ON THE GENERA *ACANTHONUS* AND *TYPHLONUS* (PISCES, BROTULIDAE)

By JØRGEN G. NIELSEN
Zoological Museum, Copenhagen

These two genera were described by A. GÜNTHER in 1878 on the basis of specimens caught by the "Challenger" Expedition in the Indo-Australian area. Very few specimens are known of either genus, viz. *Acanthonus* with 11 specimens of which 7 were never described, and *Typhlonus* with 7 specimens of which only 2 have been described. These genera are quite different from the typical brotulids, the former in having large, strong spines on the gill-cover and on the snout, and the latter, among other features, in having a swollen head provided with large muciferous cavities in the dermal bones, a ventrally placed mouth, and very small eyes hidden under the skin, at least in the larger specimens.

The fact that the present genera are treated together does not imply that they are especially closely related, even if they have in common some characters not often found among other brotulids. For example, the remarkable prolongation of the frontals, the unusually large otoliths, the enlargement of parts of the kidneys, and the position of the thymus externally in the gill-cavity. In other characters, such as the position of the mouth and the ventral fins and the size of the eyes, the two genera do not agree.

GÜNTHER paid only little attention to the meristic and morphometric characters, but with additional material it is now possible to form an idea of the variation of these characters. In addition some remarks have been made on the biology and distribution of these genera, based among other things upon stomach contents.

When nothing else is mentioned, the measurements are taken in accordance to HUBBS and LAGLER (1958).

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Acanthonus Günther, 1878

The genus *Acanthonus* (with the type species *armatus* Günther, 1878) was described on the basis of a specimen caught by the "Challenger" north of New Guinea at St. No. 218. Another specimen was caught at St. No. 205, but only the former was used in the original description. Due to the exellent descriptions given by GÜNTHER in 1878 and 1887 only a few characters will be added in the present paper: Number of vertebrae 60-65; 16-22 long rakers on the anterior gill arch.-However, there is a disagreement between the preliminary description of 1878 and that published in the Challenger Report in 1887 as GÜNTHER wrote in the former "ventrals reduced to simple filaments" and in the latter "ventrals each reduced to a bifid filament". An examination of the holotype showed that the ventrals are bifid.

According to COHEN (1961) and ALCOCK (1890), there are some similarities between *Tauredophidium* Alcock, 1890, *Xyelacyba* Cohen, 1961, and the present genus.

Besides the type species, the type of which is kept in the British Museum, only one additional species has been described, *A. spinifer* Garman, 1899. However, as discussed below, the latter most certainly is identical to *A. armatus*.

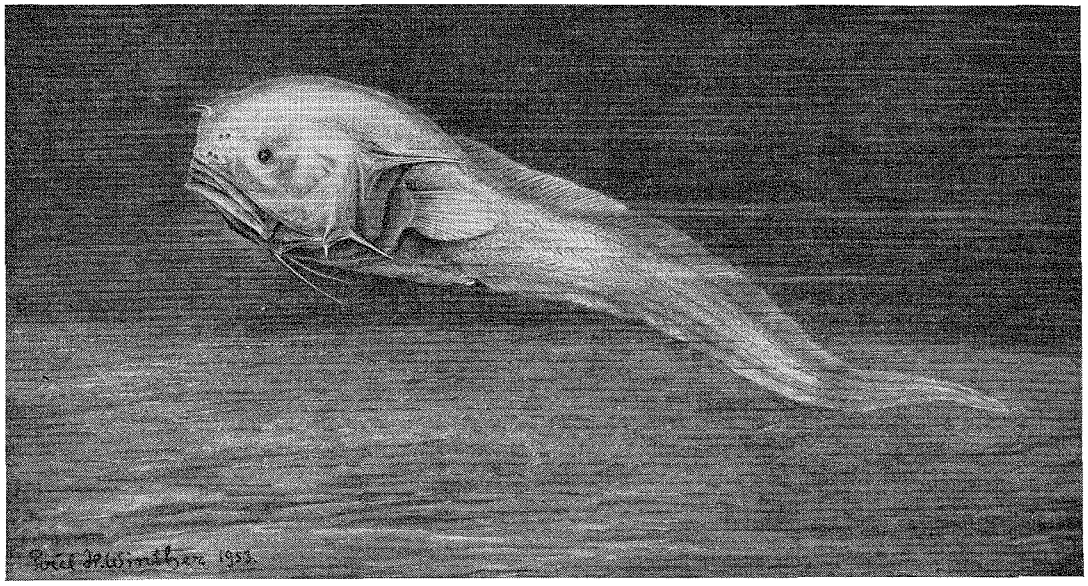

Fig. 1. *Acanthonus armatus*. "Galathea" St. 52, std. l. 220 mm. (POUL H. WINTHER del.).

Acanthonus armatus Günther, 1878
(Plate XI and plate XIII Figs. 1 and 3)

Acanthonus spinifer Garman, 1899.

The following list includes all the specimens of *A. armatus* (s. lat.) known to the author:

1. Holotype of *armatus*. "Challenger"; St. 218 (2° 33′S, 144°4′E); 1957 m; blue mud; bottom temp. 2,5°C. 1-3-1875. Brit. Mus., London.
2. 1 specimen. "Challenger"; St. 205 (16°42′N, 119°22′E); 1920 m; blue mud; bottom temp. 2,8°C. 13-11-1874. Brit. Mus., London.
3. 1 specimen. "Investigator"; St. 316 (5°43′30″N, 80°5′30″E); 2743 m; green mud; bottom temp. 1,7°C. 17-4-1902. Zool. Survey of India, Calcutta.
4. 1 specimen. "Michael Sars"; St. 35 (27°27′N, 14°52′W); 2603 m; yellow mud; 18-5-1910. Zool. Mus., Bergen.
5. 1 specimen. "Galathea"; St. 52 (1°42′N, 7°51′E); 2550 m; muddy clay; bottom temp. (3,0°C). 30-11-1950. Zool. Mus., Copenhagen.
6. 1 specimen. "Galathea"; St. 726 (5°49′N, 78° 52′W); 3270-3670 m; clay; bottom temp. (2,0° C). 11-5-1952. Zool. Mus., Copenhagen.
7. 4 specimens. "Oregon"; St. 2567 (25°21′N, 91° 02′W); 3155-3200 m; 25-7-1959. U.S. Nat. Mus., Washington.
8. Holotype of *A. spinifer*. "Albatross"; St. 3381 (4°56′N, 80°52′30″W); 3240 m; green mud; bottom temp. 2,1°C. Mus. of Comp. Zool., Harvard.

During a visit to the British Museum I examined the holotype of *A. armatus*. The "Investigator" specimen, an illustration of which was published by ALCOCK and MACGILCHRIST (1905), was never described. Dr. MENON, Zool. Survey of India, Calcutta, sent information about the station, where the specimen was caught, but told me that the specimen was in a condition that did not allow to send it. Consequently, no characters of this specimen are available. By the kindness of various people the rest of the not-Danish material was borrowed for examination.

Comparison between *A. armatus* and *A. spinifer:*

In his description of *A. spinifer* GARMAN (1899 p. 171) stated that "the shape is similar to that of *A. armatus,* but differences appear in the following characters":

1. The number of branchiostegal rays.
2. The ventral fins.
3. Presence or absence of scales.
4. Presence or absence of lateral line.

GARMAN mentioned these four characters without further comments as to how they varied in the two species. A discussion of the four points follows below.

1. According to the original descriptions the number of branchiostegal rays is 9 in the holotype of *armatus* and 8 in *spinifer*. However, as shown in

Table 1 the number of rays varies from 8-9, being most often 8. After an examination of the holotype of *spinifer* it seems rather uncertain whether there are 8 or 9 rays, as the specimen is small and very fragile.

