

BEAUFORTIA

SERIES OF MISCELLANEOUS PUBLICATIONS

ZOOLOGICAL MUSEUM - AMSTERDAM

No. 24

1953

FEBRUARY 10

Bomolochus soleae Claus, 1864 and *B. confusus* n. sp.:
two hitherto confounded parasitic copepods,
with remarks on some other *Bomolochus* species*)

by

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INTRODUCTION

While studying the parasitic copepods of the Dutch Waddensea, at the Zoological Station Den Helder, I came across a species of *Bomolochus* from the gills of the Black Sole, *Solea solea* (L.). Except for the second leg, the various appendages resembled those of *B. soleae* CLAUS, as figured by TH. & A. SCOTT in their Ray Society Monograph (1912—13). According to them, the endopod of the second leg has narrow joints, like the exopod. They stated that the second and third leg have about the same structure. In my material, however, the endopod of the second leg has widened joints; second and third legs have, therefore, quite a different aspect.

Of TH. and A. SCOTT's material, 2 samples remained**) in the collections of the British Museum (Natural History), London. The specimens proved to be quite distinct from the Dutch ones, differing not only in the structure of the second leg, but also in several other, less striking, characters.

The Dutch material was collected not far from CLAUS' type-locality of *B. soleae*, and, like CLAUS' material, from the gills of *Solea solea*. SCOTT's material was collected in British waters from the nostrils of the Cod-fish, *Gadus callarias* L. For this reason, the Dutch specimens have been regarded as topotypes of *B. soleae* CLAUS, the British specimens as belonging to a new species, which I propose to call *B. confusus*, since it has been confused hitherto with *B. soleae*.

*) Received November 19, 1952.

**) One other sample, labelled by SCOTT as *B. soleae*, and present in the British Museum, did not really belong to that species, but to *B. onosi* TH. SCOTT, which is redescribed in the sequel.

