior third and the upper jaw symphysis are toothless. The vomer is provided with few teeth only. In the right half there is one very large fang and three smaller, pointed teeth. Two of the smaller teeth are apparently lacking in the left half of the vomer. The vomer of the holotype has no fangs, but it seems as if there are remains of a broken, larger tooth laterally. The anterior third of the dentaries bears numerous small teeth mixed with a few relatively large ones. They are arranged in five irregular rows anteriorly decreasing to one row further back. The middle third of the dentaries is provided with 3-4 large, recurvated teeth and the posterior third is edentate. The lower jaw symphysis is dentigerous. No teeth are developed on the palatines, the tongue, and on the basibranchials.

Vertebral column. All the remarks below are based on radiographs. There are 34-37 precaudal and 47 caudal vertebrae. Only the Monaco specimen is well ossified. The anterior neural spine, which is almost vertical, is the longest. The length decreases gradually to the caudal fin, becomming more depressed. The haemal spines and arches are similar in form and length to the corresponding neural ones. As shown in Fig. 39 the spines are much shorter in the holotype than in the larger Monaco specimen. Judging from the radiographs there are thin pleural ribs on the 3rd-8th precaudal vertebrae, longest most anteriorly. Parapophyses are developed on the 9th-34th precaudal vertebrae, but only slightly in the holotype. The vertebral centra of the Monaco specimen are all sand-glass shaped, while those of the holotype are rectangular in lateral view. In the Monaco specimen the ratio

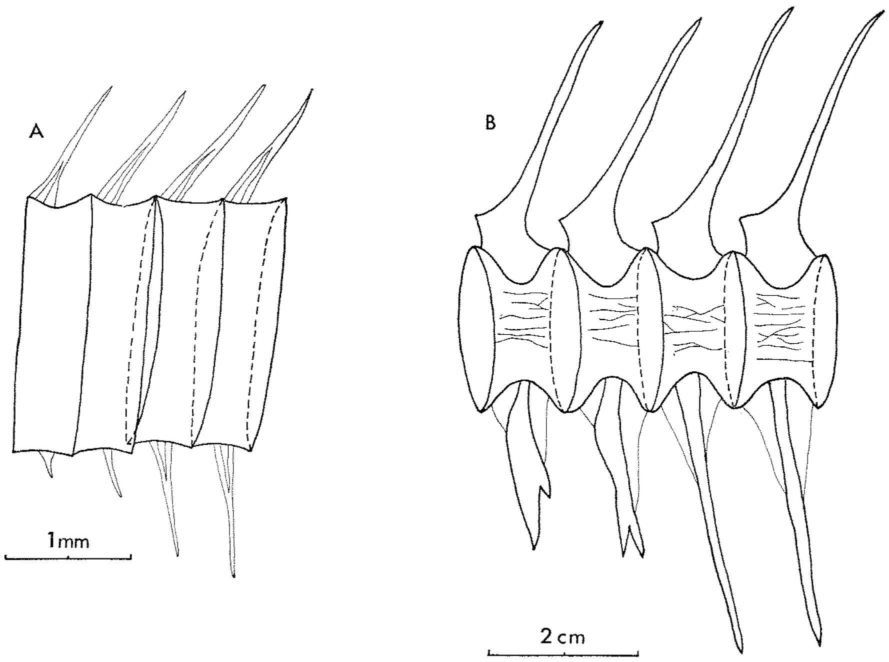

Fig. 39. Transition between precaudal and caudal vertebrae in *B. parfaiti*. A: SL 40 mm (holotype), B: SL 100 mm (Monaco specimen).

between the length and the height of the last precaudal vertebral centrum is 0.5 and 0.7 for the 20th caudal vertebral centrum. The ratio in the holotype is 0.25 and 0.4, respectively. The hypurals seem to form two large plates.

Gill cavity. The anterior gill arches are very similar to those of *B. bicolor* (Fig. 28). The outer row consists of six epibranchial rakers, one of which is very short, one long raker in the angle between the epi- and ceratobranchiale, 20 long rakers on the latter bone and 2-3 shorter rakers on the hypobranchiale. The stubby rakers in the inner row of the 1st arch are equal in length to the rakers in both rows of the 2nd-4th arches. Those on the last arch are much shorter. All rakers are dentigerous except for the long rakers of the holotype. Below is given a survey of the number of rakers from the outer row from both specimens:

1st gill arch with 6/1/22-23 rakers
2nd gill arch with 2-3/18-19 rakers
3rd gill arch with 1-2/17-18 rakers
4th gill arch with 1-2/15-16 rakers
5th gill arch with 13+?-16 rakers

There are c. 50 gill laminae on the anterior arches, all of a feather-like composition and 3-4 times the length of the rakers from the inner row. A pseudobranch consisting of 2-3 well separated filaments are present on each side. The five upper pharyngeal plates are arranged in a pattern like those in *B. bicolor* (Fig. 29). Teeth on the basibranchials are apparently not developed. The Monaco specimen, dorsally in each gill cavity, has a yellow spot, 2 mm in diameter, which most probably is the thymus.

Colour. The entire fish is coloured in the present condition in variations of yellow and light brown, except for the peritoneum, which is more or less covered with dark brown spots, and the black eye-pigmentation. The peritoneum appears purple, owing to the underlying yellow tissues. The greyish skin is almost transparent. The musculus infracarinalis medialis is seen as a light band against the peritoneum. ROULE (1919, p. 74) described the colouration of the newly caught Monaco specimen: The body has a uniform greyish colour. Around the jaws and eyes the specimen is somewhat more yellow and darkish. The fins are bluish with the fin bases ochrous.

Viscera. The thick-walled oesophagus and stomach are 16 mm long. The anterior part of the intestine is broader than the stomach, but the wall is very thin and provided with a reticular pattern. The intestine forms three coils and measures about 65 mm, while the distance from the posterior part of the stomach to the anus is 20 mm only. The small liver ends under the middle part of the pectoral fin. A 4 mm long, oval urinary bladder is present. The gall-bladder measures 4 mm in diameter.

Gonads:

No gonads or copulatory apparatus are seen in the holotype. In the Monaco specimen the narrow gonads are 13 mm long. Sectioning (Ser. No. 31) of a part of the left gonad showed that it is an unripe testis. The seminiferous tubules contain many spermatogonids and spermatocytes, but no spermatids and spermatozoa were observed. This corresponds well with the poorly developed penis (Fig. 31). The copulatory apparatus consists of a large, thick-walled urogenital sinus and a c. 1 mm long penis.

Biology and reproduction:

Some authors, e.g., NYBELIN (1954, p. 65 and 1957, p. 281), GREY (1956, p. 221) and MARSHALL (1960, p. 111) write that *B.parfaiti* is pelagic, all referring to a specimen from the stomach contents of an albacore, *Germo alalunga* (Gmelin, 1788), reported by LEGENDRE (1934, p. 406). However, LEGENDRE's specimen was recently shown to be a postlarval brotulid belonging to the genus *Oculospinus* Koefoed, 1927 (NIELSEN 1966), which invalidates the evidence of the abovementioned authors.

The holotype is a juvenile, judging i.a. from the short, high vertebrae, and it occurs as such most probably pelagically (cf. *B.bruuni*). No other fishes were caught in the trawl together with the holotype. The Monaco specimen was taken together with a number of typical bottom fishes, but the possibility exists that it was caught during the hauling up of the trawl.

There are no gonads in the holotype, and the poorly developed testes and penis of the Monaco specimen do not show whether *B.parfaiti* has interior fertilization like the other *Barathronus* spp. However, specimens of, e.g., the viviparous *B.bicolor* with unripe testes had a short penis, so also *B. parfaiti* may be viviparous.

Distribution:

The depth at the type locality is c. 5000 m and 1846 m for the Monaco specimen. Fig. 33 shows the two localities.

Barathronus specimen

Material:

SL 156 mm, ♂; "Albatross" St. D-5065, off Japan (35°05′40″N, 138°39′30″E); 386-430 m; 9′ trawl; bottom temp. 9°C. 15. Oct. 1906. USNM 150285.

This specimen, the meristic and morphometric characters of which are given in Table 18 (p. 46), has been separated from the five *Barathronus* spp. for several reasons. The frequency distribution of the meristic characters (Tables 5-13) shows that the specimen has characters in common with *B.bicolor* as well as with *diaphanus*. The tables show that some of the morphometric characters differ from both the abovementioned species, but this might be due to allometric growth, as the present specimen is 156 mm long, the longest recorded *Barathronus* specimen. There are no palatine teeth, as in *B.diaphanus,* and the ratio between the length of the testicular excretory duct and the length of the unripe testes is 0.7, viz. similar to *B.bicolor*. The copulatory apparatus differs from that of both species, but not too much importance should be given to this, since apparently it is somewhat molested. The presence of a short penis, 1.3 % of the SL, is also here correlated with unripe testes (Fig. 31). Sections (Ser. No. 67) of a part of one of the 17 mm long, thin gonads showed very unripe tissues, impossible to sexidentify.

Another possibility was to describe this specimen, the only one known from the Pacific Ocean, as a new species. However, since many of the characters in which it differs from the most closely related species *(B.bicolor* and *diaphanus)* most probably are submitted to allometric growth and poor preservation, I have refrained from this. It is astonishing that not more material has been procured, since deep-sea trawling is rather common off Japan, where the present specimen was caught at a depth of 400 m approx. Additional material may show the correct systematic position of this specimen.

Meteoria n. gen.

Type species by monotypy *M.erythrops* n.sp. (see below). Two specimens are known, both taken near the Azores. The juvenile specimen was described by NYBELIN (1957, p. 313). However, since it is a young stage it was not given a name, but was designated "Gen. et spec. indet.". The only aphyonid species, with which NYBELIN found good agreement, was *Barathronus parfaiti* (Vaillant, 1888), and he considered it "not quite improbable" that this young specimen was a juvenile of *B.parfaiti* (cf. the discussion p. 28).

Diagnosis:

The body is elongate and the snout is blunt. The caudal part of the fish only represents about 30 % of the standard length. The very small, black-

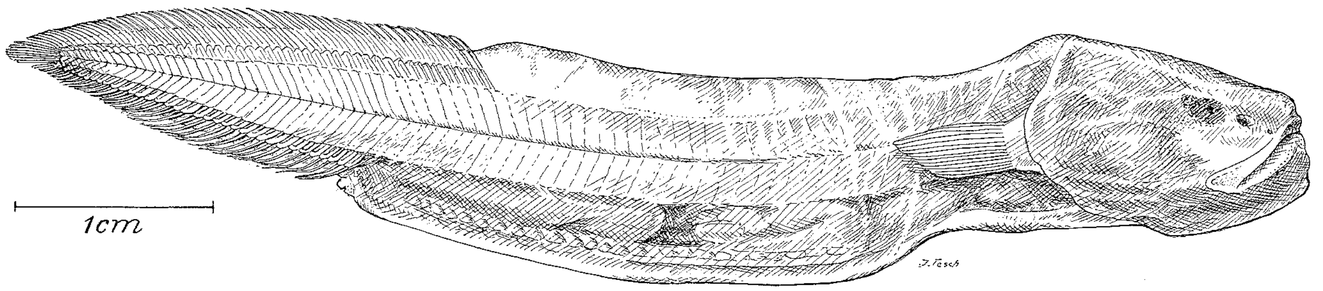

Fig. 40. Holotype of *Meteoria erythrops* n. gen. et sp., SL 63 mm.

pigmented eyes are placed under the skin. The interorbital width is very great, and the dorsal part of the head is flat. The mouth cleft forms an angle of 30° approx. with the horizontal plane. The dentaries, premaxillaries and vomer are dentigerous, but all without fangs. The outer row of rakers on the anterior arch is edentate and very poorly developed, each raker being shorter than any raker in the remaining rows. Pseudobranchs are not developed. The ratio between the maximum length and height of the pectoral peduncle is 1 approx. There are 48-50 dorsal, eight caudal, 34 anal and 13-15 pectoral fin-rays. The dorsal and anal fins are very short. Ventral fins are not present. There are 39-41 precaudal and 29 caudal vertebrae. According to radiographs no ventrally directed processes are developed on the precaudal vertebrae except for the last four. A copulatory apparatus is hardly developed in the only adult specimen known (a female).

The generic name derives from the German R/V "Meteor" which caught the holotype.

Relationships:

Meteoria apparently is nearest to *Sciadonus* Garman, 1899 and *Leucochlamys* Zugmayer, 1911, but differs in the following characters (*Meteoria* mentioned first): Pectoral peduncle not prolonged (the peduncle is pedicellate); outer row of rakers on the anterior gill arch edentate and hardly developed (small and dentigerous rakers); no claspers in the female (a pair of long claspers in the female); number of rays in the caudal fin 8 (6-7), in the pectoral fin 13-15 (9-14) and in the ventral fin 0 (0-1). – *Meteoria* differs from *Aphyonus* Günther, 1878 as the latter has 3-9 well developed, dentigerous gill rakers in the outer row of the anterior arch, 1 ventral fin-ray, fewer precaudal vertebrae (32-33 *vs.* 39-41), quite another tooth-pattern on, i.a., the premaxillaries and better developed parapophyses and haemal arches and spines. – *Meteoria* and *Nybelinia* (cf. p. 23) differ in the number of pectoral fin-rays (13-15 *vs.* 23-25), ventral fin-rays (0 *vs.* 1), well developed gill rakers on the anterior arches (0 *vs.* 7-8) and length of pectoral fin base (normal *vs.* somewhat prolonged). – *Meteoria* differs from *Barathronus* Goode & Bean, 1886 in the number of rays in the pectoral fin (13-15 *vs.* 21-25), well developed rakers on the anterior gill arches (0 *vs.* 24-33), in the angle of the mouth cleft (slightly oblique *vs.* very oblique) in the number of ventral fin-rays (0 *vs.* 1) and caudal fin-rays (8 *vs.* 10, very rarely 9) and finally in the shape of the vertebral centra of ripe specimens (rectangular *vs.* sand-glass formed).

Meteoria erythrops n. sp.

Fig. 40

Gen. et spec. indet.: Nybelin 1957, pp. 313-314, pl. 7 figs. 4 and 11.

Material (2 specimens):

Holotype (SL 63 mm, ♀); "Meteor"-cruise 3, St. 37, east of the Azores (42°06.3′N, 14°42′W – 42°08.1′N, 14°30.7′W); 5320 m; Agassiz trawl. 18.-19. Mar. 1966. ISH 1660/66.

1 specimen (SL 25 mm, juv.); Swedish Deep-Sea Exped. St. 387, west of the Azores (40°32′N, 35°24′W – 40°34′N, 35°52′W); 4540-4600 m; trawl. 7. Sept. 1948. NHMG Pi. ex. 1746.

Both the holotype and the Swedish specimen are in a good condition.

Diagnosis:

With the characters of the genus (see above). – The specific name derives from the reddish tissue surrounding the eyes.

Description of the holotype:

Most of the meristic and morphometric characters are given in Table 22.

The body is rather elongate and compressed.

Table 22. Meristic and morphometric characters of *M. erythrops*.