2. If GARMAN compared his specimen to GÜNTHER's description from 1878, he was correct when announcing a difference in the ventral fins between the two species, but a comparison with GÜNTHER (1887) would not have shown any disagreement. (See page 33). GARMAN characterized the ventrals as follows: "Ventral bases below the eye, fins each with two slender filamentary rays, the longer of which reaches quite to the vent". A re-examination of *spinifer* showed that both ventral fins are broken, and that the filaments in the remaining part are coalesced. In all the examined specimens of *armatus* (s. str.) each fin has the two filaments free in their distal halves.

3. GÜNTHER (1878) wrote: "Scales extremely small", and GARMAN: ""Existence of scales a matter of some doubt". Scales were found in the present material on the larger "Galathea" specimen, on the two specimens from the "Challenger", on the larger "Oregon" specimen, and on that from the "Michael Sars". The small, thin, cycloid scales occur both on the head and on the body. No scales were found on the five smaller specimens, but empty scale pockets indicate that scales have been present. The holotype of *spinifer* shows the existence of a few scales situated at rather long intervals in a row along the median line. The reason why only these scales remain might be that they lie in a median groove in which they were not rubbed off in the trawl.

4. In his 1878 description GÜNTHER did not mention the lateral line, while in 1887 he wrote: "The lateral line is represented by a series of small, distant pores, running along the proximal end of the interneural spines". GARMAN stated that "the lateral line is not apparent". The small black or brownish lateral line pores are easily seen on the specimens in Table 1, columns 1-4 and 6, while none was found on the remaining specimens, including the type of *spinifer*, which all are smaller than the 5 specimens mentioned above.

This discussion shows that none of the four points justifies a segregation of *Acanthonus armatus* and *A. spinifer*. According to the rule of priority, *spinifer* should be regarded as a junior synonym of *armatus*.

Explanation to Table 1 (p. 36):

1. Std. l. (= standard length) is measured from the distal tip of the snout-spines to the base of the caudal fin. In the larger "Oregon" specimen a few mm's are broken off the snout-spines. Concerning the holotype of *spinifer* see the text below.
2. The vertebral count does not include the urcstyle.
3. Measurements to the anus are made to the "anal area".
4. Measured from the upper jaw symphysis to the caudal base.

Table 1 shows close agreement among the meristic characters of the two species, but quite a few differences are found in the morphometric characters. However, it should be borne in mind that the std. l. of *spinifer* is only 71 mm, while *armatus* varies from 93-335 mm. GARMAN (1899) gave the total length of *spinifer* as "hardly more than three inches", and M. GREY (1956 p. 219) indicated "length about 76 mm". The main cause why the std. l. is only 71 mm in its present state is that the two snout-spines have been broken off.

In the last two columns of Table 1 the morphometric characters of *spinifer* and the smallest "Oregon" specimen are compared. In these columns the lengths are measured from the upper jaw symphysis to the base of the caudal fin, enabling a more fair comparison. However, a few divergences still exist, but it can be added here that the specimen of *spinifer* is in a condition that does not allow as precise measurements as can be obtained from the collection of *armatus* (s. str.).

The rather poor drawing accompanying GARMAN's description shows a row of white dots in the median line. According to the description, it can neither be scales nor a lateral line. The only explanation must be that they illustrate the vertebrae, which (in the present state of the specimen) are clearly indicated exteriorly along the sides of the body, except for the anterior part.

When comparing the two original drawings of the holotypes there is apparently a disagreement in the length of the upper preopercular spine, which is very short in *spinifer*. However, the examination of the holotype showed that the said spine is almost of the same relative length as that of *armatus*, (see also "snout – larger preopercular spine" in Table 1).

A re-examination of the specimen caught by the "Michael Sars" has been made, as KOEFOED (1927) only gave a very short description.

Table 1. Comparison of all examined specimens of *A. armatus* (s. lat.).

	Acanthonus armatus									*Acanthonus spinifer*	*A. spinifer*	*A. armatus*
	"Challenger"		"Michael Sars"	"Galathea"		"Oregon" st. 2567				"Albatross"		
	Holotype	♂	♂	St. 52 ♂	St. 726	♀				Holotype	Holotype	"Oregon"
Meristic characters												
Std. 1.[1]	285	313	335	220	135	242	145	113	93	71	70[4]	91[4]
Dorsal fin	100	101	106	108	101	107	103	103	101	101		
Caudal fin	8	8	8	8	8	8	8	8	8	8		
Anal fin	95	93	98	97	94	97	94	96	99	92		
Ventral fin (s-d)	2–2	2–2	2–2	2–2	2–	2–2	2–2	2–2	2–2	2		
Pectoral fin (s-d)	16–16	17–16	17–17	–16	18–18	16–16	17–17	18–18	19–19	16–16		
Branchiostegal rays (s-d)	–9	9–8	–8	8–8	8–9	8–8	8–8	8–8	8–8	–8		
Gill rakers on anterior arch s	4+18+5	4+18+5	4+18+5	4+18+5	4+17+4	4+18+5	4+22+3	4+18+3	4+17+4	5+19+4		
Gill rakers on anterior arch d	4+16+5	4+20+5	5+19+4	4+20+4	4+17+3	4+19+4	5+20+4	5+20+3	4+17+4	4+19+4		
Vertebrae[2]	62(9+53)	62(10+52)	65(10+55)	62(9+53)	61(10+51)	61(9+52)	61(9+52)	60(9+51)	62(9+53)	61(9+52)		
Morphometric characters in % of std. 1.												
Head (excl. opercular spine)	30.0	26.0	26.5	27.0	28.0	26.0	25.5	27.0	26.5	24.0	23.5	24.0
Snout	–	9.1	10.0	10.0	–	9.2	9.4	9.9	–	–	–	–
Snout-opercular spine	32.0	31.5	31.0	33.5	32.5	30.0	31.5	32.5	30.5	29.5	32.0	30.0
Upper jaw	15.0	14.0	14.5	14.5	14.0	15.5	14.5	15.5	13.0	14.5	14.5	13.5
Lower jaw	–	16.0	14.5	15.5	15.5	15.0	16.0	16.5	14.5	15.0	15.5	15.0
Horizontal dia. of pigmented eye	2.4	2.6	2.4	2.1	2.2	2.5	2.4	2.2	2.2	2.9	2.9	2.2
Snout-anus[3]	35.0	32.5	33.5	34.5	33.5	32.0	29.0	31.0	28.5	28.5	29.0	26.0
Predorsal	32.0	32.5	32.0	30.0	32.5	29.5	29.0	30.5	29.0	25.5	27.0	27.5
Preanal	37.5	36.5	36.0	37.5	36.5	35.0	34.0	34.5	31.5	32.5	30.5	29.0
Snout-larger preopercular spine	29.5	28.5	28.5	30.5	29.5	–	29.5	30.0	28.5	24.0	23.0	25.0
Base of V-anus	18.0	17.5	19.0	18.0	18.0	17.5	15.5	18.0	15.5	19.0	19.5	16.0
Base of D	69	68	72	71	71	73	74	73	76	76	77	77
Base of A	63	66	66	66	67	65	68	66	68	66	67	70

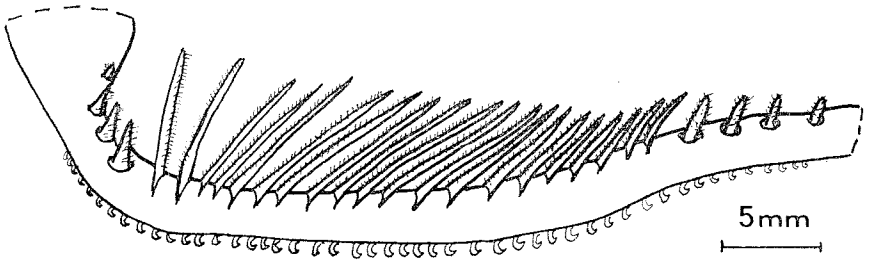

Fig. 2. Dextral, anterior gill arch of *A. armatus*. "Galathea" St. 52, std. 1. 220 mm.