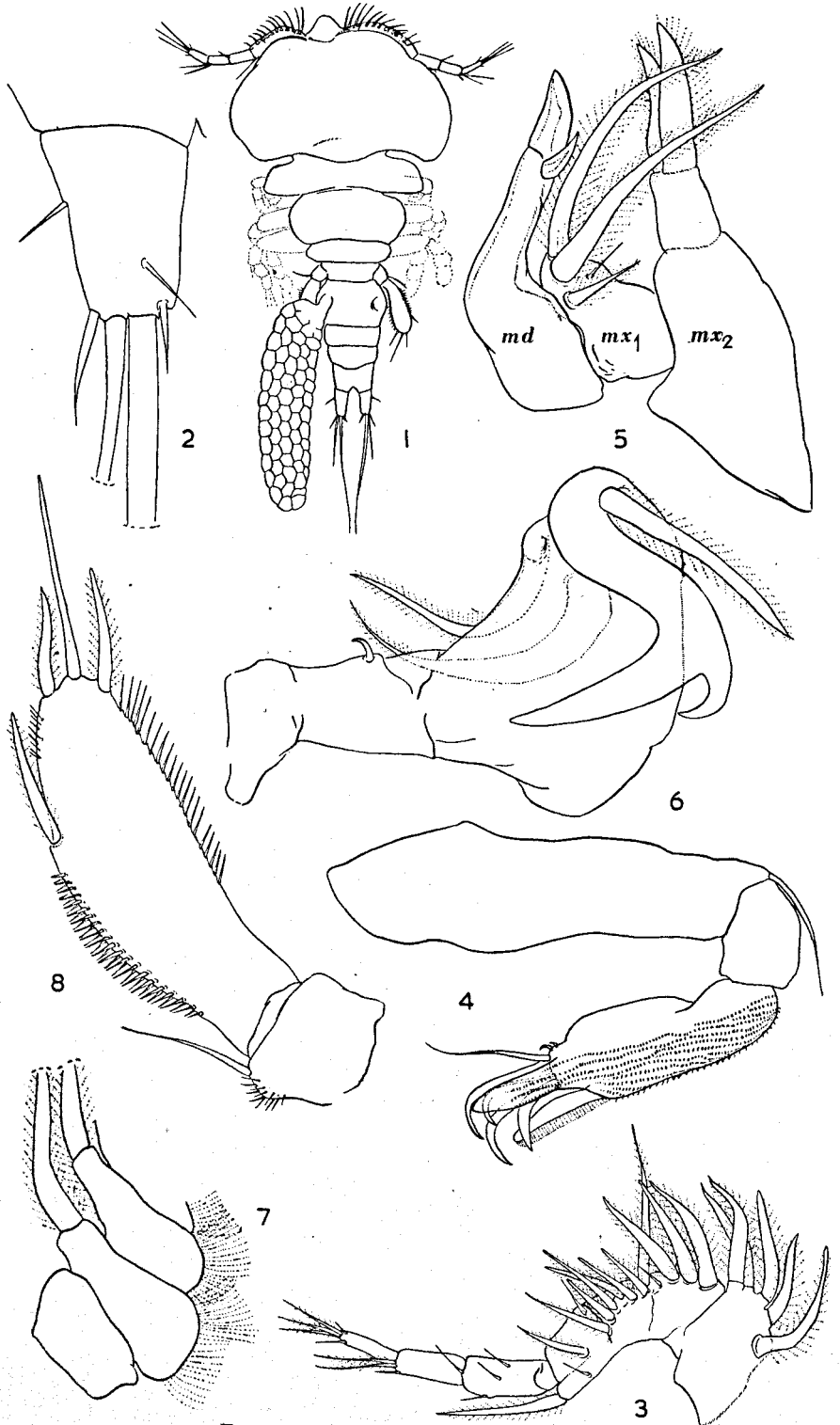


Fig. 1—8. *Bomolochus soleae* CLAUS (♀).

REDESCRIPTION OF *Bomolochus soleae* CLAUS, FROM TOPOTYPES.

Principal literature: CLAUS, 1864 — Zeitschr. Wiss. Zool. 14, pp. 374–377, Pl. XXXV figs. 16–20, Pl. XXXVI fig. 28; VAN BENEDEN, 1871 — Mém. Acad. Roy. Belg. 38, no. 4, p. 78, Pl. I, fig. 5.

Female (Figs. 1–14). Cephalothorax much wider than long. First thoracic segment fused with the head. Free thorax segments diminishing regularly in width. Third segment not overlapping the fourth segment. Furca about as long as the last segment of urosome, tipped with 4 setae, provided moreover with 1 outer-edge bristle — at about $\frac{2}{5}$ of the length of the furcal joint — and 1 inner-edge bristle — at about $\frac{4}{5}$ of the furca. Urosome 4-segmented.

First antennae 7-jointed; 4 basal joints indistinctly articulated, provided with broad plumose setae. Terminal 3 joints distinctly segmented, about subequal.

Second antennae with a powerful, elongated basal joint, terminating in 1 seta; second joint squarish, unarmed. Third joint at least $\frac{1}{3}$ shorter than the basal joint; the entire ventral surface roughened by numerous rows of squamose spines. The 3rd joint terminates in an indistinctly articulated, finger-shaped joint, on the surface of which the rows of squamose spines are continued. At about $\frac{1}{7}$ from the tip of the 3rd joint, a slender, membranous joint is excentrically implanted, having 1 setose edge. The tip of the 3rd joint is armed moreover with 4 curved claws, 1 seta and 2 very small hook-like spinules.

Mouth-parts consisting of mandible, first and second maxillae, maxillipeds, and paragnaths. The latter are implanted between the first and second maxillae, forming a one-jointed chitinous structure, which was described already by Claus, 1864. Maxillipeds 3-jointed. Two basal joints comparatively narrow. Third joint powerful, armed with 3 plumose setae and 1 sigmoid, twisted, strong claw. The outer curve of the claw is provided with a tooth, which is curved again in itself.