	Holotype "Meteor" St. 37	Swedish Deep-Sea Exped. St. 387
Standard length	63	25
Meristic characters		
Dorsal fin	50	48
Caudal fin	8	>5[2]
Anal fin	34	34
Ventral fin	0	0
Pectoral fin[1]	14-15	13-13
Branchiostegal rays[1]	8-8	7-8
Gill rakers on anterior arch[1]	9-9	—
Vertebrae (incl. urostyle)	$41+29$	$39+29$[2]
Anterior anal-ray below dorsal-ray No.	14	15
Anterior anal-ray below vertebra No.	41	39
Anterior dorsal-ray above vertebra No.	34	28
Morphometric characters as % of standard length		
Head	20.0	22.0
Snout	8.2	8.3
Upper jaw	9.5	10.0
Interorbital width	8.7	8.0
Preanal	73	69
Predorsal	63	56
Base of anterior 10 dorsal-rays	7.2	10.0
Base of anterior 10 anal-rays	8.0	8.2

1. Right and left side, respectively.
2. See the explanation in "Meristic characters" on p. 61.

There are layers of small lipoid spheres just under the skin on parts of both the head and the body. The square head is of the same height as the body and only slightly broader. The skin is swollen on the head and in continuation of the dorsal and anal fins. The caudal part forms a very small portion of the fish (preanal 73 %). The middle "fields" of the very distinct musculus infracarinalis medialis (cf. p. 9) are twice as long as wide. The base of the dorsal fin forms only one-third and the anal fin-base one-fourth of the standard length. The ratio between the maximum length and height of the pectoral fin-peduncle is 1 approx. The pectoral fin-rays are all branched. The branchiostegal membranes are free of the isthmus. The very small, pigmented eyes are clearly visible through the overlying tissues. The anterior nostril is placed near the upper lip and the posterior, which is the largest, midway between the eye and the anterior nostril. Otoliths are not seen on the radiographs.

Lateral line system. There are a few, very small lateral line papillae along the midline of the body and on the snout and lower jaw.

Dentition. The dentition of *M. erythrops* is rather poor. No fangs are present. The premaxillaries are provided with 3-4 irregular tooth-rows near the symphysis including a few double-sized, strongly recurvated teeth. The rest of the anterior half of the premaxillaries have two rows, while the teeth are arranged monoserially in the posterior half. The vomer has 14 conical teeth in 1-2 rows placed on the median half of the bone. The palatines are edentate. The dentaries are provided with 2-3 rows of unevenly placed conical as well as pointed, recurvated teeth, the latter equal in size to the larger ones in the premaxillary symphysis.

Vertebral column. There are 41 precaudal and 29 caudal vertebrae. The anterior four vertebrae are provided with relatively long, thin neural arches and spines. From the fifth vertebra the neural spines of the precaudal vertebrae are like those shown on Fig. 41, and they gradually decrease in length posteriorly. The most posterior spines are much depressed. Judging from several differently exposed radiographs no parapophyses or ribs are developed on the anterior 37 precaudal vertebrae. The last four precaudal vertebrae are provided with ventrally directed processes. There is a rather distinct transi-

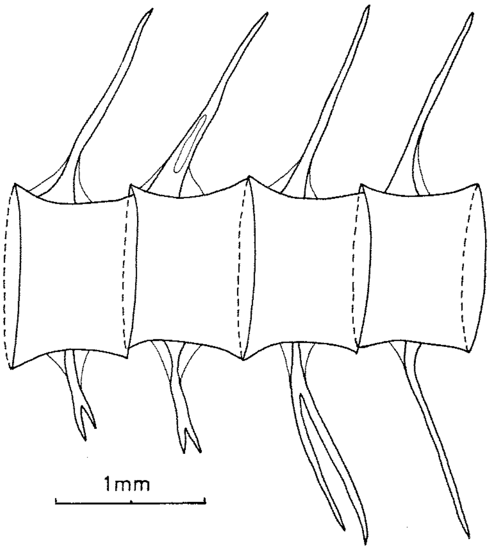

Fig. 41. Transition between precaudal and caudal vertebrae in the holotype of *M. erythrops*, SL 63 mm.

tion between the precaudal and caudal vertebrae (Fig. 41). The haemal spines have the same size and shape as the corresponding neural spines. The vertebral centra are almost rectangular in lateral view. The ratio between the length and the height of the last precaudal vertebral centrum is 0.6 approx. and that of the 20th caudal vertebral centrum is 1.1. The radiographs do not show any details of the caudal skeleton.

Gill cavity. The outer row of rakers on the anterior gill arch, which in most fishes is the strongest, in *M. erythrops* contained the least developed rakers of all the five arches. Fig. 42 shows nine rakers, some of which are barely recognizable, and none are provided with teeth. All of them are found on the ceratobranchiale. No rakers have been excluded although not all of the epi- and hypobranchial bone is shown in Fig. 42. The inner row consists of nine rakers which also are seen in the figure. Each of these is provided with 1-3 teeth. On the 2nd-4th arches the outer and inner rows contain the same number of equally sized, toothed rakers. Below is given a survey of the number of rakers in the outer rows from both sides:

1st gill arch with 9 rakers
2nd gill arch with 9 rakers
3rd gill arch with 9-10 rakers
4th gill arch with 7-8 rakers
5th gill arch with 5-6 rakers

The gill laminae are very poorly developed on the anterior arch. Only the ventrally placed laminae are long and compound. The 2nd-4th arches have a complete row of laminae, all of equal size to the longest on the anterior arch. Pseudobranchs are not developed. The upper pharyngeal plates are provided with rather large teeth.

Colour. The skin is transparent so the underlying light-yellow tissues colour the specimen. However, an area surrounding each of the small black-pigmented eyes is red-brown and the liver is brown. The peritoneum is dorsally speckled with black pigment which also is found at the base of the pectoral rays. The colour observations were made six months after capture.

Viscera. The oesophagus and stomach are whitish, thick-walled and narrow, measuring 15 mm in length. There is a constriction between the stomach and the intestine. The intestine is transparent, thin-walled and relatively voluminous; it is 42 mm long. There are two coils, one in which the pyloric part of the stomach and the anterior part of the intestine form part and one in the middle of the intestine. The rectal part of the intestine has a greater diameter than the rest of the intestine from which it is limited with a constriction. The distance from the pectoral base to the anus is 32 mm which is about half the length of the digestive canal. The liver is small and brown. The gall-bladder is only 1 mm in diameter.

Gonads:

The two almost cylindrical ovaries were rather distended owing to the large number of eggs. The length of each ovary, measured to the excretory duct, was 8 mm. Pl. IV Fig. 5 shows that the differently sized eggs are unevenly dispersed in the ovaries. Fig. 43 illustrates the number and diameter

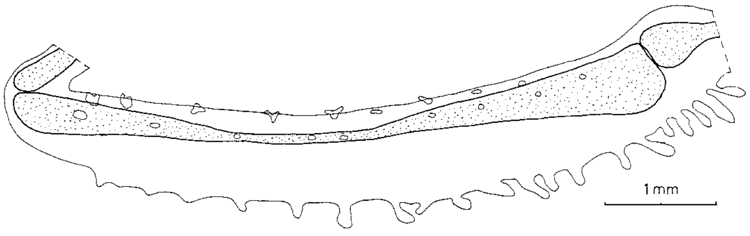

Fig. 42. Anterior, right gill arch of the holotype of *M. erythrops*.

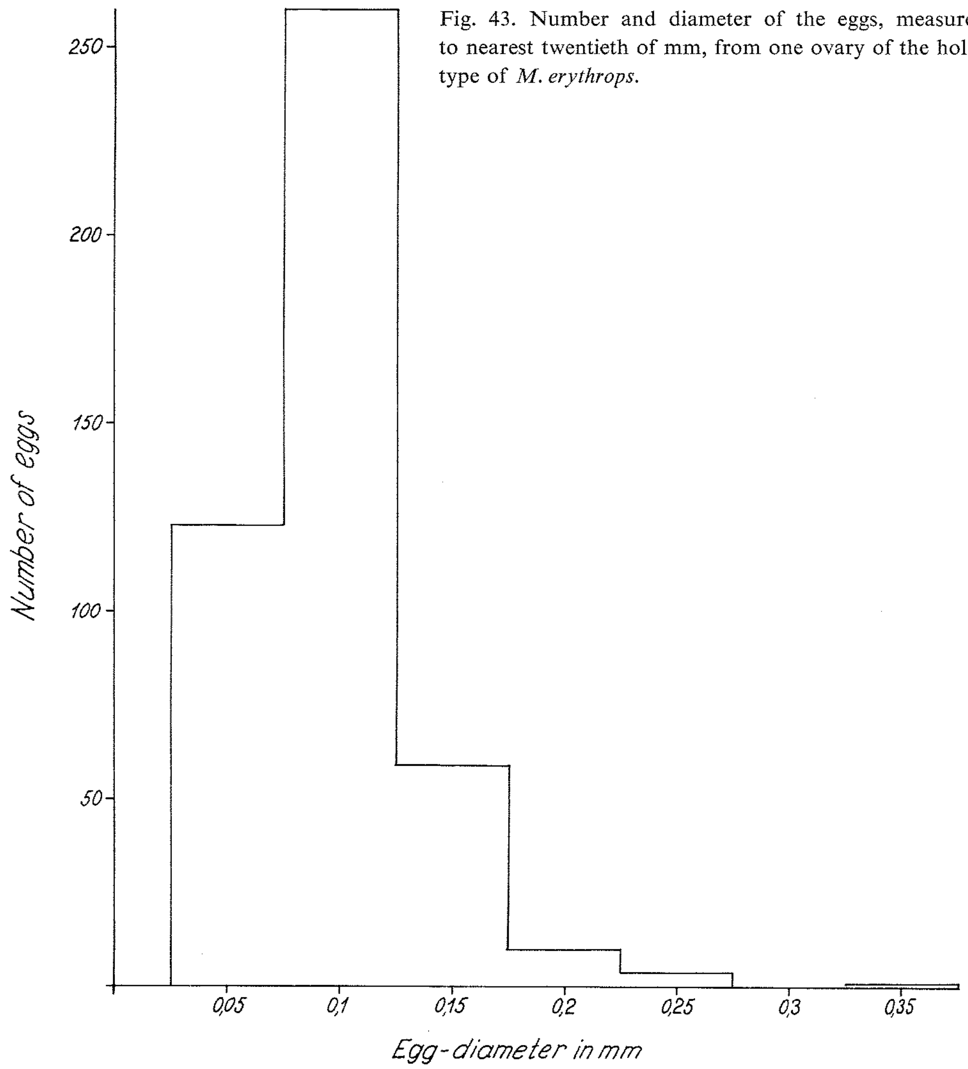

Fig. 43. Number and diameter of the eggs, measured to nearest twentieth of mm, from one ovary of the holotype of *M. erythrops.*

of the eggs from the left ovary. It appeared that the greater part of the about 450 eggs were provided with a rather large, dark, circular nucleus. The smallest eggs had no distinct nucleus, and the largest eggs had a somewhat enlarged, centrally placed nucleus which vaguely resembled small embryos of other aphyonid species. However, a histological examination of the caudal half of the right ovary showed that none of the many eggs of different size were fertilized. It furthermore appeared that neither spermatophores nor spermatozoa were present in the part of the ovary examined. The epithelium between the duct and the ovarian tissue is high, and corresponds to what is found at stage "a" of *B. bicolor* (Pl. II Fig. 1). The very small, transparent eggs are difficult to see which means that most probably some eggs should be added to the 0.05 mm group in Fig. 43. The copulatory apparatus consists of a very small urogenital sinus. Claspers are not developed.

Description of the juvenile specimen:

The only character clearly indicating the juvenile stage is the absence of gonads. NYBELIN (1957, p. 313) also mentioned the very voluminous notochord and the not fully developed caudal skeleton. The former of these characters do not indicate a juvenile stage as this is a common feature for adults of all aphyonid genera, excl. *Barathronus.* Generally, only characters which differ from the holotype are mentioned below.

Meristic characters. The most striking disagreement is the number of caudal fin-rays which is found only in a number of 5 (8 in the holotype). However, apparently at least one caudal ray is broken at its base, and Nybelin (1957) stated that "the caudal fin skeleton is not fully developed". Since a proper radiograph of the specimen could not be made, details of the caudal skeleton were not obtainable in this way. This also involved that the number of vertebrae and the position of the anterior haemal spine could not be observed on the radiograph. However, the specimen is so thin that it was possible to count the vertebrae in transparency. The vertebrae could not be separated in precaudal and caudal vertebrae, as the first haemal spine was invisible so "39+29" (cf. Table 22) only indicates that the anterior anal fin-ray is situated below the 39th vertebra. (In the holotype the anterior anal-ray was placed below the last precaudal vertebra). The difference in "Anterior dorsal-ray above vertebra No." (28 *vs.* 34 in the holotype) may be explained by the change in the shape of the vertebral centra.

Morphometric characters. Table 22 shows that there are minor divergencies in almost all the morphometric characters which is not surprising considering that the comparison was made between a juvenile and an adult specimen. By examining the specimen in transparency the ratio between the length and the height of the 39th vertebral centrum was found to be 0.3 and for the 59th centrum 0.5; (in the holotype the ratio for the 41st and the 61st was 0.6 and 1.1 respectively). This may explain the difference in the predorsal and -anal lengths.

Other characters. The musculi infracarinales mediales are rather indistinct, and the muscular "fields" are not recognizable. The lateral line papillae are more distinct, on the body as well as on the head, than those observed on the holotype. No reddish tissue is found around the eyes which may be due to the juvenile stage and/or to the preservation. The number and form of the gill rakers and laminae correspond to those of the holotype except for the rakers in the front row on the anterior arches which were too undeveloped for an exact count. The ratio between the length of the pectoral fin-peduncle and the base of the pectoral fin is 1. There are a smaller number of vomerine teeth than in the holotype. Urogenital appendages are not developed, but this does not prove that the juvenile specimen is a female, since it is unknown if and when the males form these appendages.

Colour. Because of the transparent skin the brown muscular tissues dominate the colour of the specimen. Black pigment is found at the base of the caudal, anal, and pectoral fin-rays. Chromatophores are numerous in the dorsal part of the peritoneum. The small eyes are black.

Reproduction and biology:

The graph (Fig. 43) shows a distinct peak for eggs with a diameter of about 0.1 mm. The few larger eggs most probably belong to the same clutch as the smaller ones. It is very unlikely that all the eggs complete the development, so the final clutch will be much smaller than indicated by Fig. 43. It would f. inst. be impossible for an ovary to hold 450 ripe eggs or embryos. There is no direct proof of *M. erythrops* being viviparous, but the small number of eggs favours this point of view. Both specimens were taken with a gear which under the present circumstances caught bottom as well as pelagic living organisms. The very scarce stomach contents were indeterminable. The high degree of neoteny suggests a deep-pelagic occurrence (cf. p. 79).

Distribution:

M. erythrops was caught at stations with a depth of 5320 m and 4540-4600 m. Fig. 48 shows that both specimens were caught close to the Azores.

Sciadonus Garman, 1899

Sciadonus Garman, 1899, p. 171, type species *Sciadonus pedicellaris* Garman, 1899 by monotypy.

This genus was described on the basis of a single specimen caught by the U.S. "Albatross" in the Gulf of Panama. The type specimen is kept in MCZ, Harvard. Since GARMAN's description only one additional specimen of *Sciadonus* has been reported. It was described as a new species, *S. kullenbergi* Nybelin, 1957. However, most probably the two specimens are conspecific.

Diagnosis:

An aphyonid fish with a long and slender body. The caudal part of the body forms only c. 30 % of the standard length. The very small, indistinct eyes are placed under the skin. The mouth is upward directed, forming almost 45° with the horizontal plane. The anterior nostril is tube-formed and placed near the upper lip. The dentaries, premaxillaries and vomer are provided with fine teeth. No fangs are developed. The 14 rakers on the anterior gill arch are formed as small, dentigerous knobs. Pseudobranchs are not developed. There are 9-10 branchiostegal rays. The ventral fins are poorly developed with one ray each. There are 90-93 dorsal, six caudal, 46 anal and 12-14 pectoral fin-rays. There are 43-44 precaudal and 38-39 caudal verte-

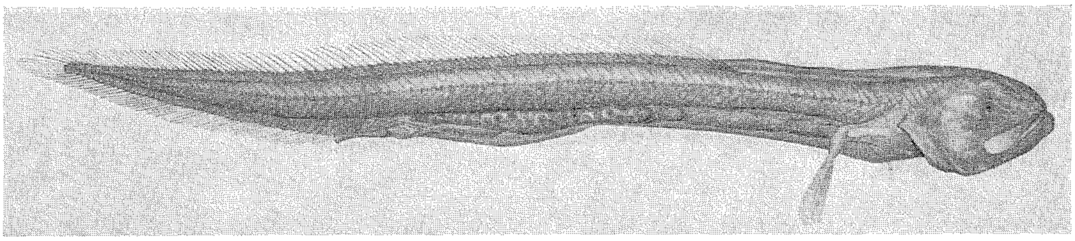

Fig. 44. Holotype of *Sciadonus kullenbergi* (= *S. pedicellaris* Garman, 1899), SL 102 mm. (From NYBELIN 1957).

brae. Apparently, ventrally directed processes are present only on the posterior three precaudal vertebrae. The female copulatory apparatus is provided with a pair of slender claspers. (No males are known).