Variation in A. armatus (s. lat.)

Only a few specimens of the present material have previously been described in the literature, and little information has been given on the meristic and morphometric characters. The variation can be read from Table 1, which includes all the material seen by the author. Considering the worldwide distribution of this species (Fig. 5) it is astonishing to note so little variation.

Meristic characters: The numbers of vertebrae, dorsal, and anal fin-rays are counted from radiographs, the best method for counting the small anterior dorsal rays hidden below the soft skin. It is difficult to count the most anterior of the precaudal vertebrae, but the number seems to vary between 9 and 10. The branchiostegal rays are also often difficult to count; (the numbers given for the holotypes derive from the original descriptions). The gill rakers (Fig. 2) on the anterior arch are 4-5 on the upper branch, all being short and rather stout. The lower branch has 16-22 long rakers; the most ventrally placed 3-5 rakers are almost the same shape as those on the upper branch. Interestingly enough, only three of the 10 specimens from Table 1 had the same number of rakers on the right and left anterior gill arches. The greatest divergence was 2 rakers.

Morphometric characters: If the morphometric characters used are related to the standard lengths, there is no indication of allometric growth, except in the two smallest specimens (columns 9 and 10). In these, most characters are found either above or below the rest of the specimens. The four specimens from the Gulf of Mexico taken by the "Oregon" do differ slightly in a few characters from the rest of the *armatus* specimens, viz. in the length of "Snout – anus", "Predorsal", "Preanal", and "Base of dorsal fin". However, the differences are so small that there is no reason at all for considering them as being of taxonomic significance. None of the remaining characters shows a variation which can be correllated with the distribution.

Description:
This species is easily distinguishable, having the head several times thicker than the body and a long tapering tail and long, stiff spines on the operculum, pre-operculum, and on the snout. The snout-spines are prolongations of the frontals. The thick, transparent skin is loosely attached to the body. – The eyes are placed deeply in the head over the middle of the upper jaw. – Small, cycloid scales or scale-pockets are found in all the four larger specimens, both on head and body. – The rakers on the anterior gill arches are very stiff and spiny. (See Text-fig. 2 and Plate XI, Fig. 6). The gill laminae are very short.

Vertebrae and ribs: The length of the first neural spine is half the length of the second spine. The third spine is the longest, and the length decreases again to the 8. spine. The next few spines increase in length before they gradually become shorter, approaching the tip of the tail. All neural spines are pointed. The three anterior neural spines are placed in front of the dorsal fin. The parapophyses are very poorly developed or absent on vertebrae 1-4, while the rest of the precaudal vertebrae have well -developed parapophyses. No ribs are attached to vertebrae 1-2. Vertebrae 3-4 with the pleural ribs apparently directly attached to the centra. Vertebrae 5-8 with the pleural ribs connected to the parapophyses. No ribs on vertebra 9. Epipleural ribs not developed, judging from radiographs of the present material (see Pl. XI, Fig. 2).

Dentition: All the teeth on the dentigerous bones (Fig. 3) are rather small, but they are numerous, strong, conical, and more or less recurved. They are placed in very irregular rows or at random. The premaxillaries are flat and very broad in the middle with room for about 10 tooth rows. The vomer is arched in section with approx. 10 tooth rows. The palatines are of the same shape in section as the

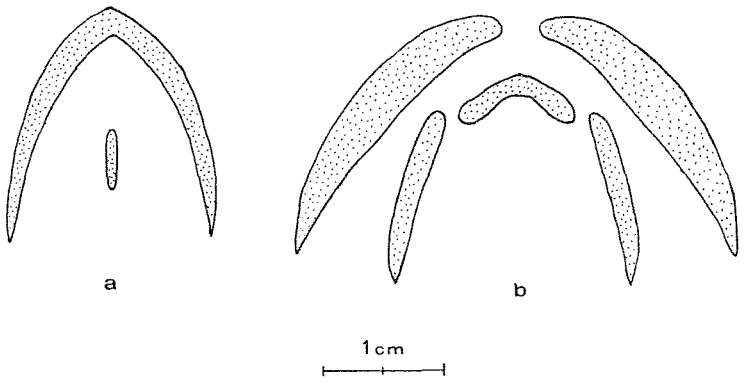

Fig. 3. Dentition of *A. armatus*. "Galathea" St. 52, std. 1. 220 mm. a. Dentary and basibranchials. b. Premaxillaries, vomer, and palatines.

vomer, except most posteriorly, where they are flat. The dentaries are similar to the palatines in section and dentition. – The basibranchials form one small tooth-bearing plate. – The pattern of the upper pharyngeal tooth-plates is shown in Fig. 4. The lower pharyngeals form a continuous plate ending anterior to the foremost of the upper pharyngeals.

Otolith: All the radiographs of the present material show very clearly the otoliths, placed just anterior to the base of the opercular spine. In one of the specimens the otoliths were placed halfway between the base of the opercular spine and the snout spine close to the dorsal edge of the head. This unusual position of the otoliths can not be explained by the specimen being damaged as this was not the case.

One of the otoliths was removed from the small "Galathea" specimen (std. 1. 135 mm). It had an irregular oval shape (approx. 5 × 3 mm). An attempt to determine the age of the specimen on the basis of this otolith was unsuccessful. Exteriorly was a shell of lime composed of 3-4 layers. When this frail shell broke, the inner part of the otolith appeared to consist of a suspension of lime with no structure at all. The explanation most probably is that this specimen was kept in formaldehyde for several years before being transferred to alcohol. An otolith was also removed from the "Oregon" specimen, standard length 242 mm (see Pl. XIII, Fig. 1), but no structure at all could be seen.

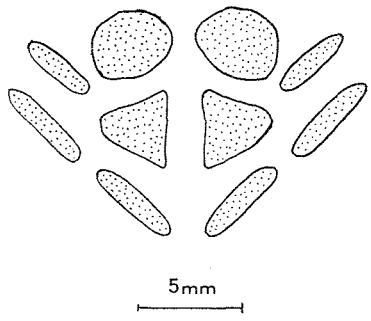

Fig. 4. Upper pharyngeal teeth of *A. armatus*. "Galathea" St. 52, std. 1. 220 mm. The anterior plates below.

Thymus: Plate XIII, Fig. 3 shows the presence of a small "body" placed dorsally on the inner wall of the gill cavity. All the *A. armatus* specimens examined had a similar yellow, circular body varying from 1-4,5 mm in diameter in each cavity. Staining and sectioning one of these showed it to be the thymus, with characteristic lymphoid tissue.

Very little has been written about the thymus in the modern teleost-groups. Normally, the thymus is formed as a long, narrow, yellowish gland, placed longitudinally and dorsally close to the branchial cavity. In some cases it is clearly seen, when opening the gill-cover, while in other cases the epithelium has to be removed before the thymus is visible.