First leg a flattened, distorted structure. Exopod indistinctly 3-segmented. Terminal joints hardly articulated. Outer side of 1st and 2nd joint with a foliate spine. Inner side of exopod with plumose setae, 3 on the 2nd, 3 on the 3rd joint. Endopod 4-jointed, basal joint narrow, unarmed. Second joint much wider than long, inner side projecting and bearing 1 plumose seta. Third joint likewise with a projecting part at the inner side, with 1 seta. Outer edges of segments 2 and 3 with dense setation. Terminal joint with 5 plumose setae.

Second leg with 3-jointed rami; the endopod with widened joints, exopod normally developed. Outer edge of exopod with curiously shaped spines (cf. figure).

Third leg normally with 3-jointed, narrow rami.

Fourth leg likewise with 3-jointed rami. The joints, especially those of the endopod, elongated.

Fifth leg 2-jointed. Basal joint small, outer edge with some spinules and 1 seta. Terminal joint elongate, outer edge with 2 rows of small spines; at $\frac{3}{4}$ of its length a plumose seta is borne. Three more setae on the tip of the joint. Inner edge with a row of spinules.

Sixth leg reduced, 1-jointed, armed with 3 long setae.

Male (figs. 15–20). Much smaller than female. First segment, like in female, fused with the head. Urosome 3-segmented.