This diagnosis has added some characters to those given by GARMAN (1899, pp. 171-172) and also some alterations have been made. GARMAN wrote "Eyes absent", "Forehead occupied by a mass of mucus, possibly light producing" and "Branchiostegal rays seven", but as seen from the diagnosis, small eyes are present, no structure is found in the large forehead indicating light producing tissues, and both the holotype and the Swedish specimen have 9-10 branchiostegal rays.

Relationships:

Sciadonus is very closely related to *Leucochlamys* Zugmayer, 1911, but differs in the following characters *(Leucochlamys* mentioned in brackets): Ventral fins present (no ventral fins), anterior nostril tube-formed (anterior nostril with a very low rim), no fangs on the vomer (two fangs on the vomer).

WAITE (1905, p. 77) found his new brotulid genus, *Dipulus,* to be related to *Sciadonus* and *Aphyonus,* disagreeing with *Sciadonus* by having united gill-membranes and non-pedicellate pectorals. However, *Dipulus* does not belong to the Aphyonidae, and its relatives among other ophidioids are still unknown (COHEN 1966, p. 185).

Species:

Two species are described, but as shown below I consider *S. kullenbergi* a synonym of *S. pedicellaris.*

Sciadonus pedicellaris Garman, 1899
Fig. 44

Sciadonus pedicellaris Garman, 1899, p. 172, pl. F fig. 4.
– –: WAITE 1905, p. 77.
– –: BRAUER 1906, p. 407.
– –: MARSHALL 1954.
– –: GREY 1956, p. 221.
– *kullenbergi* Nybelin, 1957, p. 310, pl. VII figs. 2, 6 and 8.
– *pedicellaris*: NYBELIN 1957, p. 310.
– *kullenbergi*: MARSHALL 1960, p. 111.
– –: MUNK 1965, p. 27, pl. X fig. 4.
– –: MUNK 1966, p. 37.
– *pedicellaris*: NORMAN 1966, p. 497.

Material examined (2 specimens):

Holotype of *S. pedicellaris* (SL 70 mm, ♀); "Albatross" St. 3365, Gulf of Panama (5°31′N, 86°31′ W); depth 1847 m; Agassiz trawl. 27. Febr. 1891. MCZ 28628.

Holotype of *S. kullenbergi* (SL 102 mm, ♀); Swedish Deep-Sea Exped. St. 387, north Atlantic (40°32′ N, 35°24′W – 40°34′N, 35°52′W); depth 4540-4600 m; trawl. 7. Sept. 1948. NHMG Pi. ex. 1744.

GREY (1956, p. 221) wrote in connection with *S. pedicellaris* "(?) specimens" indicating that probably more specimens than the holotype exist. I have never seen this suggestion verified.

Condition of the material:

GARMAN did not discuss the condition of the type of *S. pedicellaris,* but the present condition of the specimen is very bad. It is broken into two parts 20 mm approximately from the caudal tip, the head is badly damaged, and the specimen had obviously dried up during preservation, as it is now very stiff and shrunk with the vertebral column clearly seen through the skin. The bones and tissues are poorly fixed and easily torn. The standard length is 70 mm approx. However, GARMAN stated the total length of the specimen as 4 1/8 inches, and GREY (1956) indicated "length 105 mm". It seems difficult to explain the disagreement between the length given in the original description and the length of the specimen in its present condition. The difference, length minus standard length = 35 mm, would be due to the caudal fin, which seems rather unlikely, as, e.g., the length of the caudal fin of the holotype of *S.kullenbergi* Nybelin, 1957 (see below) is only 5 mm approx. in a specimen with a standard length of 102 mm. The difference also can not be explained as shrinkage of the specimen. (The caudal fin of *S. pedicellaris* is now broken). – The length stated by GREY apparently is just a transcription of GARMAN's 4 1/8 inches to mm's.

Comparison between *S.pedicellaris* and *S. kullenbergi:*

In the description of *S.kullenbergi* NYBELIN mentioned that his specimen agreed rather well with *S.pedicellaris,* not only in general appearance, but also in most details. However, in four morphometric characters he found disagreement, which indicated a new species. Before discussing these differences it should be remembered that NYBELIN had no access to the holotype of *S.pedicellaris,* but used GARMAN's description and illustration (1899, pp. 171-172, pl. F fig. 4) for his comparison. The only measurement given in GARMAN's description is the "length", so NYBELIN has to use the illustration in order to obtain additional measurements. However, a re-examination of the holotype of *S. pedicellaris* showed that the illustration is not in accordance with the holotype itself.

In the following four paragraphs the supposed specific characters mentioned by NYBELIN are discussed, the observations from the re-examination of the two holotypes (cf. Table 23) being used.

1. Predorsal length: Judging from the illustration the predorsal length represents 20 % of the standard length, but a re-examination of the type of *S. pedicellaris* gave 28.5 % (that of *S.kullenbergi* was 30.5 %).
2. Preanal length: The preanal length represents 64 % of the standard length measured on the figure, while a re-examination gave 70 % (68 % in *S.kullenbergi).*
3. Pectoral peduncle: The length of the pedicellate peduncle of the pectoral fins according to the illustration, equals the length of the upper jaw, while measurements on the specimen itself showed only c. 60 % of the upper jaw and 5.5 % of the standard length (the pedicellate peduncle in *S.kullenbergi* was 63 % and 5.5 %, respectively).
4. Ovary: GARMAN's colour-drawing shows that the ovaries extend forward to below the base of the pedicellate peduncle of the pectoral fin, i.e., anterior to the dorsal fin. However, the ovaries actually begin more posteriorly, below the 15th-17th dorsal fin-ray (in *S.kullenbergi* they begin below the 17th dorsal fin-ray).

Due to the poor condition of the type specimen of *S. pedicellaris* it cannot be decided whether the general appearance of the two species agree. However, the above discussion shows that none of the characters emphasized by NYBELIN (1957) have specific value, and also Table 23 indicates so good agreement between the two species that it is not justifiable to maintain two species. This involves that *S.kullenbergi* Nybelin, 1957 should be regarded as a junior synonym of *S.pedicellaris* Garman, 1899.

Diagnosis:

With the characters of the genus (see above).

Description:

Table 23 gives the more important meristic and morphometric characters of the two specimens. The discrepancy concerning the length of the holotype of *S.pedicellaris* is discussed on p. 63. According to GARMAN there are seven branchiostegal rays and 12 pectoral rays. A re-examination of his specimen gave nine branchiostegal rays on the right side and 13-14 pectoral fin-rays. NYBELIN's specimen has 9-10 branchiostegal rays. The remaining meristic characters vary only slightly. Owing to the poor condition of GARMAN's type a number of the morphometric characters could not be measured, but those shown in Table 23 agree well with those of the Swedish specimen. GARMAN gave a rather detailed description of *S.pedicellaris.* Comments to his and NYBELIN's descriptions are given below, and some additional characters are mentioned.

The body is long and slender. The head is almost twice as wide as the body. The transparent skin and thin body make it possible to see the viscera and most of the vertebrae in transparency. The dorsal fin arises just behind the tip of the pectorals, and the anal fin issues much closer to the caudal base than to the snout (preanal length 68-70 % of the standard length). The caudal fin is long and narrow, consisting of six rays. The ventral fins are extremely short and thin. The pectoral peduncle is pedicellate. The ratio between its width and length is 0.3, and the length forms 5.5 % approx. of the standard length in both specimens. The lower jaw protrudes. The upward directed mouth cleft forms an angle of al-

Table 23. Meristic and morphometric characters of *S. pedicellaris*

	Holotype of *S. pedicellaris*	Holotype of *S. kullenbergi*
Standard length	70	102
Meristic characters		
Dorsal fin	c. 90	93
Caudal fin	6	6
Anal fin	46	46
Ventral fin[1]	1-1	1-1
Pectoral fin[1]	14-13	12-12
Branchiostegal rays[1]	9-	9-10
Gill rakers on anterior arch[1]	14-14	14-
Vertebrae (incl. urostyle)	43 + 39	44 + 38
Anterior anal-ray below dorsal-ray No.	47	53
Anterior anal-ray below vertebra No.	45	44
Anterior dorsal-ray above vertebra No.	13	14
Morphometric characters as % of standard length		
Head	15.5	15.5
Upper jaw	9.0	8.8
Lower jaw	—	11.0
Diameter of pigmented eye	0.4	0.4
Preventral	—	16.5
Preanal	70	68
Predorsal	28.5	30.5
Distance from base of ventral fins to anterior anal-ray	—	52
Base of anterior 10 dorsal-rays	—	5.4
Base of anterior 10 anal-rays	6.4	6.9

1. Right and left side, respectively.

most 45° with the horizontal plane. The anterior nostril has a tube-formed prolongation and is placed near the upper lip. The posterior nostril, which is not prolonged, is found midway between the eye and the anterior nostril. (The nostrils could not be found in the holotype of *S.pedicellaris).* Garman wrote "Eyes absent", which corresponds to my observation of his specimen, but the dorsal part of the head is now very much damaged. Nybelin (1957, pl. VII figs. 2 and 6) showed that the eyes are only small black spots "placed in the interior of the transparent head". Munk (1965, p. 27) observed that the eyes of *S.kullenbergi* are the most degenerated of all the deep sea fishes examined. "No identifiable remnants of the normal constituents of the eye were recognized." The musculi infracarinales mediales (cf. p. 9) are distinct. The ratio between the length and the width of the middle muscular "fields" is 1.5.

Lateral line system. A few apparently irregular arranged lateral line papillae are found on the lower jaw and on the snout, but nowhere else. They are very short and difficult to see especially because of the loose skin. No papillae were discernible on the holotype of *S.pedicellaris.*

Dentition. All the teeth are pointed, relatively strong and almost of the same size. None are developed as fangs. Both the upper and lower jaw symphysises are tooth-less. The condition of the holotype of *S.pedicellaris* does not allow a thorough examination of the dentigerous bones. The premaxillaries of the Swedish specimen are provided with two tooth-rows anteriorly, decreasing to one row only and with the posteriormost part tooth-less. There seems to be three rows of teeth anteriorly in the premaxillaries of the other specimen. Common for both specimens is the semicircular vomer with 10-15 teeth evenly distributed on the entire bone. The dentaries are provided with 3-4 irregular rows of pointed, recurvated teeth anteriorly, decreasing to one row. They are somewhat longer than the premaxillary teeth. The posteriormost part is edentate.

Vertebral column. The neural and haemal spines are all thin and pointed. The anterior arch and spine are of the same length as the following ones. Fig. 45 shows the transition between the pre-

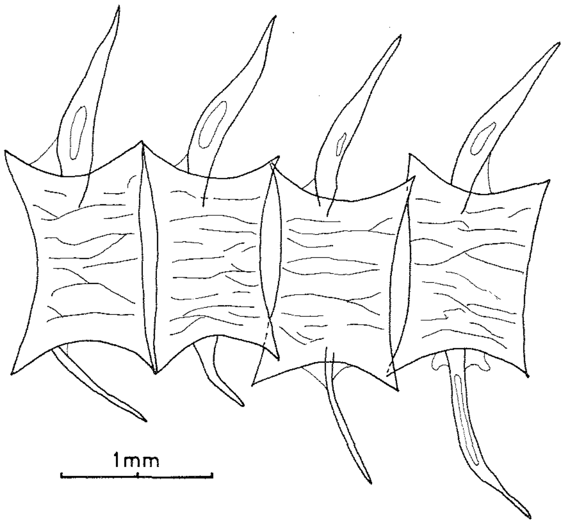

Fig. 45. Transition between precaudal and caudal vertebrae in the holotype of *S. pedicellaris*, SL 70 mm.

caudal and the caudal vertebrae. It is difficult to decide where the transition is, as it is impossible to indicate with certainty the vertebra which is provided with the anteriormost haemal spine. However, judging from the shortness of the two anterior, ventrally directed, processes on Fig. 45 these consist apparently of haemal arches, but not of haemal spines as well. Also the position of the anterior anal fin-ray (below vertebra No. 44) indicates the abovementioned position of the transition. The poor radiographs of the holotype of *S. kullenbergi* showed rather few details, so also here it was difficult to distinguish the anterior caudal vertebra. The most anterior, ventrally directed, process is equal in length to the more posteriorly placed processes and is therefore considered the haemal spine of the anterior caudal vertebra. This involves that the number of precaudal and caudal vertebrae in the holotypes of *S. pedicellaris* and *S. kullenbergi* are 43+39 and 44+38, respectively. The radiographs show that, except for the three posterior vertebrae, the precaudal vertebrae are not provided with ribs and parapophyses. Fig. 45 indicates that the holotype of *S. pedicellaris* has been dried which caused shrinkage of the vertebrae, so the centra are not quite rectangular in lateral view in contrast to those of the holotype of *S. kullenbergi*. The ratio between the length and the height of the vertebral centra in *S. pedicellaris* is 0.6 for the last precaudal vertebra and 1.1 for the 20th caudal vertebra. In the holotype of *S. kullenbergi* the corresponding ratios are 0.7 and 1.1. The caudal skeleton is provided with two large hypural plates.

Gill cavity. Fig. 46 shows the right, anterior gill arch of the holotype of *S. kullenbergi*. All the rakers are small and dentigerous. No rakers are developed on the epibranchiale, 11 on the cerato- and three on the hypobranchiale. The small, very flat gill laminae are irregularly formed and seem to be protuberences of the broad, basal skin-fold. The most dorsal laminae are not seen in Fig. 46, and the stippled part indicates that the skin-fold is bent. There are a total of 35-40 laminae on the right arch. Laminae are not developed on the 4th arch. According to NYBELIN, there is one raker on the epibranchiale of the anterior gill arch of both sides. However, a re-examination showed no raker on the epibranchiale of the right arch and the left, anterior arch is apparently lost.

A survey of the number of rakers from the holotype of *S. kullenbergi* is given below. A count of those from the *S. pedicellaris* type would cause much damage to the specimen. The epibranchiale is never provided with rakers, and on each arch the outer and inner row of rakers hold the same number of equally sized rakers:

1st gill arch with 14 rakers
2nd gill arch with 12-15 rakers
3rd gill arch with 11-12 rakers
4th gill arch with 10-11 rakers
5th gill arch with 7-9 rakers

The number of rakers varies rather much from one side to another, e.g., the 2nd arch is provided with 12 on the right and 15 rakers on the left side. Pseudobranchs are not developed. The teeth on the upper pharyngeal plates are small and pointed. The gill slits are very large, and the membranes are free of the isthmus.

Colour. The muscular tissues of the holotype of *S. pedicellaris* are uniformly red-brown. The Swedish specimen is more or less transparent with red-

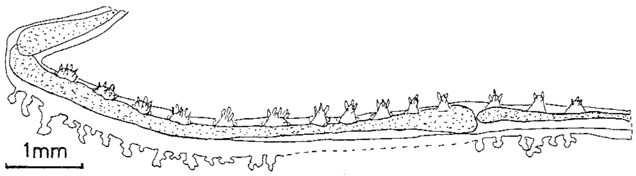

Fig. 46. Anterior, right gill arch of the holotype of *S. kullenbergi* (= *S. pedicellaris*).

brown ovaries and otherwise with variations in yellowish and greyish tinge.