GRASSÉ (1958 p. 2636) writes that an involution of the thymus takes place when the fish becomes sexually mature. HAMMAR (1909) gives examples on the form and structure of the thymus from several fish-groups, and for some species the involution is correlated with the length and body-weight. He found that in larger individuals of different species the thymus had completely vanished. Apparently, no such involution has taken place in *A. armatus*, as the smaller specimens (std. 1.'s 71-145 mm) have a thymus-diameter of 1-1,8 mm, and the bigger specimens (std. 1's 220-335 mm) a diameter, varying from 2-4,5 mm. Furthermore, none of the present specimens has an oblong-shaped thymus like those described from teleosts by HAMMAR (1909), but all are of the same irregular circular form. According to the literature cited, the explanation might be that all the present specimens are sexually mature, and, consequently, the involution is far ad-

vanced. However, in the "Oregon" material the gonads of the smaller individuals are hardly developed, which indicates that the specimens are immature. The small size of the gonads is not due to the fact that the fish is not in the spawning season, at least judging from the larger "Oregon" specimen, in which the gonads were filled with well-developed eggs (0,5-1 mm in diameter). The same condition is found in *Typhlonus nasus* (see p. 45).

Viscerae: The inside of the stomach is provided with 7 longitudinal ridges. The stomach-wall is very thick, while the diameter (in its present state) is like that in the pyloric part of the intestine. The larger "Oregon" specimen has a 5 cm long intestine the anterior part of which is yellowish with numerous long villi, apparently not arranged in rows. The posterior 2.5 cm is transparent and devoid of villi. In another "Oregon" specimen (std. l. 113 mm) a portion in the middle of the intestine is transparent and with very few villi, while the rest is yellow and provided with villi. In the "Michael Sars" specimen the intestine is yellow and with villi in its entire length. In the larger "Galathea" specimen the arrangement of the yellow and transparent parts of the intestine is still different. – No pyloric coecae present. – The swimbladder is very thin-walled and of an irregular shape. No trace was seen of rete or of muscles connected with the swimbladder. – The liver is small and yellow-brown, about the size of the stomach. – The enlarged kidney is yellowish with very fine brown spots. In the larger "Oregon" specimen it is spindle-shaped, 1 cm long and approx. $\frac{1}{2}$ cm thick.

GONADS: The abdominal cavity was opened in 7 specimens. Only one of these was definitely a female, the larger "Oregon" specimen which contained eggs with a diameter of 0,5-1 mm. The posterior parts of the ovaries were coalesced. Sections were made of the gonads from the larger "Galathea" specimen, which proved to be a male. According to GÜNTHER (1887), the specimen, on the basis of which his description was made, was a male. However, as the holotype has never been opened, GÜNTHER's sex-determination must refer to the other "Challenger" specimen. (In the description GÜNTHER also mentioned two gland-like masses attached to the liver and the intestine, probably the remains of perished parasitic worms. During the present examination these "remains" were found in the specimen from "Challenger" St. 205, which indicates that GÜNTHER actually did not describe the inner organs from the holotype). Also the "Michael Sars" specimen is a male with well-developed, separate testes. The gonads in the smaller "Galathea" specimen and in the two smaller "Oregon" specimens were poorly developed.

Colouration: It is rather difficult to give a colour description of the present material since there are some differences in the colouration of e.g. the "Galathea" and the "Oregon" specimens. This is most probably due to the fact that the former have been preserved for 13-15 years, and the latter for 6 years only. The "Oregon" material, shortly described, has the following colouration: The two larger specimens are black or dark-brown on the ventral surface of the head, the operculum, and on the peritoneum, which is visible through the transparent skin. The branchial cavity, and the top and lower sides of the head are bluish. The area between the opercular spine and the eye is light-brown coloured by the underlying muscles. The iris is olive-green. The tail is yellowish like the tissue below. The area around the anus is black-brown. In the two smaller "Oregon" specimens all colours are somewhat darker than described above. The "Galathea" specimens again, are paler than the larger "Oregon" specimens. Pl. XI, Fig. 1, shows a photograph of the larger "Galathea" specimen taken immediately after capture.

Stomach contents

The alimentary canal was opened and the contents examined in six specimens, viz. three "Oregon" specimens (std. l. 242, 113, and 93 mm), the two "Galathea" specimens, and the one from the "Michael Sars". Generally, it can be said that surprisingly small amounts of food were found, as the volume did not exceed $\frac{1}{2}$ cm^3 in any of the specimens. None had food in the stomach itself.

Five specimens contained fragments and a few almost intact crustaceans. These were referred by W. VERVOORT and T. WOLFF to the following groups: Copepoda (9 spms. 2,5-4 mm long) i.a. including the species *Benthomisophria cornuta* Hulsemann and Grice, 1964 (2 spms.) found in an "Oregon" stomach (this species lives pelagically, but close to the bottom); remnants of Ostracoda; Amphipoda (1 spm. 8 mm long). However, it was more surprising to find that large bundles of "hairs" were very numerous in all the specimens examined except the small "Galathea" specimen from St. 726. J. B. KIR-

KEGAARD found these "hairs" to be very similar to the dorsal filt of the polychaetes of the genus *Aphrodite* which is known from the bottom of almost all oceans down to a depth of about 2600 m. The *Acanthonus* which contained this dorsal filt were caught in the Gulf of Mexico, in the Gulf of Guinea, and off North West Africa at depths from 2550-3200 m.

Finally, the large "Oregon" specimen contained parts of a fish, viz. headbones and a few vertebrae (Pl. XI, Fig. 5). Judging from the form and dentition of the lower jaw and the premaxillaries and from the spiny opercular bones there is no doubt that these fish-remains belong to a specimen of the genus *Acanthonus* and most probably also to the present species. The length of the lower jaw is 6 mm, which indicates that the length of the specimen itself was approx. 5 cm. (In the approx. 7,5 cm long "Albatross" specimen the lower jaw is 9 mm).

Distribution

Geographical distribution: Fig. 5 shows that *A. armatus* has a circumtropical distribution. All specimens were caught close to larger land-masses which might be due to the fact that normally more food is available here than at similar depths further out in the oceans.

Very few larvae have been caught of brotulid fishes. By far the greatest number was taken during the "Dana" expeditions in 1920-22 and 1928-30 in the tropical and subtropical areas. These larvae were captured at depths, varying from the surface to about 2000 m, but the most common depths were 100-300 m. This means that larvae were primarily taken in the "Warmwassersphäre" (WÜST 1950) or the "thermosphere" (BRUUN 1957), viz. in waters with temperatures above 10°C. If these relatively high temperatures are necessary for the development of the larvae this might explain why so many brotulids are found only in the tropical and subtropical areas, and so few in the temperate, arctic, and antarctic areas, although the same temperatures are normally prevailing in these areas at depths below approx. 2000 m. If the larvae are unable to survive in the upper layers in the latter areas, because of low temperatures, this is sufficient to restrict most of the brotulids to the tropical and subtropical areas. The "Dana" has also been fishing between Greenland and Ireland with the same kind of gear as used when catching the larval brotulids mentioned above. Many fish-larvae were caught, but no brotulid larvae. The only brotulid known from Greenland is *Bythites fuscus* Reinhardt, 1837, of which a single specimen was taken "in very deep water" at the position 63°N, 52°W. However, judging from the well-developed intromittent organ this species is viviparous, which might mean that the