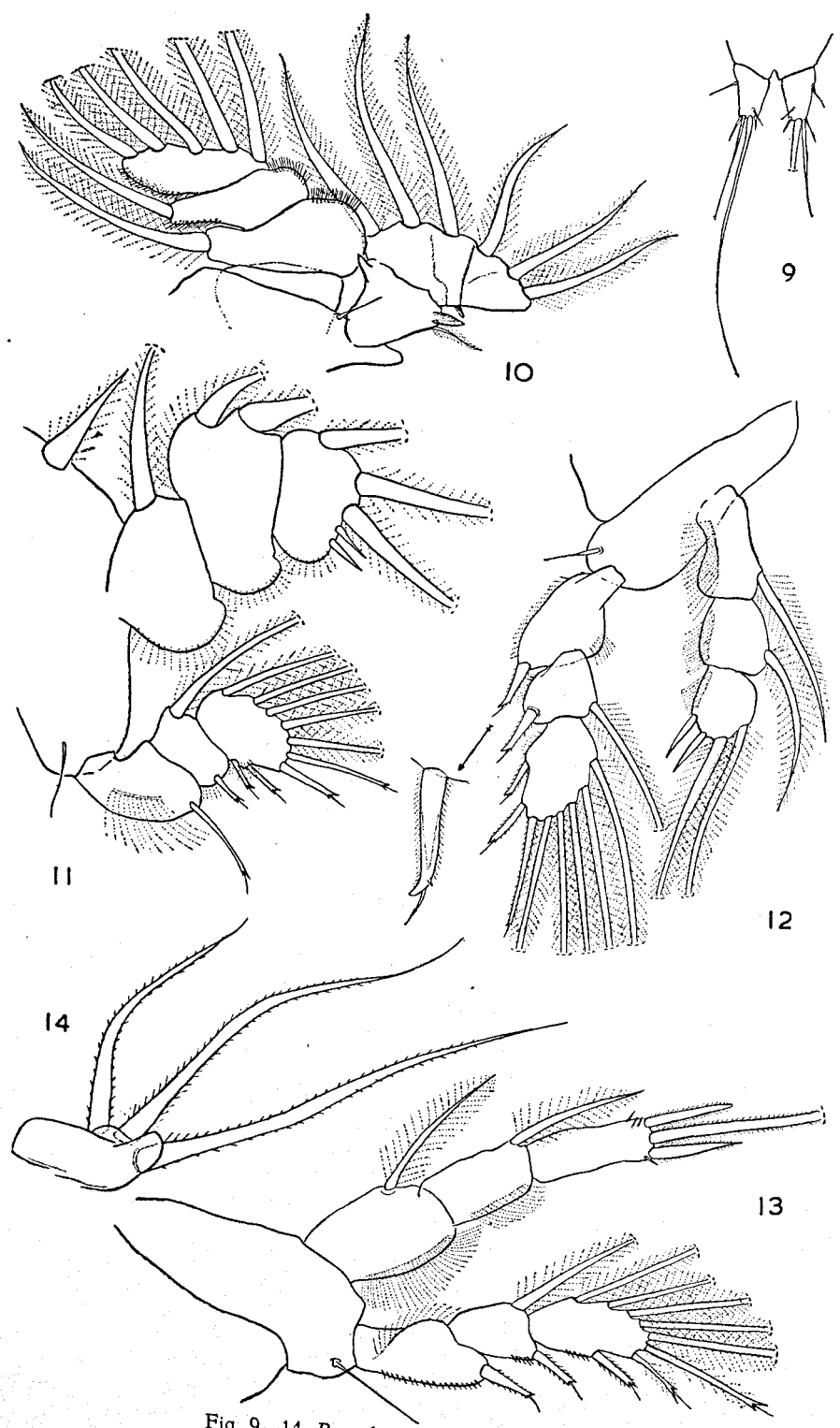


Fig. 9—14. *Bomolochus soleae* CLAUS (♀).

First and second antennae, mandibles, maxillae, and paragnaths as in female. Maxilliped 2-jointed. Basal joint elongate, unarmed. Second joint swollen, roughened at its inner edge with 3 rows of spinules, and provided with 1 seta at about half its length. Terminal claw long and slender, curved near the tip; the inside of the claw crenulated.

First leg not flattened, both rami 3-segmented.

Second leg not flattened either. Third leg as in female. Fourth leg with 3-jointed exopod and 2-jointed endopod.

Fifth leg with the terminal joint much narrower than in female, tipped with 2 hairs only. Sixth leg as in female.

Measurements : Female, total length (excluding furcal setae): 1.6 mm.

Male, total length (excluding furcal setae): 0.7 mm.

Colour : The entire live animals and the ovisacs are cream-coloured.

Distribution : Helgoland (CLAUS), Western part of Dutch Waddensea (present paper) and Belgian coast (VAN BENEDEN). On gills of *Solea solea* (L.). The Dutch material, consisting of numerous males, females (partly with ovisacs), and juveniles, has been placed in the Zoological Museum, Amsterdam, and is numbered Z.M.A. Co. 100,135—100,137.

Remarks : The male of *B. soleae* was captured together with the female on the gills of the Black Sole. The males are attached to females bearing eggs, just like in *B. multispinosa* GNANAMUTHU, 1949, a species from Madras (cf. Rec. Ind. Mus. XLV, 1947, p. 309, fig. 1 B). I share GNANAMUTHU's opinion (p. 315) that this mode of attachment of male to ovigerous female will turn out to be the usual way in the genus *Bomolochus*, since none of the males known has been captured free-living, but always together with the females on the gills or in the nasal fossae of the host. Compare also the confirmation of this opinion, in the statements of T. & A. SCOTT (1913, p. 38, small type) on *B. confusus*.

DESCRIPTION OF *Bomolochus confusus* n.sp.