Viscera. There are no information at all about the viscera in the original description of the two species of *Sciadonus*. In the holotype of *S. pedicellaris* most of the abdominal wall and the ventral part of the peritoneum are lost, and the viscera are much shrunk and almost impossible to examine. The viscera in the Swedish specimen are in a good condition. The stomach is relatively thin-walled and not very voluminous (Plate IV Fig. 4). The intestine is so thin-walled that darker parts of the contents are visible through the wall. The diameter of the pyloric part is twice that of the stomach. The intestine has a length of 60 mm approx. while there are only 30 mm from the posterior part of the stomach to the anus. The almost transparent, greenish gall-bladder is prominent. The liver is somewhat darker than the light- brown digestive canal. It ends in front of the anteriormost part of the intestine.

Gonads:

As mentioned in the original descriptions both specimens are females. GARMAN (1899, p. 172) wrote "... the eggs in the ovaries orange or red, showing through the body walls". NYBELIN (1957, p. 311) stated "... the ovaries extend forwards only to about midway between hindborder of operculum and anal opening".

As elsewhere stated the viscera of the holotype of *S. pedicellaris* are very poorly preserved. It is thus impossible to divide the ovaries, in order to count the eggs. The ovaries are much distended with red-brown eggs. By examining the 13 mm long ovaries externally it was possible to make an almost exact count of the larger eggs. There are 35 eggs approx. in each of the ovaries, all with a diameter of a little more than 1 mm. The half a dozen additional eggs were yellow and had a diameter of about 0.2 mm. The number of smaller eggs not visible from the outside of the ovaries can not be large, since the big eggs are packed very close together. The colour and state of preservation makes it impossible to see whether the eggs are fertilized. The well preserved ovaries of the holotype of *S. kullenbergi* are 28 mm long, with the posterior 4 mm grown together. They are very narrow, but with an abrupt swelling on the middle part (Pl. IV Fig. 4). The left ovary was removed, and all the eggs were counted by the method described on p. 9. Fig. 47 shows the number and diameter of the eggs. There are three "types" mixed with each other: Very small transparent eggs, medium-sized yellow eggs with a darker ring near the periphery, and unevenly dark-brown coloured, larger eggs. Since it is difficult to distinguish the smallest eggs and drops of lipoid no attempt was made to measure those with a diameter of less than 0.1 mm. The two latter categories are most probably

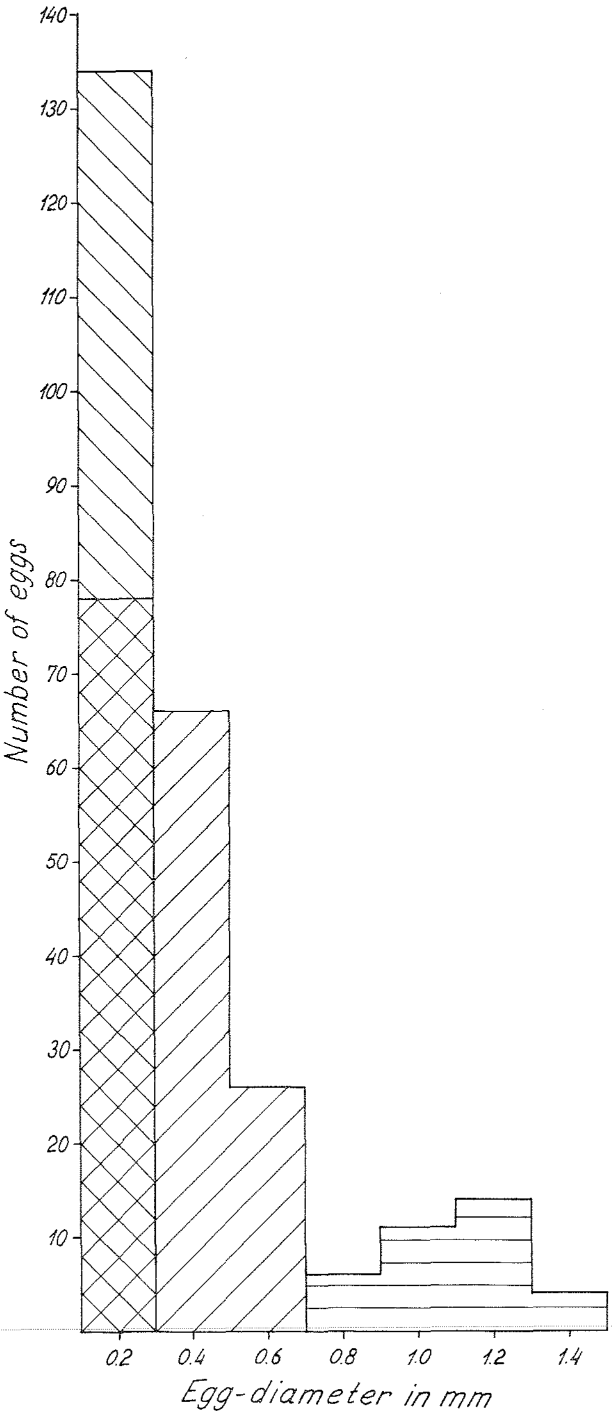

Fig. 47. Number and diameter of the eggs, measured to nearest tenth of mm, from one ovary of the holotype of *S. kullenbergi* (= *S. pedicellaris*). Transparent eggs (▧), yellow eggs (▨) and dark-brown eggs (▤).

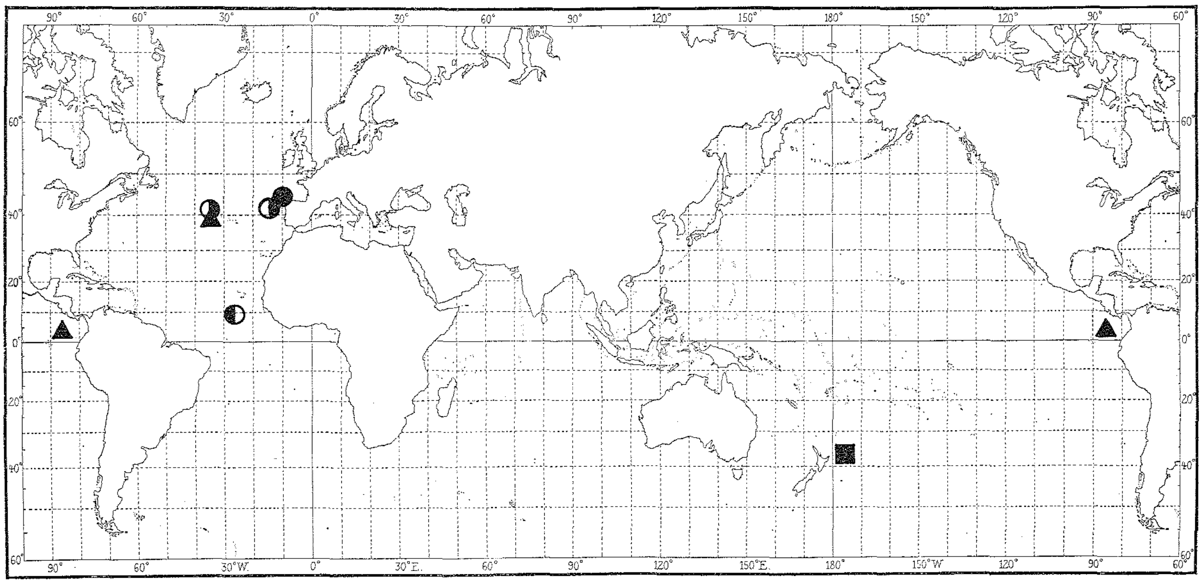

Fig. 48. Records of *Meteoria erythrops* (◑), *Sciadonus pedicellaris* (▲), *Leucochlamys cryptophthalmus* (●), *L. jonassoni* (◐), *L. galatheae* (■).

fertilized eggs, whereas it is not possible to judge whether the transparent eggs are fertilized. In contrast to the holotype of *S. pedicellaris* there are numerous smaller eggs besides the dark-brown ones in the Swedish specimen. In the left ovary the transparent 0.1-0.3 mm eggs are found in a number of 134, of the 0.2-0.6 mm yellow ones there are 170, while the 0.8-1.4 mm dark-brown eggs number 35.

NYBELIN (1957, p. 311) mentioned that there is a pair of 4 mm long finger-like appendages at the genital opening. There is no indication of such papillae, either in GARMAN's description or in his illustration of *S. pedicellaris*. However, a thorough examination of the posterior off-broken part of the abdominal wall showed the presence of a pair of shrunk 2 mm long genital papillae formed like those of *S. kullenbergi*. The present examination showed that the copulatory apparatus only consists of the abovementioned pair of claspers formed like those of *Leucochlamys galatheae* (cf. Figs. 55 and 56).

Reproduction and biology:

The presence of claspers and the few, large eggs, forming a separate peak on the graph (Fig. 47), strongly indicate that *S. pedicellaris* is viviparous, although no male specimen is known. It is interesting to note that in spite of the difference in the standard length (70 *vs.* 102 mm) each ovary, in both specimens, contained about 30 eggs with a diameter of 1 mm approx. Judging from Fig. 47, where two clutches can be compared, it seems highly probable that most of the smaller eggs do not carry through development. The size of the ovaries also limits the number of larger eggs.

GARMAN (1899, p. 172) gave the following information about the biology of *S. pedicellaris:* "The structure of the pectorals with the absence of the eye suggests a dependence upon them as tactile organs, in addition to their function as balancers" and "The entire forehead is filled with mucus, which possibly may be utilized in the production of light". With the remark about "tactile organs" GARMAN indirectly classified *S. pedicellaris* as a benthic species. The only other fish caught in the trawl together with *S. pedicellaris* was *Narcetes pleuriserialis* Garman, 1899 which, like most other alepocephalids, is supposed to live on or in close contact with the bottom (MEAD, BERTELSEN & COHEN 1964, p. 572). The presence of light-producing mucus was not confirmed by this re-examination. Even if NYBELIN considered the Aphyonidae a pelagic living family he stated that *S. kullenbergi* was taken at a depth between 4540 and 4600 m, i.e., on the bottom of the station in question. I find that *Sciadonus,* showing many neotenic features„ is another example of a deep-pelagic occurring aphyonid deprived of many communication organs: The eyes are the most degenerated of all the deep sea species examined by MUNK (1966, p. 37). No swimbladder is developed, and only a few lateral line papillae are found on the head. The stomach content does not give any biological information, as it is indeterminable. The poorly developed gill rakers indicate that *Sciadonus* can not withhold small food-items.

Distribution:

Fig. 48 shows the localities of *S.pedicellaris.* The holotype of *S.pedicellaris* was taken in the Gulf of Panama over a depth of 1847 m, and the Swedish specimen is from west of the Mid-Atlantic Ridge in the northern Atlantic Ocean over a depth of 4540-4600 m. It is unknown at what depths the specimens were caught, but the locality in the Gulf of Panama (1847 m – bottom-temperature 2.8° C) tend to characterize the holotype as bathypelagic or upper abyssopelagic. If the present synonymizing is correct *S.pedicellaris* probably has a circumtropical distribution.

Leucochlamys Zugmayer, 1911

Leucochlamys Zugmayer, 1911 p. 11, type species *Leucochlamys cryptophthalmus* Zugmayer, 1911 by monotypy.

Diagnosis:

In addition to the holotype of *Leucochlamys cryptophthalmus* this new diagnosis is based on the holotype of *L.jonassoni* Nybelin, 1957 and the two "Galathea" specimens referred to *L.galatheae* n.sp.

A long and slender fish with the anus situated much closer to the caudal base than to the snout. The mouth cleft is only slightly upward directed. The anterior nostril is provided with a very low rim and placed near the upper lip. Many fine teeth on the dentaries, premaxillaries and vomer, while the palatines, the tongue and the basibranchials are edentate. A few fangs are present on the vomer. The 11-15 gill rakers on the anterior arch are all very small and generally dentigerous. There are no rakers on the epibranchiale. The small gill laminae on the anterior arch number 20-30. The pectoral fin peduncle is long and narrow. The ratio between width and length is 0.2-0.3. No ventral fins are developed. There are 6-7 caudal, 9-14 pectoral, 68-104 dorsal and 43-48 anal fin-rays. The ratio between length and height of the last precaudal vertebral centrum is 0.6 and that of the 20th caudal vertebral centrum is 0.9. The total number of vertebrae varies from 68-86 (39-48 precaudal and 29-38 caudal vertebrae). Judging from the radiographs two species of *Leucochlamys* are devoid of ventrally, directed processes on the precaudal vertebrae and on one species, *L. cryptophthalmus,* a few of the posteriormost precaudal vertebrae bear ribs and/or parapophyses. The genus is viviparous. In the key to the aphyonid genera, NYBELIN (1957, p. 308), among other things, used the presence or absence of black pigment cells for separating *Sciadonus* and *Leucochlamys.* However, this character no longer can be used as a generic character, as *L.galatheae* is devoid of black pigment, while the other two species have numerous black spots. The female copulatory apparatus consists of a pair of long claspers, and the males have a well developed penis, partly covered by the urogenital sinus, and a pair of small papillae placed as shown in Fig. 57. These papillae may be homologous with the female claspers.

Relationships:

The original description by ZUGMAYER (1911) is very brief, since no meristic and morphometric characters are given, but in the same year ZUGMAYER (1911a) published a more comprehensive description, including a discussion of the relationship of the new genus. Here he mentioned that *Leucochlamys* ranges between *Aphyonus* Günther, 1878 and *Bellottia* Giglioli, 1883 and approaches *Alexeterion* Vaillant, 1888. It differs, again according to ZUGMAYER, from the former by the absence of ventral fins and presence of teeth in the upper jaw, from the second by lacking scales, lateral line and palatine teeth and from the latter genus by having a horizontal mouth cleft and a dentigerous vomer. A reexamination of the holotypes of the type species of the abovementioned genera made during the preparation of this paper showed that among other things the original description of the dentition of *Aphyonus* and *Alexeterion* is incorrect which means that some of the premises in ZUGMAYER's generic comparison are wrong. However, ZUGMAYER did not mention the genus *Sciadonus* Garman, 1899 in his discussion which in my opinion is the closest relative of *Leucochlamys* (cf. p. 63). As a matter of fact, the two genera show so few differences that when more material has been provided it might be reasonable to lump them together into one genus, viz. *Sciadonus* Garman, 1899. ZUGMAYER did include GARMAN's work (1899) in his list of references, but ZUGMAYER, probably due to the poor illustration of *Sciadonus pedicellaris,* apparently never suspected a relationship between the two genera. He furthermore wrote that if additional genera were found, which were characterized by the absence of the ventral fins and with the anus placed on the posterior half of the fish, it might be reasonable to establish a new family, for which he proposed the name Aphyonidae (cf. p. 8). The four known *Leucochlamys* specimens, which are all ripe, vary in standard length from 38 mm to 84 mm, but the ratio between length and height of the posterior precaudal (and of the 20th caudal) vertebral centrum is the same in all four specimens. It is known that in some fishes (NIELSEN 1966, p. 100) the form of the vertebral centra changes during growth, but it is almost constant in adult specimens. This apparently also holds good for these fishes which have retained a rectangular shape of the vertebral centra, which is typical of larvae of most other fishes.

Biology:

All four *Leucochlamys* specimens were caught in trawls which worked on the bottom at depths varying from c. 4400 - c. 5600 m. In all hauls fishes with pelagic as well as bentic occurrence were caught. Judging from the good condition of these fragile specimens and the neotenic development of a number of characters it seems reasonable to consider this genus as having a deep-pelagic occurrence. An examination of the gonads showed that *Leucochlamys* is viviparous.

Distribution:

Fig. 48 shows that until now this genus has been caught in the Atlantic and Pacific Oceans.

Species:

Three species are described, represented by a total of four specimens.

Key to the species of *Leucochlamys:*

1. Number of dorsal fin-rays 68, pectoral fin-rays 9 and vertebrae 68 .... *L. jonassoni* Nybelin, 1957
2. Number of dorsal fin-rays 83-104, pectoral fin-rays 11-14 and vertebrae 78-86.
   a. Number of precaudal vertebrae 42, black spots at base of dorsal fin and on peritoneum, base of anterior 10 dorsal fin-rays 6.7 % of SL .... *L. cryptophthalmus* Zugmayer, 1911
   b. Number of precaudal vertebrae 48, no black pigmentation, base of anterior 10 dorsal fin-rays 5.0-5.4 % of SL .... *L. galatheae* n. sp.