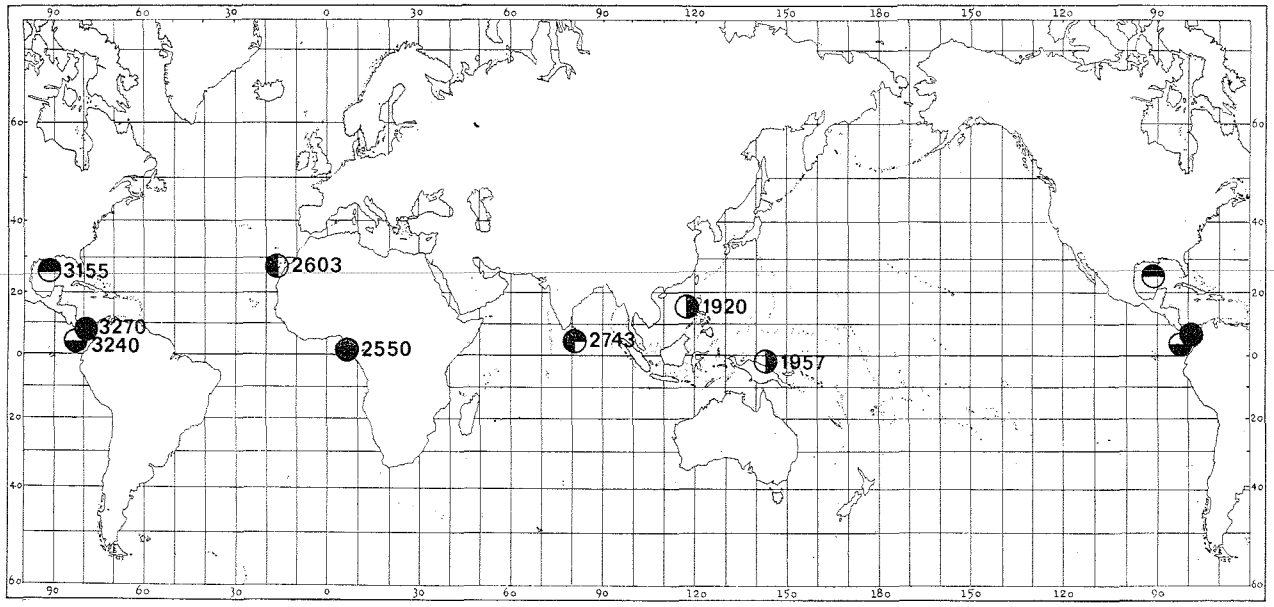

Fig. 5. Distribution of *A. armatus*. The numbers indicate the depth in metres.

newly hatched specimens never rise to the surface layers. Another explanation could be that *B. fuscus* normally occurs further south, but was accidentally brought to Greenland by the currents.

Bathymetrical distribution: The numbers in Fig. 5 indicate the depths in metres at which the material was caught. Some additional information is necessary: The depth at the "Galathea" St. 726 in the Gulf of Panama was 3270-3670 m and that at the "Oregon" St. 2567 in the Gulf of Mexico was 3155-3200 m. Consequently, the depth range for *A. armatus* is 1957-3270 m, possibly down to 3670 m, provided however that the specimens were caught at the bottom. Since none were taken by opening and closing gear it cannot be said with certainty whether the specimens occurred pelagically or benthically. However, judging from the other fishes caught in the particular hauls there is no doubt that the nets have fished on the bottom. The fact that *A. armatus* has never been caught in any of the numerous bathy- and abyssopelagic hauls made in all oceans, also supports the view that this species is benthic, although this view is based on negative evidence. However, an examination of the stomach contents (see above) revealed several bundles of dorsal filt from the benthic polychaete *Aphrodite*.

Biology

From the present information it can be concluded that *A. armatus* is found at abyssal depths, (benthopelagically, MARSHALL and BOURNE 1964), on and over a bottom consisting of mud (blue, green, and yellow) and clay and with temperatures varying from 1,3°-3,0°C. (No temperature-measurements were taken at "Galathea" Sts. 53 and 726, but an estimated temperature has been obtained by interpolation from the temperatures of the neighbouring stations). According to BRUUN (1956) the abyssal zone may be divided into an upper and a lower subzone of which *A. armatus* belongs to the former.

Judging from the rarity of this species it apparently occurs in rather sparse populations, but the capture of four specimens (plus remains of a small specimen probably of the same species in the intestine of one of the larger individuals) may indicate that it is found in schools, which is of benefit to the reproduction of the species.

The strong dentition and the well-developed pharyngeal teeth indicate that this species might be able to feed on large prey. As mentioned above, an examination of the stomach and intestine of some of the specimens only showed few remains: fish, crustaceans, and polychaetes. The long, thin rays of the ventral fins make the species fitted for a bottom-dwelling existence. The swimbladder is apparently unfit as a soundproducing organ, but perhaps the pharyngeal teeth can produce sound by stridulation. With the big head and narrow, tapering body *A. armatus* does not seem to be a good swimmer. – The number of eggs and lack of an intromittent organ indicate that this species is oviparous.

Otoliths from two specimens have been examined in the hope of finding annual rings, but without result, apparently due to a too long stay in formaldehyde. Also, it is a question whether an otolith, even from a newly caught specimen, would show annual rings, as the surroundings (temperature, food supply, etc.) do not vary much during a year-span. Many species which f.inst. occur both in the Mediterranean and in Danish waters, show fine annual rings in specimens from the northern area, but there are no trace of rings in specimens from the Mediterranean. The most plausible explanation is found in the more uniform conditions in the latter area.

Typhlonus Günther, 1878

The present genus was described by GÜNTHER from two specimens caught by the "Challenger" at stations 181 and 198 in the Indo-Australian area. GÜNTHER (1878 and 1887) gave a very fine description, and therefore only a few characters will be added here: Number of vertebrae 57-60; 10-13 long rakers on the anterior gill arch; 7-9 short rakers on the fifth gill arch. GÜNTHER did not mention any meristic characters, but the external morphology of *Typhlonus,* with head-protuberences and muciferous cavities, is sufficient to characterize the genus.

The present material differs in a few characters from GÜNTHER's description: 1) In 1887 he wrote: "Eye not visible externally ... hidden below the skin". As shown on Pl. XII, Fig. 5, this is not the case for the smaller specimen (P77444). 2) "The superficial bones ... not armed". In all the larger specimens a poorly developed bifurcate spine was found on the operculum hidden under the skin.

The present genus bears only slight resemblance to any other brotulid (see p. 33). In its outer morphology it reminds most of all of the genus *Macrouroides* Smith and Radcliffe, 1913 (family Coryphaenoididae).

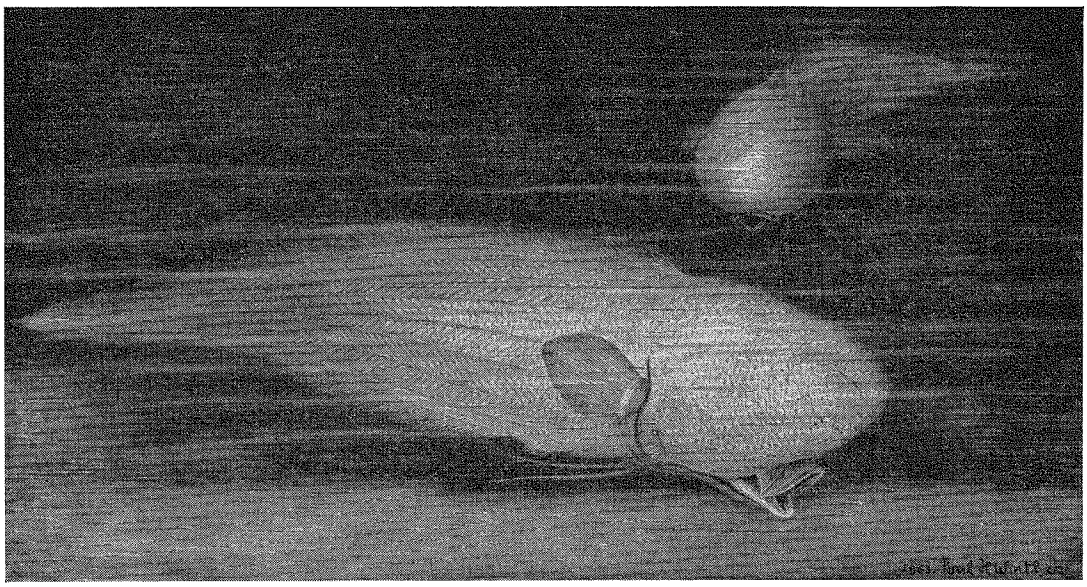

Fig. 6. *Typhlonus nasus*. "Galathea" St. 450. (POUL H. WINTHER del.).