Principal literature : *Bomolochus soleae*, auct. non CLAUS, T. SCOTT, 1893 — Eleventh Ann. Rep. Fishery Board for Scotland (1892), part III, section B, no. 2, p. 212, Pl. V figs. 1—13; T. SCOTT, 1902 — Twentieth Ann. Rep. part. III, section B, no. 4, pp. 288—289, Pl. XIII figs. 13—18; BAINBRIDGE, 1909 — Trans. Linn. Soc. London, ser. 2 (Zool.), vol. XI, part 3, pp. 45—47, Pl. 8 figs. 1—5 (literature!); WILSON, 1911 — Proc. U.S. Nat. Mus., vol. 39, no. 1788, pp. 375—377, Pl. 57 figs. 184—190, Pl. 60 fig. 219, textfig. 40; T. & A. SCOTT, 1913—14 — Publ. Ray Soc. 1913—14, pp. 36—39, Pl. I fig. 3, Pl. II figs. 6—9, Pl. III figs. 1—4 (literature!); VAN OORDE-DE LINT & SCHUURMANS STEKHOVEN, 1936 — Tierw. N. u. O. see, Lief. XXX, Teil Xc, pp. Xc 103—104, fig. 43.

Female (figs. 21—33). In general similar to the preceding species. The details not mentioned in the following description are similar to those of *B. soleae*.

Free thorax segments much stronger developed than in *B. soleae*. Third segment (= second free segment) overlapping about half the 4th segment. Ovisacs somewhat less slender.

Basal joints of second antennae as in the other species; third joint different. The membranous accessory joint and one of the terminal claws have been transferred in proximal direction and are borne now at about $\frac{2}{3}$ of the way to the distal end. The surface of the 3rd joint is rough