Leucochlamys cryptophthalmus Zugmayer, 1911
Fig. 49

Leucochlamys cryptophthalmus Zugmayer, 1911, p. 11.
– –: ZUGMAYER 1911 a, p. 131-32, pl. VI fig. 4.
– –: ROULE 1934, p. 193, pl. XI and fig. on p. 193.
– –: BELLOC 1949, p. 15, pl. III.
– –: GREY 1956, p. 222.
– –: NYBELIN 1957, p. 312.
– –: NORMAN 1966, p. 497.
– –: NIELSEN, JESPERSEN & MUNK 1968, p. 247.

L. cryptophthalmus is the type species of the genus *Leucochlamys* Zugmayer, 1911. The original description is very brief and apparently meant to be preliminary, since ZUGMAYER (1911 a) shortly after published a more detailed description accompanied by a colour-illustration. The same illustration was used by ROULE (1934, p. 193) and BELLOC (1949, pl. III). Still, so many important characters were not mentioned that a redescription of this species is needed, of which only the holotype is known, especially to compare it to the two congeneric species.

Material examined (1 specimen)[1]:

Holotype (SL 82 mm, ♂); "Princesse-Alice" St. 2994, off Cape Gata, north western Spain (44°08′ N, 10°44′W); 5000 m; trawl. 19. Aug. 1910. MOM.

Condition of the material:

The abdominal cavity was opened after capture and the body is much bent. Below are mentioned some of the divergencies between the original illustration and the specimen itself: The body is less deep, the head shorter and the pectoral peduncle is narrower than shown in the illustration. Also the distance between the posterior edge of the gill cover and the anal fin is too short in the figure. Another colour-illustration was published by ROULE (1934, pl. XI). Technically it is a rather poor picture, but it is more in agreement with the specimen itself than

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[1] About two years ago I borrowed the holotype for a short period. Since then I have included some additional characters in the redescription of the Aphyonidae and also used an air-jet during the examination. This involves that adequate information of certain characters as, e. g., lateral line papillae, position of nostrils and development of pseudobranchs were not obtained of this specimen.

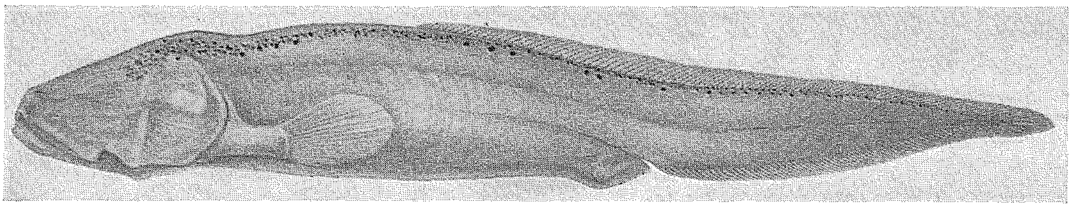

Fig. 49. Holotype of *Leucochlamys cryptophthalmus* Zugmayer, 1911, SL 82 mm. (From ZUGMAYER 1911a).

the original illustration, especially concerning the body proportions.

Diagnosis and relationships:

L. cryptophthalmus is characterized by the combination of certain meristic characters (dorsal fin with 83 rays, anal fin with 46 rays and 42+36 vertebrae) and by the relatively thick skin. From *L. jonassoni* it differs, i.a., by having more pectoral and dorsal fin-rays (13-14 *vs.* 9 and 83 *vs.* 68, respectively) and from *L. galatheae* by the black pigmentation, which is missing in *L. galatheae,* and the smaller number of vertebrae (42+36 *vs.* 48+38). The meristic characters indicate that *L. cryptophthalmus* is more closely related to *L. galatheae* than to *L. jonassoni.* See the key and Table 24.

Description:

Some of the meristic and morphometric characters are shown in Table 24, and additional particulars are given in the generic description on p. 69. A comparison with the characters mentioned by ZUGMAYER (1911a) shows relatively good agreement between the morphometric characters, while the meristic ones, as pointed out by NYBELIN (1957, p. 312), differ much. In the comparison below ZUGMAYER's counts are given in brackets: Number of dorsal rays 83 (env. 90), anal rays 46 (env. 60), pectoral rays 13-14 (15), caudal rays 7 (10) and branchiostegal rays ± 9 (4).

The dorsal fin issues just posterior to the tip of the pectorals, and the anal fin arises below the median part of the dorsal fin. The ratio between width and length of the narrow pectoral peduncle is 0.2-0.3 and the length forms 6% approx. of the standard length. The eyes are placed deep in the head. The interorbital width is great compared to the other *Leucochlamys* spp. The posterior (?) nostril is not provided with a flap and is placed a little closer to the eye than to the tip of the snout. Only one nostril was found on each side. However, since the other two *Leucochlamys* spp. both have the anterior nostril placed close to the upper lip, this most probably is also the case in this species. The musculus infracarinalis medialis can be followed from the pectoral girdle (no ventral fins developed in this genus) to the anal area. It is clearly seen how this muscle continues into the musculus infracarinalis posterioris at the base of the interhaemal spines. Midway between the pectorals and the anus the muscular "fields" of the musculus infracarinalis medialis are square.

Dentition. The premaxillaries are provided with 1-2 rows of conical teeth of different size. The posterior part and the upper jaw symphysis are edentate. The vomer has many close-set, blunt teeth and one fang in each side. The dentaries have about three irregular tooth-rows anteriorly and one row posteriorly. The teeth are somewhat recurved, but are otherwise very much like those in the premaxillaries. The lower jaw symphysis is dentigerous.

Vertebral column. There are 42 precaudal and 36 caudal vertebrae. All the neural and haemal spines are pointed and thin with the most posterior ones depressed. The anterior 3-4 neural spines are longer than the height of the corresponding vertebral centra. The first neural arch and spine are the longest. Judging from the radiographs, parapophyses and/or ribs are only developed on the nine posterior precaudal vertebrae. The form of the vertebral centra is rectangular in lateral view. The ratio between length and height of the posterior precaudal centrum is 0.6 and that for the 20th caudal centrum is 0.9.

Gill cavity. The anterior gill arch is very similar to that of *L. galatheae* (cf. Fig. 53). There are no rakers on the epibranchiale and 14-15 small, conical rakers on the cerato- and hypobranchiale. Common for all the arches is that the rakers are equally developed in the outer and inner rows on the same arch, and all rakers are provided with a few teeth. The rakers on the anterior arch are slightly shorter than those on the 2nd-4th arches. There are approx. 25 rather small gill laminae on the anterior arch. The 2-3 epibranchial laminae are extremely small. The laminae on the 2nd and 3rd arches are of

Table 24. Meristic and morphometric characters of *Leucochlamys* spp.

	L. cryptophthalmus	*L. jonassoni*	*L. galatheae*	
	Holotype	Holotype	Holotype P77456	Paratype P77457
Standard length	82	38	84	61
Meristic characters				
Dorsal fin	83	68	104	88
Caudal fin	7	6	6	6
Anal fin	46	43	48	47
Ventral fin[1]	0	0	0	0
Pectoral fin[1]	13-14	9-9	11-12	12-13
Branchiostegal rays[1]	9-9(?)	8-8(?)	9-9	-10
Gill rakers on anterior arch[1]	15-14	12-11	14-14	13-14
Vertebrae (incl. urostyle)	42 + 36(78)	39 + 29(68)	48 + 38(86)	48 + 38(86)
Anterior anal-ray below dorsal-ray No.	37	27	55	44
Anterior anal-ray below vertebra No.	43	40	49	49
Anterior dorsal-ray above vertebra No.	18	21	18	20
Morphometric characters as % of standard length				
Head	18.5	17.0	14.5	16.5
Snout	6.7	6.3	5.1	5.7
Upper jaw	10.5	7.9	7.9	9.0
Diameter of pigmented eye	±0.4	±0.4	±0.4	±0.5
Interorbital width	4.3	2.9	3.0	3.8
Preanal	64	64	65	66
Predorsal	35.5	39.5	31.0	33.0
Base of anterior 10 dorsal-rays	6.7	7.9	5.0	5.4
Base of anterior 10 anal-rays	7.1	6.8	6.4	6.7
Length of pectoral peduncle	5.9	8.4	6.0	6.4

1. Right and left side, respectively.

approx. double size and a little more numerous with well developed epibranchial laminae. Below is given a survey of the number of rakers from the outer row of both sides:

1st gill arch with 14-15 rakers
2nd gill arch with 13-15 rakers
3rd gill arch with 12 rakers
4th gill arch with 12-13 rakers
5th gill arch with 10-11 rakers

Pseudobranchs apparently are not developed. The teeth on the upper pharyngeal plates are very small, and the lower ones could not be observed.

Colour. The brown-yellow colouration of the muscular tissue is seen through the transparent skin. Several black spots are situated close to the base of the dorsal fin, and especially between the head and this fin. A few black spots are found near the anterior part of the anal fin. More chromatophores appear on the original illustration than in the specimen in its present condition.

Viscera. The specimen was opened immediately after capture, so the viscera are well preserved, but the intestine was partly torn. No comments were made on the viscera in the original description. The oesophagus and the stomach are relatively thick-walled and narrow, forming 1/5-1/6 of the standard length. The thin-walled intestine is provided with 2-3 coils and measures 35 mm approx., while the distance from the posterior end of the stomach to the anus is 20 mm only. The most anterior part of the intestine, which is much broader than the stomach, is situated below the base of the pectoral rays. The rectal part of the intestine, 5 mm, is firmer and somewhat broader than the mid-intestine from which it is delimited with a constriction. The short liver does not reach the anterior part of the intestine. The gall-bladder is large, measuring 4 mm in diameter.

Gonads:

Both gonads are damaged, and the cranial end is missing. Part of the left gonad was sectioned and showed several encapsuled bundles of long-tailed spermatozoa, i.e., spermatophores (NIELSEN, JESPERSEN & MUNK 1968, p. 247). The spermatogenic tissue contains bundles of spermatozoa as well as younger developmental stages. ZUGMAYER (1911a, p. 131) apparently mistook the large, oval spermatophores (c. 90 μ in average length) for small eggs, since he stated that "L'exemplaire en question est une femelle adulte aux ovaires remplis d'oeufs". (Already NYBELIN (1957, p. 312) mentioned ZUGMAYER's mistake). The copulatory apparatus consists of a well developed urogenital sinus which partly covers a 1 mm long penis placed close to the tip of the sinus. Furthermore, a pair of very short papillae is placed near the base of the sinus on each side of the specimen. The copulatory apparatus thus is very similar to that of *L. galatheae* (cf. Fig. 57). There is not much accordance between NYBELIN's drawing of the copulatory apparatus (1957, pl. VII fig. 10) and the copulatory apparatus itself.

Reproduction and biology:

Only the holotype, a male, is known. Judging from the presence of a well developed penis and spermatophores this species apparently has interior fertilization. No identifiable stomach contents were found. Quite a number of characters show a neotenic development (cf. p. 79). It was most probably taken deep pelagically in a trawl over a depth of 5000 m approx. The only other fish in the trawl was the pelagic *Gonostoma bathyphilum* (Vaillant, 1888).

Distribution:

Known only from the type locality in the eastern Atlantic off north western Spain (Fig. 48).

Leucochlamys jonassoni Nybelin, 1957
Pl. IV Fig. 3

Leucochlamys jonassoni Nybelin, 1957, p. 311, pl. VII figs. 3 and 9.

Material examined (1 specimen):

Holotype (SL 38 mm, ♀); Swedish Deep-Sea Exped. St. 329, south of the Cape Verde Isls. (9°38′N, 26°20′W – 9°50′N, 26°30′W); 5600-5610 m; trawl. 3. July 1948. NHMG Pi. ex. 1745.

The specimen is in good condition.

Diagnosis and relationships:

L. jonassoni is characterized by the relatively low counts (dorsal fin-rays 68 *vs.* 83-104, anal fin-rays 43 *vs.* 46-48, pectoral fin-rays 9 *vs.* 11-14 and vertebrae 68 *vs.* 78-86). Judging from the meristic characters *L. jonassoni* is more closely related to *L. cryptophthalmus* than to *L. galatheae*. See also the key on p. 70 and Table 24.

Description:

Table 24 gives some of the meristic and morphometric characters. The difference between this reexamination and NYBELIN's numbers (1957, p. 312) is mainly due to the different ways of measuring the standard length, which NYBELIN measured from the tip of the lower jaw, and in this paper from the upper jaw symphysis.

The short dorsal fin issues somewhat in front of the midpoint of the body. The caudal part of the body only represents about one-third of the standard length. The ratio between width and length of the pectoral peduncle is 0.3, and the length represents 8.4 % of the standard length which is considerably more than in the other species. The ratio between length and width of the middle "fields" of the musculi infracarinales mediales is 1.9. The head is much higher and broader than the body. The lower jaw protrudes. The mouth cleft is only slightly upward directed. The posterior end of the more or less concealed maxillary is vertically expanded and ends almost below the eye. The eyes are placed deep in the head and appear as two black dots. The anterior, tube-formed nostril is placed close to the upper lip. The posterior nostril is situated a little closer to the anterior nostril than to the eye. Otoliths are not seen on the radiographs.

Lateral line system. No lateral line papillae are observed on the body, but several are found on the head. The mandibular canal is the most distinct and is provided with seven minute papillae. The remaining canals are difficult to follow because of the loose skin and the small size of the specimen. The snout bears a number of irregularly arranged papillae equal in size to the mandibular ones.

Dentition. All the teeth are thin and pointed. There is a single, irregular row on the premaxillaries, but the symphysis and the posterior part are edentate. The vomer is provided with two fangs medially and numerous minute teeth laterally. The anterior dentary teeth, which are placed in one row, are relatively long. There are no teeth in the lower jaw symphysis.

Vertebral column. Like most of the specimens from the "Swedish Deep-Sea Exped." it also was not possible to obtain a usable radiograph of *L.*

jonassoni. Only a few details were discernible, viz. the very thin neural and haemal arches and spines and the apparent absence of ventrally directed processes on the precaudal vertebrae. Fortunately, the specimen is so thin that the vertebrae could be counted with transmitted light. The total number of vertebrae is 68. By this method precaudal and caudal vertebrae cannot be distinguished. However, it appears from Table 24, and other tables in this paper, that the anterior anal fin-ray is situated below the first caudal vertebra in many aphyonids. Using this principle for *L. jonassoni* 39 precaudal and 29 caudal vertebrae can be distinguished. The ratio between length and height of the last precaudal vertebral centrum is 0.6 and 0.9 for the 20th caudal centrum. No details of the caudal skeleton could be seen.

Gill cavity. The anterior gill arch is provided with very small, knob-formed, edentate rakers like those of *L. galatheae* (cf. Fig. 53). The dentigerous rakers in the inner row are better developed than those in the outer row of the anterior arch. The rakers on the 2nd-4th arches are all larger than those on the first arch, and the outer and inner rows consist of equally developed, dentigerous rakers. The epibranchiale never bears rakers. The best developed gill laminae are found on the 3rd and 4th arch. There are approx. 20 feather-like laminae on the 3rd arch. The 2nd arch is provided with laminae, only half the size of those on the 3rd arch. There are no laminae on the anterior arch. Below is given a survey of the number of rakers from the outer row from the right and the left gill arches:

1st gill arch with 11 rakers
2nd gill arch with 10-11 rakers
3rd gill arch with 9-10 rakers
4th gill arch with 6-8 rakers
5th gill arch with 0 rakers

The poor development of the rakers, compared to the other species of *Leucochlamys*, is probably due to the small size of the specimen. Pseudobranchs and toothed pharyngeal plates were not observed.