Only the type species of *Typhlonus* has been described. The type of the type species is kept in the British Museum.

Typhlonus nasus Günther, 1878
(Pl. XII and Pl. XIII, Figs. 2 and 4).

Material:

1. Holotype. "Challenger"; St. 181 (13°50′S, 151° 49′E); 4462 m; red clay; bottom temp. 2.1°C. 25-8-1874. British Museum, London.
2. Paratype. "Challenger"; St. 198 (2°55′N, 124° 53′E); 3933 m; volcanic mud; bottom temp. 3.9° C. 20-10-1874. British Museum, London.
3. 5 specimens from the "Galathea"; St. 450 (1°50′ N, 119°20′E); 4940-4970 m; clay; bottom temp. (3.85°C). 21-8-1951. Zool. Museum, Copenhagen.

All specimens known of *T. nasus* have been included here. The holotype was examined by the present author at the British Museum, while the paratype was examined in Copenhagen.

Explanation of Table 2:

1. Each of the seven columns is divided into two with different headings, viz. "Snout" and "Symph." (= symphysis). This signifies that the measurements in question were made either with the snout-protuberence or with the upper jaw symphysis as the most anterior point.
2. The amount of gill rakers on the anterior arch is indicated by the three numbers, of which the first gives the short rakers on the dorsal branch, and the second and third the long and short rakers on the ventral branch respectively.
3. The numbers indicate the precaudal and caudal vertebrae (the urostyle is excluded).
4. The length of the head is measured to the posterior edge of the bony operculum.

Variation

Except for the small specimen P 77444 and for P 77447 very little variation is found in the *T. nasus* material.

Meristic characters: All counts of the rays in the unpaired fins and of the number of vertebrae are based on radiographs. Except for P 77447, with a rather low number of fin rays, there is a very fine agreement in the number of rays in the dorsal and anal fins. Also the lowest number of vertebrae is found in P 77447. Judging from a radiograph the tail of P 77447 has not been broken, which might have explained the above disagreements. As in *A. armatus* (p. 37) the number of gill rakers on the anterior arch also varies in this species between the right and the left side. Only one out of six specimens had an equal number on both sides. In P 77448 three more rakers are found on the left than on the right side (see Fig. 7). The paratype and the five "Galathea" specimens all have gill rakers on the fifth arch. (This character was not examined in the holotype). These rakers look exactly like the short rakers on the anterior arch. P 77444 had 8 rakers on

Table 2. Comparison af all the examined specimens of *T. nasus*.

	Typhlonus nasus													
	"Challenger"				"Galathea"									
	Holotype		Paratype ♀		P 77444		P 77445 ♀		P 77446 ♀		P 77447 ♂		P 77448 ♂	
	Snout[1]	Symph.[1]	Snout	Symph.	Snout	Symph.	Snout	Symph.	Snout	Symph.	Snout	Symph.	Snout	Symph.
Meristic characters														
Std. length	222	210	215	207	73	70	165	152	211	196	250	235	285	265
Dorsal fin	103		102		104		100		103		93		101	
Caudal fin	8		8		8		8		8		8		8	
Anal fin	75		78		75		75		77		71		77	
Ventral fin (s-d)	1/1		1/1		1/1		1/1		1/1		1/1		1/1	
Pectoral fin (s-d)	26–26		25–27		27–28		25–26		24–26		28–27		24–25	
Branchiostegal rays (s-d)	–		7–7		7–7		7–7		7–7		7–7		7–7	
Gill raker on anterior arch[2] s	–		4+12+5		2+12+6		3+12+5		4+13+6		4+12+6		3+13+6	
Gill raker on anterior arch[2] d	–		4+13+6		3+13+5		3+13+5		3+13+5		4+12+6		3+10+6	
Vertebrae[3]	14+46		14+44		13+45		13+45		13+45		14+42		14+44	
Morphometric characters in % of std. l.														
Head[4]	26.5	22.5	26.5	21.5	25.5	20.0	27.5	20.5	27.5	21.0	29.5	23.0	26.5	20.0
Depth at ant. end of D	20.0	21.0	20.0	21.0	17.0	18.0	22.5	24.5	23.5	25.5	24.5	26.0	24.0	25.5
Upper jaw	7.0	7.4	7.9	8.2	7.9	8.1	7.6	8.2	7.1	7.7	8.2	8.7	7.7	8.2
Lower jaw	–	–	8.1	8.4	8.4	8.7	8.2	8.9	8.3	8.9	8.8	9.4	7.7	8.3
Horizontal dia. of pigmented eye	–	–	0.3	0.3	0.7	0.7	0.5	0.5	0.5	0.5	0.4	0.4	–	–
Snout – symphysis of upper jaw	–	–	10.0	10.5	10.5	11.0	12.5	13.5	12.0	13.0	11.0	12.0	11.0	12.0
Snout – anus	35.5	29.5	36.0	30.5	33.0	28.0	36.5	28.5	36.5	31.0	41.0	35.5	36.0	29.5
Preanal	43.5	37.0	41.5	36.0	37.0	34.5	41.0	35.0	41.0	35.0	45.0	40.5	39.5	35.5
Predorsal	24.5	25.0	24.5	25.0	22.0	24.5	25.5	28.5	27.0	30.0	25.0	28.5	26.5	27.0
Base of ventral fin – anus	1.3	1.4	1.3	1.4	1.3	1.4	1.2	1.3	1.1	1.3	1.2	1.2	1.2	1.3
Base of ventral fin – anal fin	2.0	2.1	1.9	1.9	1.8	1.9	1.8	2.0	1.7	1.8	1.7	1.8	1.6	1.7
Ventral rays	16.0	16.5	–	–	18.0	18.5	19.0	20.5	19.5	21.0	21.5	23	25.0	27.0
Base of dorsal fin	77	81	78	81	79	83	78	84	78	84	78	83	79	85
Base of anal fin	62	65	63	65	66	69	59	65	60	64	58	62	63	68

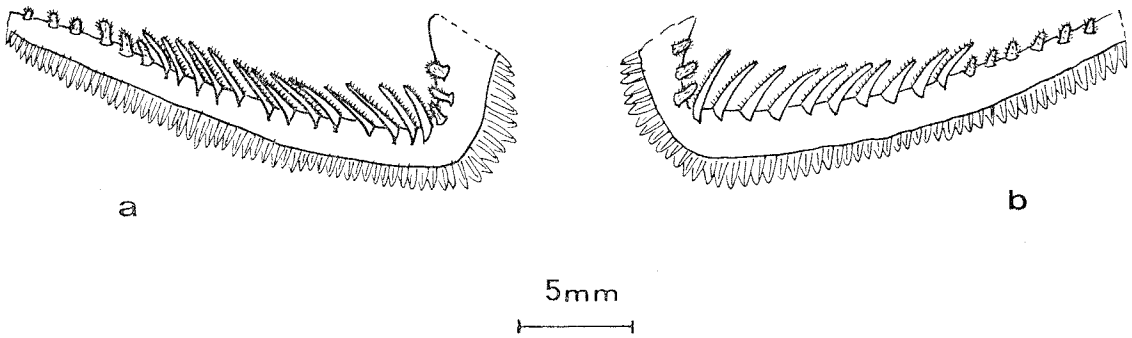

Fig. 7. Anterior gill arches of *T. nasus*. "Galathea" St. 450, std. 1. 285 mm. a. Sinistral arch. b. Dextral arch.

the right and 9 on the left arch, while the other specimens had 7 rakers on both arches.

Morphometric characters: As mentioned above (see the explanation to Table 2), the length of the specimens was measured in two ways. The most accurate method is with the upper jaw symphysis as the anterior point, since the snout protuberence (=the prolongation of the frontals) might be somewhat crushed. Apart from the smallest specimen (P 77444), there is only a slight variation in the standard lengths. When comparing P 77444 with the remaining specimens a difference is found in the following characters: "Depth of body at the anterior end of D", "Preanal", "Predorsal" and "Eye-diameter". This variation most probably is caused by allometric growth, since no differences were found in the meristic characters between P 77444 and five of the larger specimens. Most evident is the decrease in the horizontal eye-diameter with the increase of the standard length. When comparing the six larger specimens, one of these, P 77447, differs from the rest in several characters. This can hardly be explained by allometric growth, because this specimen is not the largest of the material examined. However, the present author hesitates to consider P 77447 taxonomically different from the remaining *T. nasus* specimens, at least until additional material is available.

Description:

From the radiograph (Pl. XII, Fig. 3) it appears that the bones in the head are weakly ossified. A spongy tissue fills the space between the bones. The snout-protuberence is formed by the frontals. The premaxillaries are very protractile and provided with a strong, upward directed process at the anterior tip.

The eyes, placed vertically over the upper jaw symphysis, become relatively smaller with increasing standard length. The eyes of the largest specimen are not visible before removal of the skin.

Most of the scales were rubbed off in the trawl. None is left on P 77444, but the type material and the larger "Galathea" specimens have scales around the base of the pectoral fins, where they are most protected. A few specimens also had some scales left on the head and on the anterior part of the body.

Pl. XIII, Fig. 4 shows two scales, of which the lower (b) has the typical form of a body-scale, being almost rectangular and with the focus placed eccentrically. The upper scale (a) is somewhat modified, rather resembling a lateral line scale, but the scale is not penetrated by a pore, as in a normal lateral line scale, having the bulge closed.

A poorly developed, flexible, bifurcate spine present, but hidden under the skin of the operculum in all the larger specimens.

Vertebrae and ribs: The length of the first neural spine is about two-thirds of the second spine. The following neural spines decrease in length to the 6th spine, from where the length increases again, before it gradually decreases towards the tip of the tail. All the neural spines are very pointed. Two or three spines are placed in front of the anterior dorsal ray. The parapophyses are very poorly developed or absent on vertebrae 1-4, while 5-14 have well-developed parapophyses. No ribs attached to vertebrae 1-2. Vertebrae 3 and 4 apparently with pleural ribs directly attached to the centra. Vertebrae 5-13 with long pleural ribs connected with the parapophyses. The small, thin epipleural ribs connected with the pleural ribs on vertebrae 3-7. No epipleural ribs on the caudal vertebrae. Vertebra 14, the most posterior of the precaudal vertebrae, lacking ribs.

Dentition: Figs. 8 and 9 show the dentigerous bones in the mouth and the upper pharyngeal teeth

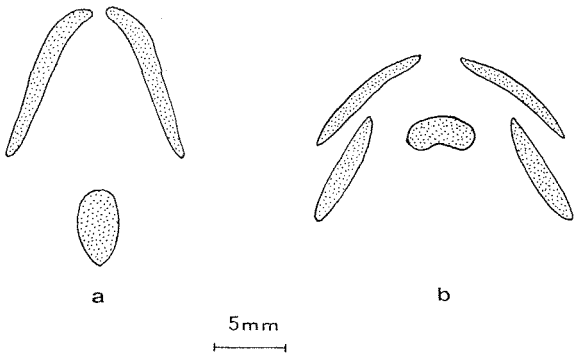

Fig. 8. Dentition of *T. nasus*. "Galathea" St. 450, std. 1. 285 mm. a. Dentary and basibranchials. b. Premaxillaries, vomer, and palatines.

respectively. The teeth are very small and close-set. The vomer, palatines, and premaxillaries are all flat, while the dentaries are arched in section. The toothbearing basibranchials consist of one arched dentigerous plate. Also the pharyngeals are very finely toothed, the upper consisting of ten plates and the lower of two small, oval plates, equaling the larger anterior upper plates and placed below the middle of the upper plates.

Otolith: The left otolith was removed in specimens P 77446 and P 77448 (see Pl. XIII, Fig. 2). A thorough examination of these otoliths (made by J. MØLLER CHRISTENSEN) showed that the outer third was modified, perhaps caused by the preservation in formaldehyde, while the rest consisted of several, irregular, concentric rings. However, these rings were rather indistinct and quite impossible to interpret.

Interesting enough, no otoliths are present in the smallest specimen, P 77444, judging from the radiograph, which normally shows even the smallest otolith very clearly. The first 5 - 6 years after capture the specimens were kept in formaldehyde and then transferred to alcohol, but this should not be sufficient to explain the disappearence of the otoliths.

In the remaining six specimens the otoliths are placed immediately anterior of the first vertebra (Pl. XII, Fig. 3).

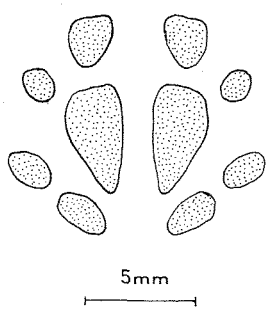

Fig. 9. Upper pharyngeal teeth of *T. nasus*. "Galathea" St. 450, std. 1. 285 mm. The anterior plates below.

Thymus: Except for P 77444, all the specimens examined had the same kind of external thymus as found in *A. armatus* (see p. 38). In P 77445 it is rather diffuse, but in the remaining five specimens it varies in diameter from 2-4 mm. One of the thymus glands in P 77446 was stained and sectioned. Pl. XII, Fig. 4, shows one of the sections. Like *A. armatus* the thymus in *T. nasus* differs from the description given e.g. by HAMMAR (1909) and GRASSÉ (1958 p. 2636) of the involution of this organ, after the specimen had become sexually mature.

Gill rakers: The dorsal and ventral gill rakers on the anterior arch are small and robust, while the the medium ones (10-13 in number) are long and slender (Fig. 7). The rakers on the second, third, and fourth arch are all of the same size as the most ventral ones on the anterior arch. Finally, 7-9 very small rakers are found on the fifth arch on all the specimens examined.

Viscerae: The black, thick-walled stomach provided with longitudinally running lists. Pyloric coecae not present. Very large kidneys. The swim bladder is thin-walled and more or less transparent with brown or grey spots. It is rather long, ending below the anterior end of the enlarged kidneys. The shape is oval, but pointed in the cranial part. Apparently no muscles were connected with the swim bladder wall, which indicates that it can not be used as a sound-producing organ.

Gonads: The holotype was not opened and the paratype, on which GÜNTHER based his description of the internal organs of *T. nasus*, is a female with eggs 0,3–0,5 mm in diameter. None of the "Galathea" specimens had well-developed gonads. In P 77444 it was not even possible to identify the sex. Both P 77445 and P 77446 are females, and the two larger specimens are males. One of the gonads of P 77448 was stained and sectioned in order to determine the sex. A thorough examination of the series of sections showed no trace of hermaphroditism. In the latter specimen the testes were long and narrow (15×3 mm) and uniformly yellowish. In P 77445 the ovaries were spindle-shaped (5×2 mm) and yellowish.