Colour. Owing to the transparent skin the colour of the specimen is dominated by the colour of the underlying tissue. There are many black spots at the base of the dorsal and the anal fin, along the midline of the body from the base of the pectoral peduncle almost to the caudal fin and on the predorsal part of the body. Besides the small, black eyes there are several minute black spots on the head situated behind the eyes. Black-brown pigment is also found dorsally on the peritoneum.

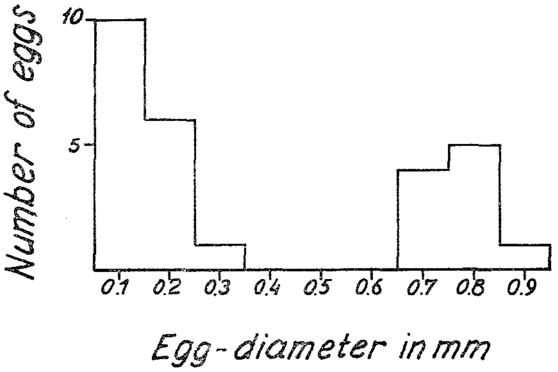

Fig. 50. Number and diameter of eggs, measured to nearest tenth of mm, from one ovary of the holotype of *L. jonassoni*.

Viscera. The abdominal cavity is very long. The digestive canal forms a long tube without any coils. The stomach and oesophagus are separated from the intestine by a slight constriction. The transparent intestine is three times the length of the stomach and the oesophagus. The brownish liver is relatively long and ends near the posterior tip of the stomach.

Gonads:

In spite of the small length of the specimen the ovaries are well developed, measuring 10 mm in length. The unpaired excretory duct forms 2 mm approx. The eggs from the right ovary were measured and counted and the result is shown in Fig. 50. The total number of eggs is very small (27). They are divided into two groups: The smaller eggs (a number of 17, varying from 0.1-0.3 mm in diameter) are all yellowish, while the eggs from the other group (a number of 10, varying from 0.7-0.9 mm in diameter) are brown and contains numerous grains of yolk. Also the left ovary seems to contain rather few, small eggs and nine large, brown ones, if examined in transparency. It was not possible to see whether the large eggs were fertilized. The ratio between the number of small and large eggs is quite different from what was found in *Leucochlamys galatheae*, in which a specimen of 84 mm contained 186 small and 11 large eggs in one ovary (cf. Fig. 54). The copulatory apparatus consists of a pair of nearly 1 mm long, soft claspers, resembling those of *L. galatheae* (cf. Fig. 56).

Reproduction and biology:

Since only 20 eggs approx. are developing simultaneously in the only known specimen of *L. jonassoni* (Fig. 50) this species is undoubtedly viviparous.

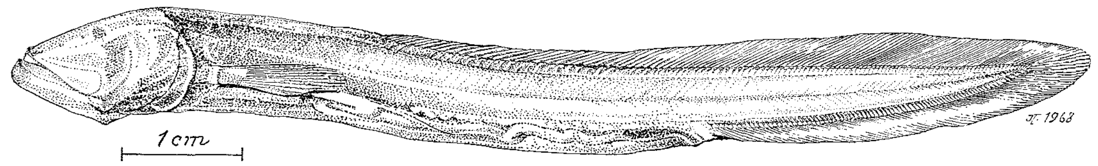

Fig. 51. Holotype of *Leucochlamys galatheae* n. sp., SL 84 mm.

This is also supported by the fact that the female copulatory apparatus is very similar to that of *L. galatheae* which is known to be viviparous. The trawl worked at the bottom for about four hours (NYBELIN 1951, p. 14), but several pelagic fishes were caught besides the benthic species. This, and the neotenic development of many characters, supports the suggestion that *L. jonassoni* lives deep-pelagically. None of the stomach contents could be identified.

Distribution:

Only known from the type locality south of the Cape Verde Isls. (Fig. 48). The depth of the locality was 5600-5610 m.

Leucochlamys galatheae n. sp.

Fig. 51

Leucochlamys sp. NIELSEN, JESPERSEN & MUNK 1968, p. 247.

Material examined (2 specimens):

Holotype (SL 84 mm, ♀); "Galathea" St. 663, Kermadec Trench (36°31′S, 178°38′W); 4410 m; herring otter trawl. 24. Febr. 1952. ZMUC P77456.

Paratype (SL 61 mm, ♂); "Galathea" St. 663. Same data. ZMUC P77457.

Except for the somewhat torn skin the two specimens are in good condition. A drawing of the holotype was published by BRUUN (1953, p. 187) with the following figure-text (translated): A blind semitransparent brotulid fish from 4410 m. North east of New Zealand.

Diagnosis and relationships:

L. galatheae has more dorsal fin-rays (88-104 *vs.* 68-83) and more vertebrae (86 *vs.* 68-78) than the other two species of *Leucochlamys*. There is also a difference in the length of the base of the anterior 10 dorsal fin-rays (5.0-5.4 *vs.* 6.7-7.9, expressed as percentage of the standard length). *L. galatheae* is not provided with black pigment in contrast to the other two species. The anterior neural spines are shorter than the centrum while they are longer in *L. cryptophthalmus*. The meristic characters (Table 24 p. 72) show that *L. galatheae* is most closely related to *L. cryptophthalmus*. See also the key on p. 70. The specific name indicates that the type material was caught during the Galathea Expedition.

Description of the holotype:

Many of the meristic and morphometric characters are given in Table 24. (See also the generic diagnosis on p. 69).

The body is long and slender with only a short caudal part, forming c. 35 % of the standard length. The dorsal fin arises just behind the tip of the pectoral fins, and the anal fin issues below the middle of the dorsal fin. The pectoral peduncle is long and narrow. The ratio between the width and the length is 0.3, and the length represents 6 % of the standard length. The eyes are seen as small black dots placed rather deep in the head. The mouth cleft is directed slightly upward. The maxillary ends a little posterior to the eye and is not concealed. The lower jaw protrudes. The tongue is large with a short, free tip. The anterior nostril, which is formed as a circular hole, is placed close to the tip of the snout near the upper lip. The circular posterior nostril is situated midway between the eye and the anterior nostril. The musculi infracarinales mediales are very distinct (cf. p. 9). The ratio between length and width forms 1.4 in the middle muscular "fields". Otoliths are not seen on the radiographs.

Lateral line system. No lateral line papillae could be found either on the body or on the head, in contrast to *L. jonassoni*.

Dentition. The premaxillaries are provided with 3-4 rows of coneformed, pointed, almost uniform teeth anteriorly, gradually decreasing to one row more posteriorly. The posteriormost part of the premaxillaries and the upper jaw symphysis are without teeth. The vomer is arched and has many small, blunt teeth placed very close together. The dentigerous part of the vomer is broader laterally than medially. There is one long, pointed tooth in each side of the vomer. The dentaries have 2-3 rather irregular toothrows with teeth of different

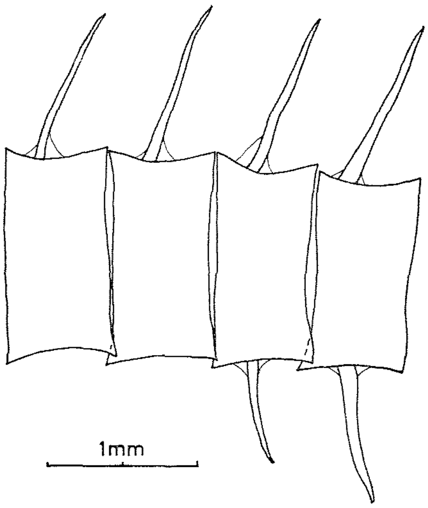

Fig. 52. Transition between precaudal and caudal vertebrae in the paratype of *L. galatheae*, SL 61 mm.

size, mixed with each other. The larger ones are recurvated. The posterior part of the dentaries is edentate. The lower jaw symphysis is provided with teeth.

Vertebral column. There are 48 precaudal and 38 caudal vertebrae. Judging from the radiographs all the neural and haemal arches and spines are thin and pointed. The first neural spine is the longest, being a little shorter than the centrum of the first vertebra. The most anterior neural spines are not markedly longer than the following. It is difficult precisely to locate the transition between the precaudal and caudal vertebrae, as the anterior two, ventrally directed processes are very thin, and a little shorter than the remaining ones. However, the position of the first anal fin-ray below the vertebra with the anteriormost ventrally directed process, makes it reasonable to count this vertebra as the anterior caudal vertebra (cf. Fig. 52 and the paratype p. 78). The posterior neural and haemal spines are depressed. None of the precaudal vertebrae are provided with parapophyses or ribs. The ratio between length and height of the posterior precaudal vertebral centrum is 0.6 and that for the 20th caudal vertebral centrum is 0.9. Except for two large hypural plates no details of the caudal skeleton can be seen.

Gill cavity. Fig. 53 shows the anterior, left gill arch of the holotype with 11 rakers on the cerato- and three rakers on the hypobranchiale. The drawing was made, seen in antero-lateral view, whereby the rakers appear too short and plate-like. Some of the rakers from the inner row appear on the drawing. The rakers in the inner and outer rows of all the arches are short and broad and provided with teeth. No rakers are found on the epibranchiale. The gill laminae were not visible when the drawing was made in that particular view. However, on the anterior arch there are 25-30 rather short laminae which all are confined to the cerato- and hypobranchiale. The 2nd and 3rd arch have well developed laminae, while those on the 4th arch are very scarce and small. Below is given a survey of the number of rakers in the outer row from both sides of the holotype:

1st gill arch with 13-14 rakers
2nd gill arch with 11-12 rakers
3rd gill arch with 10-11 rakers
4th gill arch with 9-10 rakers
5th gill arch with 7-8 rakers

Pseudobranchs and teeth on the pharyngeal plates are not developed.

Colour. Owing to the almost transparent skin the colouration of the specimen is dominated by the light brown and yellow muscular tissue. There is no black pigment anywhere except for the eyes.

Viscera. The oesophagus and the stomach are narrow and short, forming approx. one-fifth, while the distance from the posterior end of the stomach to the anal opening forms about one-third of the standard length. The intestine is only provided with two small coils. The diameter of the anterior fourth of the intestine is twice that of the anterior part of the stomach, and the wall is much thinner. The posterior fifth of the intestine, the rectum, is rather thick-walled and of a more brownish colouration. There is a constriction between the rectum and the mid-intestine. The middle part is narrow and so thin-walled that food items are distinguishable in transparency. The gall-bladder is transparent and

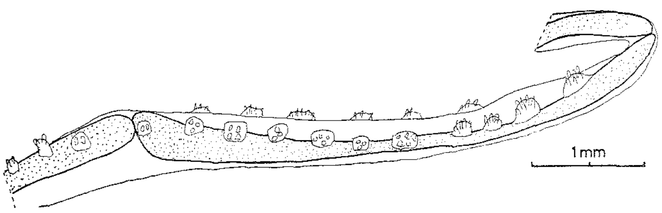

Fig. 53. Anterior, left gill arch of the holotype of *L. galatheae*.

about 2 mm in diameter. The liver ends in front of the anteriormost part of the intestine.

Gonads (holotype):

The distended ovaries are 21 mm long and grown together along the posterior 2 mm. The left ovary was removed and the eggs measured and counted (Fig. 54). The ovary held approx. 200 eggs which are divided into two distinct groups. The bulk of the eggs vary from 0.1-0.7 mm in diameter, all apparently unfertilized. The smallest of these are transparent while the larger ones are more or less brown, often with numerous yolk granules. (Eggs smaller than 0.1 mm were not counted). The other egg-group contains 11 eggs with a diameter of 1.0-1.4 mm, and in all of them a small embryo is visible. The number of large, fertilized eggs was found to be nine in the right ovary, where they were seen with transmitted light. The copulatory apparatus consists of a pair of 2 mm long, soft claspers (Figs. 55 and 56).

Part of the left ovary was sectioned. The ovary contained very little ovarian tissue and many eggs of different size. All were unfertilized, but the largest egg sectioned was only about 0.5 mm in diameter. Among the eggs were free spermatozoa, and a few

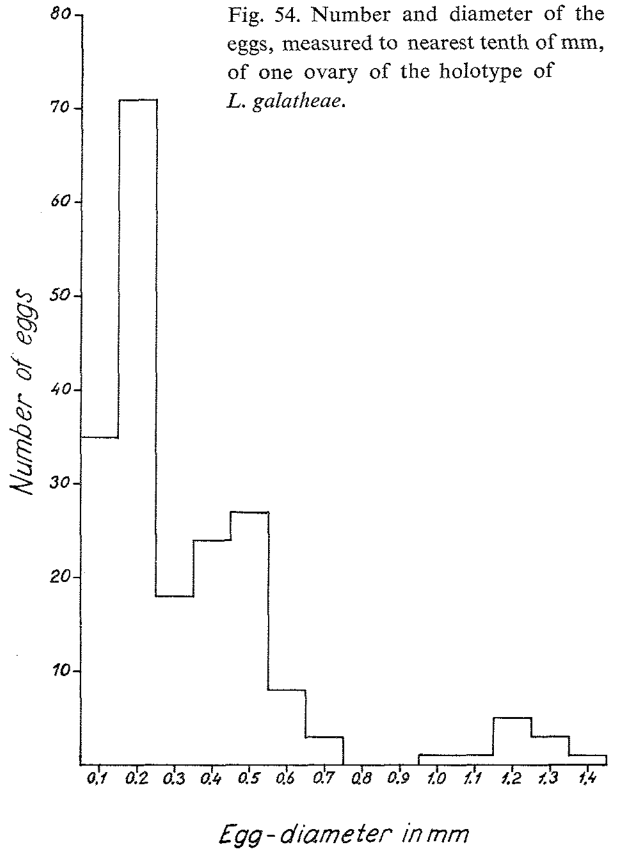

Fig. 54. Number and diameter of the eggs, measured to nearest tenth of mm, of one ovary of the holotype of *L. galatheae.*

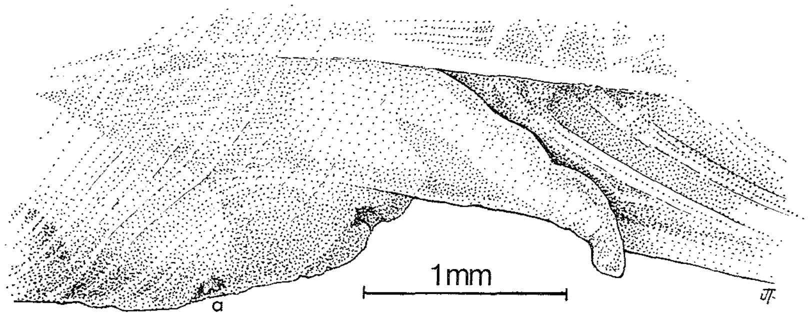

Fig. 55. Lateral view of anal opening (a) and female copulatory apparatus of the holotype of *L. galatheae.*

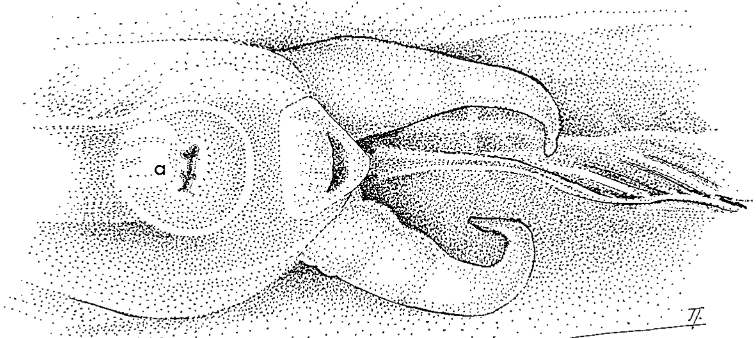

Fig. 56. Ventral view of anal opening (a) and female copulatory apparatus of the holotype of *L. galatheae.*

partly emptied spermatophore-capsules (Nielsen, Jespersen & Munk 1968, pl. XXIV fig. 3).

Description of the paratype:

In the following description only those characters which differ from the holotype are mentioned.

All the meristic characters show fine agreement except for the number of dorsal fin-rays, of which there are much fewer in the paratype (88 *vs.* 104), but this is not considered of specific significance, since the specimens otherwise are very similar. In spite of the difference in number of dorsal rays the "Predorsal length" varies only little (33 % *vs.* 31 %) and also the "Base of the ant. 10 dorsal-rays" agrees (5.4 % *vs.* 5.0 %).

Dentition. There are only 1-2 rows of teeth in the premaxillaries and in the dentaries, and fangs are not present on the vomer. However, since the fangs are easily broken off, I would rather explain the absence in the paratype as due to damage than to sexual dimorphism. Furthermore, there is a mark on the vomer which might derive from a broken large tooth.

Vertebral column. The paratype has the same number of vertebrae as the holotype. The anterior two haemal spines are somewhat stronger than those of the holotype. The ratio between length and height of the last precaudal vertebral centrum (Fig. 52) and of the 20th caudal centrum is 0.5 and 0.8, respectively.

Viscera. The stomach and anterior part of the intestine are relatively thick and short. The transparent gall-bladder is large (3 mm in diameter).

Gonads (paratype):

The length of the narrow testes are 11 mm. Except for a small part close to the unpaired, excretory duct the testes are not united. A piece of the left testis was sectioned. The dorsal testicular duct is rather small, but it contained a number of oval spermatophores. In most of these the spermatozoa are not orientated with the heads in the same direction, in contrast to what is found in other aphyonids. The testicular tissue contains many younger spermatogenetic stages besides fully developed spermatophores. Fig. 57 shows the copulatory apparatus in lateral view. It consists of a large urogenital sinus, of a median placed, upward-directed penis, and of a pair of very short papillae situated in the angle between the sinus and the anterior anal fin-ray. These papillae are probably vestigal claspers.

Reproduction and biology:

The presence of fertilized eggs as well as of spermatozoa in the ovaries show that this species has interior fertilization. The trawl worked on the bottom, but of the nearly 15 species of fish represented in the catch about $\frac{2}{3}$ occurred pelagically. This indicates that *L. galatheae* may have been caught pelagically. Also this species shows many neotenic characters. There were no identifiable stomach contents.

Distribution:

Known only from the type locality in the Kermadec Trench (Fig. 48).

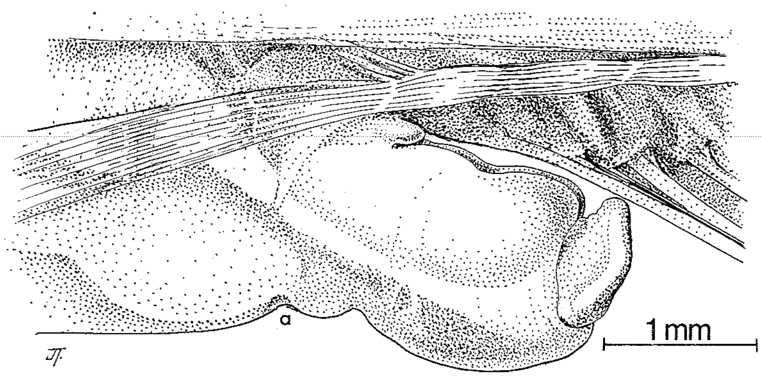

Fig. 57. Lateral view of anal opening (a) and male copulatory apparatus of the paratype of *L. galatheae*.

III. GENERAL REMARKS

Description

In this chapter a description is given of certain family characters, which are not included in the family diagnosis (cf. p. 10). Some of the characters may prove to be of diagnostic value, when corresponding descriptions have been given of the other ophidioid families.

The species of Aphyonidae all have a large head, and the caudal part of the fish represents half or less of the standard length. The ventral fins, when present, are placed in a jugular position. No fin-rays seem to be prolonged. A mental barbel is not developed. The mouth opening is large and directed more or less upward. The degenerated eyes of the adults are always placed somewhat under the skin. Photophores were not observed. The dentition is rather weak. The tongue and basibranchials are always edentate, and only in *Barathronus bicolor* were teeth observed on the palatines (Table 15, p. 35). The number of branchiostegal rays varies from 7-10. Many of the osteological characters of the Aphyonidae are only known from *B. bicolor,* the only species of which material was alizarin stained. There are normally two ridges on the operculum, forming a V. The preoperculum, at least in *B. bicolor* has an anteriorly directed bony membrane. *B. bicolor* is provided with five pectoral radials, while the remaining aphyonids and all other ophidioids are supposed to have only four radials (GOSLINE 1968, p. 25). The ventrally directed processes on the precaudal vertebrae are weakly developed compared to most Brotulidae. The radials of the dorsal and anal fins are distinct. The ratio between the number of anal fin-rays and the corresponding number of vertebrae is 1.2-1.6. This is somewhat less than the ratio for Ophidioidea in general, which, according to GOSLINE (1968, p. 18), is about 2. Although the shape of the vertebral centra remains rectangular in lateral view in all aphyonids (excl. *Barathronus)* the ratio between length and height of the centra changes from juveniles to adults. However, the ratio seems to be constant in adult specimens of the same species, despite differences in the standard length. The caudal skeleton consists, i. a., of two large hypural plates. In three genera the anterior gill arch has some of the rakers prolonged, while the rakers on the 2nd-5th arches are always very short, but usually provided with small teeth. The gill laminae on the anterior arch are shorter than those on the 2nd-4th arches. The gill slit is long. The pharyngeal tooth-plates are weak. An oval thymus is found dorsally in the gill cavity in some aphyonids. The oesophagus and the stomach are thick-walled. The intestine is wide and thin-walled near the stomach and more thick-walled caudally. The length of the intestine is relatively longer in adults than in juveniles, in which it often forms a straight tube without any coils. The liver is short, reaching the anterior part of the intestine.

Neoteny

As underlined in this paper, most aphyonid genera comprise species with many neotenic developed characters. The term neoteny is here used in the broad sense mentioned by DE BEER (1951, p. 52). It is rather difficult to decide whether a species or a family of fishes are neotenous, without making a comparison to other fishes, as neoteny is a relative concept. Here, the Aphyonidae are compared to the related family Brotulidae. Some of the viviparous brotulids were examined by NIELSEN ET AL. (1968, p. 241). Males of three species were found to be ripe at small standard lengths, *Bellottia apoda* Giglioli, 1883 (SL 28 mm), *Calamopteryx goslinei* Böhlke & Cohen, 1966 (SL 36 mm) and *Microbrotula rubra* Gosline, 1953 (SL 35 mm). However, these small species can hardly be regarded as neotenous since they, among other features, have a well ossified skeleton, sand-glass formed vertebral centra and a normal squamation (see NIELSEN & COHEN 1968). Listed in Table 25 are the more important neotenic characters of the six aphyonid genera.

Table 25 shows that *Barathronus* is the least neotenic of the Aphyonidae, followed by *Aphyonus.* The remaining four genera are typically neotenous.

As regards other deep sea fishes, all stages occur from species with normally developed features to species with many neotenic developed characters. MARSHALL (1960) stated that all pelagic fishes occurring below a depth of 1000 m and about half of the abyssal fishes have no swimbladder. Most of the deep pelagic species also have a poorly ossified skeleton, e. g., the bathypelagic *Bathylaco* Goode & Bean, 1896 (NIELSEN & LARSEN 1968, pl. XIV). COHEN (1960, p. 148) shows that the deep pelagic *Dolichopteryx* Brauer, 1901 (Isospondyli, Opisthoproctidae) has a number of neotenic characters, e. g., poorly developed body musculature, vestigal scales,

Table 25. Neotenic developed characters in the aphyonid genera.

	Aphyonus	*Nybelinia*	*Barathronus*	*Meteoria*	*Sciadonus*	*Leucochlamys*
Rectangular-shaped vertebral centra in a lateral view	+	+	—[1]	+	+	+
Prolonged pectoral peduncle	(+)	(+)	—	—	+	+
Slightly ossified skeleton	+	+	—	+	+	+
Scaleless	+	+	+	+	+	+
Oblique mouth cleft	—	+	+	(+)	(+)	—
Poorly developed musculature	(+)	+	—	(+)	+	+
Exclusively short rakers on anterior gill arch	—	—	—	+	+	+
Reduced laminae on anterior gill arch	+	+	(+)	+	+	+
Sexually mature at a small size (<100 mm)	+	+	+	+	+	+

+ = presence; — = absence of neoteny.
The brackets indicate that the character is not typically developed.

[1] Juvenile specimens have rectangular-shaped vertebral centra.

prominent fin-peduncles, transparent skin and ripe gonads in small specimens (<85 mm). The meso- and/or bathypelagic zoarcid genera *Parabrotula* Zugmayer, 1911 and *Leucobrotula* Koefoed, 1952 show much resemblance to the aphyonid genera *Sciadonus* and *Leucochlamys* as they have rectangular-shaped vertebral centra in lateral view; they are furthermore poorly ossified, have short gill rakers, are scaleless, have no swimbladder, are viviparous, become ripe at a size only 3-4 times the length of newly born larvae and produce only few larvae in one clutch (Nielsen 1968).

Various authors have tried to explain why adult specimens of many deep-occurring pelagic fishes show a number of larval characters:

Bertin (1936, p. 510 and 1949, p. 363) discussed some characters found in deep sea eels which showed signs of degeneration and rachitis. He was of the opinion that this "rachitism congénital" was caused by the deep sea surroundings, such as the absence of ultraviolet rays, the minimum of plankton organisms containing the anti-rachitic vitamin, owing to predation from the animals living in the upper zones, and the small concentration of calcium and phosphorus.

Parr (1937, p. 27) also came to the conclusion that the poorly ossified skeletons of pelagic deep sea fishes was an adaptation to the small amount of D-vitamin.

Marshall (1955, p. 324) mentioned that many pelagic deep sea fishes, living near layers where D-vitamin is produced, have a slightly ossified skeleton, while it is well ossified in benthic deep sea fishes. He concluded that owing to the absence of a swimbladder in many of the pelagic fishes, they would be apt to sink. However, a reduced ossification may lower the specific gravity so as to be similar to that of sea water, which makes it unnecessary for the fish to use energy in order to prevent sinking. Marshall (1960, p. 111) suggested that the many characters which are developed in the aphyonids, as mentioned in Table 25, are ascribable to an adaptation to the food-poor environment.

Walters' (1961, p. 307) interpretation of neoteny agrees well with that of Marshall. Walters stated that "It is my opinion that neoteny, indications of which are widespread in many deep-sea groups, has been one of the major avenues of evolution in the energy-poor deep-sea environment". By eliminating the development of "adult" structures much energy is conserved for the biomass.

I fully agree with Marshall and Walters, and I find that the Aphyonidae support their theory, as the benthic-living genus *Barathronus* (and probably also *Aphyonus)* contrasts the pelagic-occurring genera by lacking many of the abovementioned neotenic characters. Cohen (1963, p. 3) mentioned in connection with the original description of the brotulid *Thalassobathia pelagica,* that "I believe that neoteny has played an important part in the evolution of the aphyonines". – In addition to a smaller food-requirement, neoteny is an advantage also in other ways. Owing to the soft body and gelatinous skin these fishes produce a relatively weak pressure-wave when swimming and when hit by a pressure-wave, the echo, which reaches other fishes (predators), is fainter than the echo from normally built fishes.

Gonads and reproduction

All aphyonids are dioecious and most probably viviparous. Judging from a histological examination of *Barathronus bicolor* (ten specimens) no sex reversal occurs during growth in contrast to what is the case in, e.g., the mesopelagic *Gonostoma gracile* Günther, 1878 (KAWAGUCHI & MARUMO 1967). Histological examinations (8 and 10 μ sections) were made of ten females and 13 males, representing seven and eight species, respectively. Furthermore, a gross examination was made of the gonads of all specimens.

Females. See also the discussion of the ovaries of *B. bicolor* (p. 39). Sections were made of three ripe specimens belonging to two species. The small number of ripe specimens examined is due to lack of material, technical difficulties in connection with section of ovaries containing large eggs, and the need to count and measure all the eggs from an ovary. All three specimens appeared to contain spermatozoa in the ovaries. In *Leucochlamys galatheae* even partly emptied spermatophore-capsules were observed. In *Barathronus bicolor* no remains of the capsules were found, not even in the most caudal end of the unpaired excretory duct, which in the specimens sectioned was filled with free spermatozoa. This seems to indicate that the capsules are dissolved soon after copulation. In two *B. bicolor* females spermatozoa were seen with their head embedded in the ovarian tissue, probably being nourished in this way. This was earlier described by TURNER (1947, p. 510) in the microcyprinid *Heterandria formosa* Agassiz, 1853 and by NIELSEN, JESPERSEN & MUNK (1968, pl. XXIV fig. 2) in *Barathronus bicolor*. The gonads of seven small, unripe females were sectioned, representing six species. The ovaries of one of these, *Aphyonus gelatinosus*, were very poorly fixed. In *Meteoria erythrops* the ovary examined contained eggs with a maximum diameter of 200-300 μ, but none were fertilized, and spermatozoa were not observed. The remaining four species all belonged to the genus *Barathronus*.

The eggs from one or both ovaries of seven specimens, representing five genera, were counted and measured (Figs. 16-30-43-47-50-54). In addition, an estimation of the number of eggs from one ovary of *Aphyonus gelatinosus* was made. The graphs show that the size of the clutches varies much when comparing the genera. In the benthic species *Barathronus bicolor* and in *A. gelatinosus*, which may also be benthic, the clutches vary from 1200 to 1600 eggs (from both ovaries) with a diameter of 0.5 to 1 mm. In the remaining four genera, which most probably are all pelagic, the clutches are much smaller. In *Nybelinia erikssoni, Sciadonus pedicellaris, Leucochlamys jonassoni* and *galatheae* the number of eggs in the supposed clutch varies from 20 to 70 (from both ovaries) with a diameter of 0.2 to 1.4 mm. *Meteoria erythrops,* which is believed to occur pelagically, is apparently an exception, since the two ovaries together contain 900 eggs approx., forming a single peak in the graph (Fig. 43). However, the diameter of the eggs is very small, 0.05 to 0.35 mm, so most probably only a minor part of the eggs will produce larvae. Except for *M. erythrops,* the larger eggs seemed to be fertilized in all the species examined. Fig. 47 shows that more than one clutch develops at a time, and also that some of the eggs perish during development. A number of free embryos were found in the ovaries of *N. erikssoni* and *B. bicolor*. They varied in length from 4 to 9 mm which means that the larvae hatch or are delivered at an advanced stage of development. This is in agreement with MARSHALL (1953) as regards the size of eggs and larvae of deep sea fishes.

The female copulatory apparatus is not developed in *Aphyonus, Meteoria* and in most specimens of *Barathronus*. Exceptions are 2-3 specimens of *B. bicolor,* which are provided with a pair of 0.5 mm long claspers, and the holotype of *B. bruuni,* in which a minute medially placed papilla is surrounded by a low rim (Fig. 38). In *Sciadonus* and *Leucochlamys* a pair of long claspers is developed (Figs. 55 and 56) and in *Nybelinia* there is moreover a median fold (Fig. 17).