Colouration: MURRAY (1885 p. 520) noted: "The fins were black, but the body was white. Almost all the scales were rubbed off and with them apparently a thin, black skin, so that probably the

fish when first caught by the trawl was of a uniform black colour; the mouth and gill-chambers were black". Pl. XII, Figs. 1 and 2 show P 77448 immediately after it was brought on the deck. These photos support MURRAY's remarks about the colour of the fins, but none of the "Galathea" specimens was black on the body or the head. The only colouration of the skin was a thin brown line that encircled the scale-pockets on the anterior half of the body. The mouth and the gill cavity were dark and in the smallest specimen, P 77444, the peritoneum also was black. The rest of the fish was yellowish and partly transparent. The head of the four larger "Galathea" specimens appeared reddish, in the present state, coloured by the underlying tissues.

Stomach content: Generally, the content of the alimentary canal was very small and almost all of it was found in the intestine. The identifiable contents from the specimens examined (only the five from the "Galathea") consisted, besides two fish scales, exclusively of crustaceans. W. VERVOORT and T. WOLFF referred the crustaceans to the following groups: Copepoda (12 spms. 2-7 mm long), i.a. including *Heteroptilus acutilobus* G.O.Sars (3 juv. spms), *Phyllopus helgae* Farran (1 spm.), and Aetideidae (1 unknown male); remnants of Ostracoda; Isopoda Asellota (5 spms. 3,5-12 mm long) including *Munnopsis* sp. (7 mm) and *Ilyarachna* sp. (3,5 mm); Amphipoda (12 spms. 4,5-12 mm long). Some of the Isopoda are definitely benthic e.g. *Ilyarachna* sp., while some of the Copepoda are known to live pelagically, but not far over the bottom. Fish scales very much alike, were found in two specimens. The larger was rectangular (4×2 mm) and very similar to the scales of *T. nasus*.

Distribution

Geographical distribution: The only three localities from which *T. nasus* is known are all within the same area, viz. the Indo - Australian area (Fig. 10).

Bathymetrical distribution: The numbers in Fig. 10 indicate the depths in metres at which the *T. nasus* specimens were caught. (The depth at the "Galathea" station varied from 4940-4970 m). Assuming that the specimens were captured, while the trawl fished on the bottom, the present species has the following depth-distribution: 3933-4940 m. In addition to what is said above of *A. armatus* (see p. 41), also the position and the protractility of the mouth indicate that *T. nasus* has a benthic occurrence. However, some of the crustaceans from the intestine occur pelagically and some benthically.

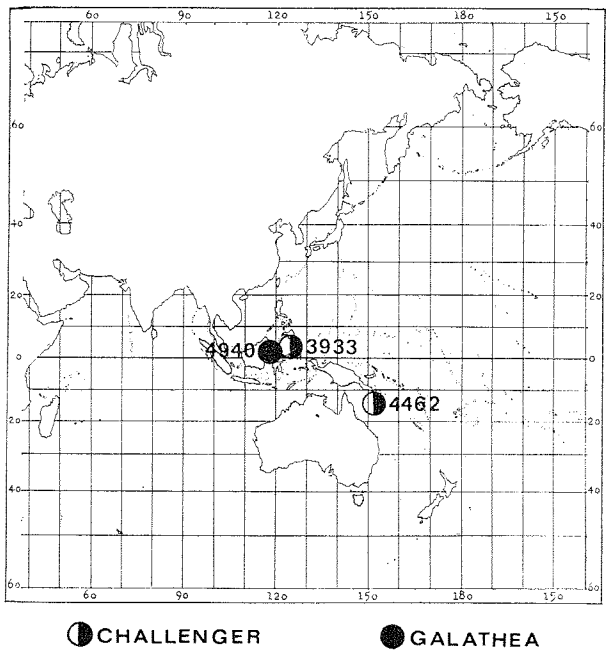

Fig. 10. Distribution of *T. nasus*. The numbers indicate the depth in metres.

BEAUFORT and CHAPMAN (1951) gave information concerning the depths at which the type material was caught, viz. 3870 m and 3392 m instead of 4462 m and 3933 m.

Biology

T. nasus is apparently very rare, judging from the few specimens caught. Although it occurs at rather great depths, quite a number of trawl-hauls have been made in all oceans at the said depths. However, the capture of five out of seven known specimens from one station indicates that this species has a rather concentrated occurrence since the area fished by the trawl (approx. 1/5 km²) constitutes a very small part of the known distribution of this species.

On the basis of this scarce material the following remarks can be made: *T. nasus* occurs abyssopelagically and abyssally on and over mud and clay and within a temperature interval of 2,1°-3,9°C. Judging from the stomach contents, it feeds primarily on crustaceans which are swallowed in rather intact condition. The position of the protractile mouth on the ventral side of the head (Fig. 6) is helpful to a fish, feeding on animals living in the mud. The teeth

are small, and the lower pharyngeal teeth are poorly developed, compared to e.g. *A. armatus,* which indicates that this species presumably is unable to feed on "hard-shelled" animals. The well-developed swimbladder enables the fish to hover over the bottom, thus involving a benthopelagic occurrence. – It seems rather difficult for the sexes of this species to meet, since they lack a lateral line, photophores, and maybe do not even have the possibility of sound production in connection with the swimbladder. On the other hand, this species apparently occurs in schools, so that the above-mentioned ways of communication are not so important for *T. nasus.* Furthermore, this species might be able to produce sound by stridulation with the teeth, and in this way keep the school together. – Judging from the ovaries of the paratype, which contain a large number of small (0,3-0,5 mm) eggs, and the absence of an intromittent organ in all the males this species seems to be oviparous. – The very thin tail and the rather plump head suggests that *T. nasus* is a slow swimmer.

SUMMARY

A review is given of the genera *Acanthonus* and *Typhlonus* (Pisces, Brotulidae), both described by GÜNTHER (1878). His descriptions were based on two specimens of each genus, but due to later expeditions, mainly the "Galathea" and the "Oregon", 11 specimens are now known of the former and 7 specimens of the latter genus. Consequently, it is now possible to get an impression of the variation of these genera. Some remarks are made on the biology of the two genera, mainly based on the stomach contents and data from the localities. Two species have been described of *Acanthonus,* but it is quite evident that *A. spinifer* Garman, 1899 is synonymous with *A. armatus* Günther, 1878. This species has been found in all oceans. *Typhlonus* is monotypic, with the species *T. nasus* Günther, 1878 known only from the Indo-Australian waters.

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PLATE XI

Fig. 1. *Acanthonus armatus* photographed immediately after capture. "Galathea" St. 52, std. l. 220 mm.

Fig. 2. Radiograph of *A. armatus*. "Galathea" St. 52, std. l. 220 mm. Exposures: Anterior part 25 KV 100 m.amp.sec., posterior part 15 KV 200 m.amp.sec. (Gevaert D 7 Structurix).

Fig. 3. *A. armatus* from "Oregon" St. 2567, std. l. 93 mm.

Fig. 4. Holotype of *A. spinifer*. "Albatross" St. 3381, std. l. 71 mm.

Fig. 5. Bundles of dorsal filt from the polychaete *Aphrodite* and headbones of *Acanthonus* sp. from the stomach of *A. armatus*. "Oregon" St. 2567, std. l. 242 mm.

Fig. 6. Gill raker from the anterior arch of *A. armatus*. "Galathea" St. 52, std. l. 220 mm.