Males. See also the discussion of the testes of *B. bicolor* on p. 41. Males are known in eight aphyonid species, the testes of which were all examined histologically. The testes of six specimens of *B. bicolor* were sectioned, while the remaining seven species were represented only by one specimen each. Except for two specimens, the testes of all the sectioned males contained a varying number of encapsuled spermatozoa, i.e., spermatophores. Within the genus *Barathronus* the length of the penis varies much. Fig. 31 shows that the penis is extremely short in seven specimens of which the five small ones (SL 60-75 mm) belong to *B. bicolor,* one to *B. parfaiti* (SL 100 mm) and one to *"Barathronus* specimen" (SL 156 mm, cf. p. 57). The testes of a 69 mm long specimen of the five small ones were sectioned. They contained only a few spermatophores, and most of the testicular tissue consisted of younger developmental stages of spermatozoa. The testes of all the five specimens were very thin and unripe. Sections of the testes of the other two specimens with a short penis showed that no spermatophores or even spermatozoa were developed. All specimens with a long penis had ripe testes. This indicates that the length of the penis increases when the specimens become adult. It appears that *B. bicolor* becomes ripe at a length of c. 85 mm. If ripeness occurs at the same length in the other species of *Barathronus* it means that the abovementioned two large specimens (100 and 156 mm) are adults, which were caught with newly spent testes. This again would involve that the length of the penis would vary according to the ripeness of the testes. In that case, the length of the penis can not be used to distinguish juvenile and adult specimens. – The two large specimens of *Barathronus,* with the poorly developed testes, might be examples of expatriation (O'DAY & NAFPAKTITIS 1967), which in some cases may cause degeneration of the gonads and loss of the secondary sexual characters. O'DAY & NAFPAKTITIS found wide differences especially in the temperature conditions in the reproduction area and in the expatriation area. However, the *B. parfaiti* specimen was caught very near the locality of the only other known specimen of the same species, and the *Barathronus* specimen was trawled at a station at almost the same depth and temperature as those of the most closely related species, *B. bicolor* and *diaphanus;* these two specimens therefore can hardly be expatriates.

The male copulatory apparatus is developed in all species. Primarily, it consists of a urogenital sinus and a penis, the proximal part of which is covered by the sinus, but there are some modifications. In all specimens of *Barathronus* a rather small urogenital sinus and a long penis are found (Fig. 34). In ripe specimens of *Sciadonus* and *Leucochlamys* the sinus is large and the penis short. In addition, a pair of small papillae are developed at the base of the sinus (Fig. 57). In *Nybelinia* the sinus ends in a penis-like appendage (Fig. 18). The copulatory apparatus in *Aphyonus* is differently developed in the two species. In *A. gelatinosus* it consists of a penis and a medially placed clasper ventrally to the penis and a sinus is not developed (Fig. 4). In *A. brevidorsalis* there is a urogenital sinus ending in a penis and a pair of short claspers (Fig. 11). The great difference between these congeneric species indicates that the shape of the copulatory apparatus is a specific rather than a generic character, while in other genera the copulatory apparatus is no doubt of generic significance *(Barathronus* and *Leucochlamys).* D. M. COHEN (personal communication) found that two species of a viviparous brotulid, *Calamopteryx* Böhlke & Cohen, 1966, have a differently developed male copulatory apparatus.

NIELSEN, JESPERSEN & MUNK (1968, p. 249) discussed the biological significance of the spermatophores. They concluded, that exclusive of the *Barathronus* spp., the aphyonids are so rare, that the two sexes probably meet rather seldom. It is therefore of importance that females with unripe eggs are able to store live spermatozoa in the ovaries until the eggs have developed into a stage ready for fertilization. It is known that if spermatozoa are kept immobile their life span increases, and this is effected by means of the spermatophores. In representatives of two species of ophidioids, both belonging to the Brotulidae (NIELSEN ET AL., table 1), the ovaries proved to contain numerous spermatophores and unripe eggs. It may be possible for the female to keep the spermatozoa alive for so long a period that they are able to fertilize more than one clutch of eggs (superfoetation). *Barathronus bicolor* apparently occurs in such dense populations that it is not necessary for the females to store spermatophores. On the other hand, a few observations seem to show that spermatozoa may be kept alive by being nourished through the ovarian epithelium.

Distribution

Most species of Aphyonidae are known from so few specimens that it would seem premature to use the expression "Zoogeography" for the heading of this chapter.

Vertical distribution. All authors who have discussed the biology of the Aphyonidae (in the present sense) have considered them a pelagic family (NYBELIN 1957, MARSHALL 1960, MEAD, BERTELSEN & COHEN 1964 and RASS 1967). Most of these authors relied on the record of a single specimen of *Barathronus parfaiti* found in the stomach of a *Germo alalunga* (cf. p. 57).

Except for a single specimen, viz. the holotype of *Barathronus bruuni,* all aphyonids were caught in non-closing gear which fished on the bottom as well as during the hauling in. It is therefore with reluctance that a species is referred to as benthic or pelagic.

The genus *Barathronus* differs from the remaining genera by showing only few neotenic characters (cf. Table 25). This agrees well with the supposed bathymetrical distribution, as the discussion p. 30

Table 26. Known geographical distribution of the Aphyonidae.

	Central Atlantic Ocean	West Atlantic	East Atlantic	Indian Ocean	West Pacific	East Pacific
Aphyonus gelatinosus	.	2	.	.	1	.
A. brevidorsalis	.	.	.	1	.	.
Nybelinia erikssoni	1	.	.	1	.	.
Barathronus affinis	.	.	.	1	.	.
B. bicolor	.	42	.	.	.	.
B. bruuni	.	.	.	1	.	.
B. diaphanus	.	.	.	4	.	.
B. parfaiti	.	.	2	.	.	.
Meteoria erythrops	.	.	2	.	.	.
Sciadonus pedicellaris	1	.	.	.	.	1
Leucochlamys cryptophthalmus	.	.	1	.	.	.
L. jonassoni	1	.	.	.	.	.
L. galatheae	.	.	.	.	2	.

shows that adult specimens of *Barathronus* most certainly occur on the bottom at bathyal depths (366 m to about 1850 m). Juvenile specimens of *Barathronus* apparently live pelagically.

The genera *Meteoria, Sciadonus* and *Leucochlamys* without doubt occur deep-pelagically. They were all fished over great depths (1850 m to 5600 m) and show many neotenic characters.

Nybelinia was also caught over great depths (4820 m to 5300 m) and except for a few long gill rakers it shows the same neotenic developed characters as the three genera mentioned in the previous chapter, so *Nybelinia* too is considered pelagic.

Aphyonus shows more neotenic developed characters than does *Barathronus,* but less than the remaining genera (Table 25), so it is difficult to decide whether *Aphyonus* is pelagic or benthic. All specimens were caught at stations close to the shore at depths varying from 914-4360 m.

Horizontal distribution. Table 26 shows the geographical distribution of the 13 species of Aphyonidae. The numbers indicate the amount of specimens.

It appears from Table 26 that all the five species of the benthic-living *Barathronus* are found in only one ocean or part of an ocean. Of the remaining eight probably pelagic species, three, known from 2-4 specimens each, are distributed in two oceans, two species, both known in two specimens, are found in one ocean, and three species are known only in one specimen each.

One of the six genera was caught in one ocean only, while all the others were taken in 2-3 oceans.

The Aphyonidae occur in the tropical and subtropical zones like nearly all other ophidioids.

Biology

The Aphyonidae occur at rather great depths, either pelagically or on the bottom. The pelagic living species probably occur only a few hundred meters above the bottom, where they can avoid large, benthic predators. There is probably so much turbulence in the water that food-items are whirled up from the bottom on which these small, easily sustained fishes can feed. Neoteny might be an adaptation to the pelagic occurrence. The aphyonids are dioecious and viviparous. Owing to the poorly developed musculature they are most probably slow swimmers, but with their large mouth-opening and mouth-cavity they may be able to catch their prey by sucking it in. They are poorly provided with sense organs, and, e. g., MEAD ET AL. (1964, p. 583) wrote: "We are at a loss to understand how these fishes find each other in midwater". The present examinations have shown that the eyes of the adults are poorly developed compared with the eyes of the free embryos (Figs. 19 and 32). This strongly indicates that the sense of sight may be of some importance for larval specimens, but not for adults. Photophores are not developed. The absence of a swimbladder precludes sound production by means of drumming muscles. The pharyngeal tooth-plates are provided with weak teeth, and the lower ones are most often edentate whereby also sound production by grinding is excluded. Radiographs show that otoliths are only found in the benthic *Barathronus* and in the possibly benthic *Aphyonus gelatinosus.* It was recently shown that the otolith (sagitta) may serve the sense of hearing rather than the sense of balance (MORRIS & KITTLEMAN 1967). If so, pelagic aphyonids have a reduced sense of hearing. Judging from a histological examination of the olfactory organs of *Barathronus bicolor* (cf. p. 35) the sense of smell seems to be rather poorly developed. (Fishes with some senses reduced often compensate for this by having other senses abnormally well developed). One of the best developed sense organs seems to be the lateral line system. In spite of what is stated by many earlier authors all aphyonids have lateral line canals both on the body and on the head, most often provided with small papillae.

It is still an unsettled question whether the larvae remain at the same depths as the adults, or whether they ascend to higher water-levels which are richer in food, but also in enemies. The number of ophidioid larvae present in collections is very inconsiderable. The majority of the known larvae, c. 400 specimens, were caught by the Dana Expeditions at oceanic stations. During the Dana Expedition around the world (1928-30) about 3000 horizontal hauls with stramin-nets were taken at depths varying from the surface to c. 2200 m, but mainly concentrated on depths of 20-200 m. Considering that the number of ophidioid species is 200-300, the larval material is surprisingly small. This indicates that the larvae of most ophidioid fishes, of which many oviparous species produce a great number of eggs, do occur near the shore or at great depths. It was not possible to state with certainty whether there were aphyonid larvae among the 400 specimens. Most probably deep-pelagic aphyonids with their very small clutches (20-70 eggs) can not risk to have epipelagic larvae. It therefore seems reasonable to assume that the larvae remain at the same depths as the adults. The larvae of the benthic *Barathronus,* which has rather large clutches (1000-1500 eggs), occur pelagically (cf. p. 30). Judging from the size of the free embryos in *B. bicolor* and *N. erikssoni* the newly born larvae are well developed. There is no indication of an exterior yolk sack, so the larvae probably start active feeding soon after delivery.

According to Gosline (1968, p. 19), there is a close relationship between the method of locating the food by means of the ventral fins and the jaw structure of, e. g., the Brotulidae and the Ophidiidae. Among the aphyonids *Barathronus* and *Aphyonus* are provided with well developed ventral fins which may be used to search the bottom, although the mouth is terminal or upward directed, which is not an adequate position for taking the food on the bottom. The remaining four genera have no or very poorly developed ventral fins, which agrees with their supposed pelagic occurrence.

The digestive canals of all specimens were examined, but they contained only unidentifiable remains, mostly of crustaceans.

Judging from Table 17 (p. 40) *B. bicolor* apparently has no fixed mating season. This does not necessarily mean that the individual specimens are producing eggs and spermatophores continuously from the time they become adults until they die. On the contrary, there seems to be intervals at which the gonads, of at least other *Barathronus* spp. (cf. p. 81), are in an unripe stage. However, at a given time ripe specimens of both sexes will be present in the population. This unseasoned mating might be expected primarily in species living at relatively great depths, where the physical conditions are fairly constant (cf. Nielsen 1964, p. 121). It is therefore surprising to find this type of spawning in *B. bicolor* which is generally caught at rather shallow depths, from c. 400 to c. 1000 m, where a seasonal change of the physical factors would be expected. All the pelagic-occurring aphyonids are known from so few specimens that it is impossible to form any idea of their type of spawning, but supposing that they live deep-pelagically an unseasoned spawning probably takes place.

IV. SUMMARY

The deep-occurring percomorph, ophidioid family Aphyonidae is defined and compared to the other families belonging to the suborder Ophidioidea. It is most closely related to the Ophidiidae and the Brotulidae. A historical survey of the Aphyonidae is given. All material mentioned in the literature has been examined and as many additional specimens as possible procured. This gives a total of 65 specimens of which 45 have not been recorded earlier. The first specimen was caught in 1874 which indicates that the aphyonids are rare fishes and/or inhabit water masses where fishing seldom takes place.

Six genera and 13 species belong to this family. Of these, two genera and four species are here described as new. All the old specimens, including holotypes, were re-examined.

The genus *Aphyonus* Günther, 1878 comprises two species, viz. the type species *A. gelatinosus*

(Western Atlantic and Western Pacific Oceans) and *A. brevidorsalis* n. sp. (off south east Africa). *A. mollis* Garman, 1899 is here synonymized with *A. gelatinosus.*

Nybelinia n. gen. is based on *Barathronus eriksson*i Nybelin, 1957 from the central Atlantic and Western Indian Oceans.

Barathronus Goode & Bean, 1886, which includes *Alexeterion* Vaillant, 1888, comprises five species of which *B. bruuni* is described here. A number of 42 specimens of *B. bicolor* Goode & Bean, 1886 was examined which made it possible to form an idea of the intraspecific variation, the reproduction, bathymetrical distribution, etc. Two specimens were cleared and stained for osteological examination. *B. bicolor* occurs in the West Indian area, *B. parfaiti* (Vaillant, 1888) near the Azores, and *B. affinis* Brauer, 1906, *B. diaphanus* Brauer, 1906 and *B. bruuni* all in the Indian Ocean.

Meteoria erythrops n. gen. et sp. is based on two specimens caught near the Azores.

Sciadonus with the type species *S. pedicellaris* Garman, 1899 was captured in the Gulf of Panama. The central Atlantic species *S. kullenbergi* Nybelin, 1957 is considered a synonym of the type species.

Leucochlamys consists of three species, *L. cryptophthalmus* Zugmayer, 1911 and *L. jonassoni* Nybelin, 1957 from the Atlantic Ocean and *L. galatheae* n. sp. from the western part of the Pacific.

Some authors regard the Aphyonidae as an artificial family and they consider all the characters which unite the aphyonid genera as neotenic, thus the affinity of these genera would be due to convergence. However, the presence of some non-neotenic characters typical of the Aphyonidae seem to justify the maintenance of this family.

Compared to the other ophidioid families the Aphyonidae are characterized by having poorly developed eyes, a more or less loose skin, a large number of precaudal vertebrae, and long arches and spines on the anteriormost vertebrae. Scales, swimbladder and pyloric caeca are not developed. All aphyonid species are viviparous and most often both sexes are provided with a copulatory apparatus, which varies from one genus to another, and sometimes even within a genus.

Most aphyonids show a neoteny in many characters, such as transparent, scaleless skin, adult specimens with rectangular shaped vertebral centra, viewed laterally, ripe gonads in small specimens, and pedicellate pectoral peduncle. Such neotenic characters are often found in pelagic deep-occurring fishes, probably as an adaptation to the food-poor deep sea environment. The genus *Barathronus* (and partly also *Aphyonus)* does not show as many neotenic characters which agrees with the fact that this genus probably lives on the bottom at bathyal depths, while the remaining genera occur deep-pelagically.

Gross examination was made of the gonads of all specimens and besides, a histological examination (8 μ and 10 μ sections) was undertaken of most species. It appeared that ripe males of all species produce spermatophores, i. e., the spermatozoa are encapsuled in a thin sack. This strongly indicates interior fertilization. This is further supported by the fact that sections of three ripe females, representing two species, showed the presence of spermatozoa in the ovaries. In one of the species partly emptied spermatophores were observed. The biological significance of the spermatophores may be that unripe females, of these apparently rare species, are able to store live spermatozoa until the eggs are ready for fertilization. The life span of spermatozoa is much prolonged if they are kept immobile, e. g., in a capsule. The possible storing of spermatozoa may also insure that the spermatozoa from one copulation can fertilize more than one clutch of eggs, especially in species in which more than one clutch ripens annually. Counts and measurements of the eggs from the ovaries revealed the size of the clutch and the number of clutches developing at a time. *Barathronus bicolor,* the only common aphyonid species, showed that there is no fixed mating season.

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PLATES

PLATE I

(The scale indicates 5 mm).

Fig. 1. Ventral view of testes and excretory duct of *Barathronus bicolor,* SL 110 mm. UMML 7800.

Fig. 2. Ventral view of ovaries, excretory duct and urinary bladder of *B. bicolor,* SL 97 mm. UMML 24227.

Fig. 3. Caudal part of an alizarin stained *B. bicolor,* SL 110 mm. UMML 7800.

Fig. 4. Ventro-lateral view of anterior part of an alizarin stained *B. bicolor,* SL 110 mm. UMML 7800.