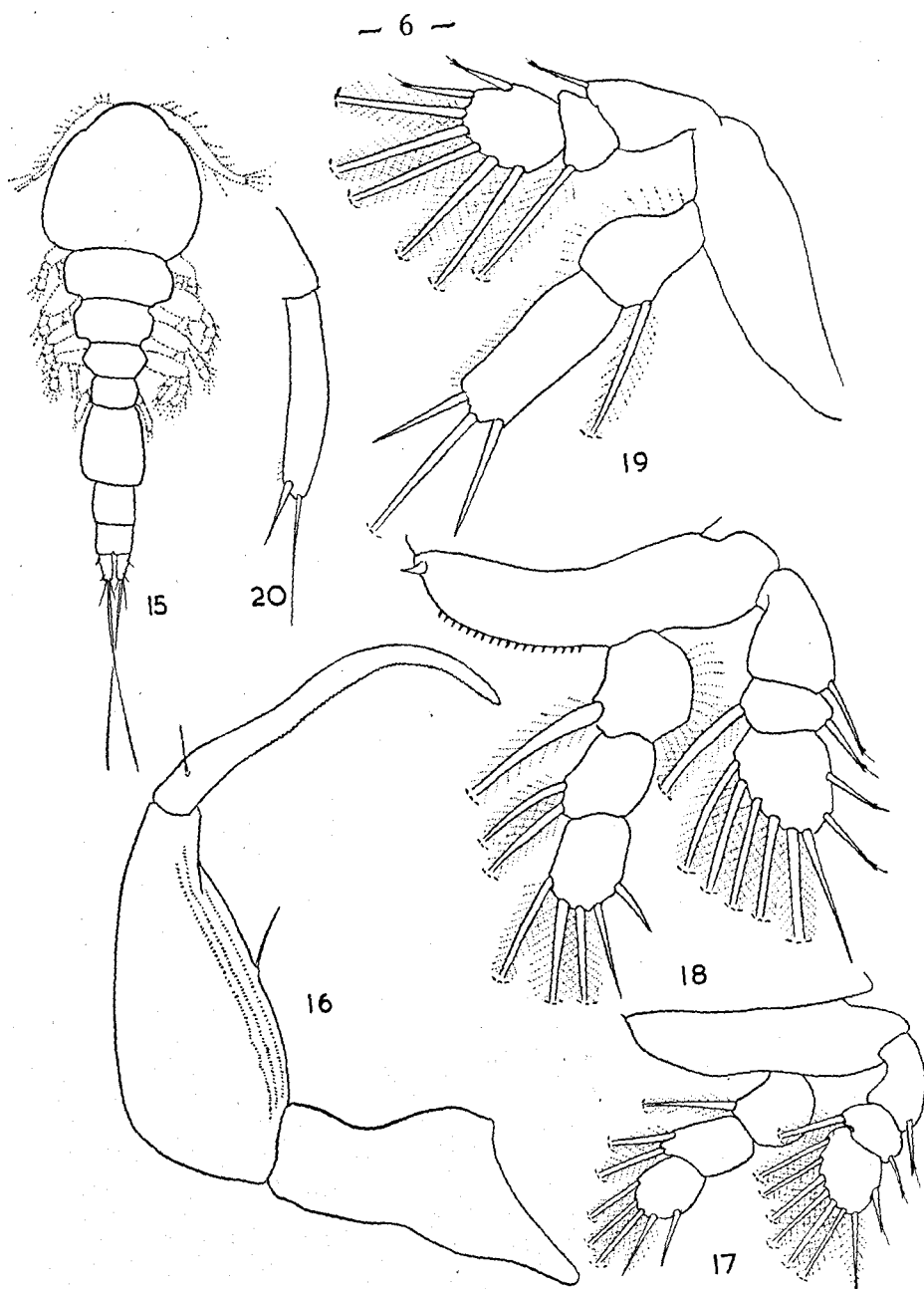


Fig. 15—20. *Bomolochus soleae* CLAUS (♂).

like in *B. soleae*, the spines, however, being conical instead of squamose. Maxillipeds not as powerful as in *B. soleae*. Claw less twisted. Auxiliary tooth of the claw comparatively small, not curved. First leg, exopod more reduced. Endopod, terminal two joints of quite a different structure from *B. soleae*, without projecting parts at the inner side.

The second leg shows the most distinctive characters. Its endopod joints are not flattened at all. The spine formula of the joints completely agrees, however, with that of *B. soleae*. The compound spines on the

outer edge of the exopod have a structure somewhat different from the preceding species.

The joints of the exopod of the third leg are less elongate; the second joint of endopod bears 2 setae, instead of one.

The terminal joint of the exopod of the 4th leg is 1.4 times as long as it is wide (in *soleae*: 1.7 times as long as wide). The terminal joint of endopod is widest at the tip (in *soleae*: widest at the base).

The outer-edge spine of the fifth leg is situated at 63% of the way to the distal end of the terminal joint (in *soleae*: at 75%). The inner terminal spine is about half as long as the terminal segment (in *soleae*: much shorter).

All legs are distinctly smaller than those of *B. soleae*, as will be clear from the figures of the legs of both species, which have been drawn to the same scale.

Male. Unfortunately, the British Museum collection did not contain a single male of the new species. There are, however, some statements in literature on the male of "*B. soleae*", referring to the male of *B. confusus* actually. The following statements have been compiled after BAINBRIDGE, 1909, and WILSON, 1911.

Except for the first thorax segment, which appears to be separated from the head (in female of *confusus* and in both sexes of *soleae*: fused with the head), external shape as in *B. soleae*. Maxillipeds similar to that of *B. soleae* (BAINBRIDGE, Pl. 8 fig. 5). First leg rather different, since the inner ramus is flattened much more than in the preceding species (WILSON, Pl. 60 fig. 219). Second and third leg apparently resembling those of the former species. Second joint of endopod of fourth leg much more elongated than in *B. soleae*.

Historical. The present species has been regarded by all British and American authors as *B. soleae* CLAUS. The confusion may be due to the fact that CLAUS, though he correctly described the legs, did not figure them, although of all differences those in the legs are the most striking.

The best account on the mouth-parts of *B. confusus* is that of Miss BAINBRIDGE, 1909, who was the first to describe the paragnaths in this species. The legs of the female have been figured by T. SCOTT (1893) and T. & A. SCOTT (1913—14). The mouth-parts have been incorrectly pictured in T. SCOTT's 1893 paper. In his 1902 paper, SCOTT corrected the mistakes; the references to the figures in this paper are marred, however, by minor errors. WILSON, 1911, included "a description of the hitherto unknown male". It evidently escaped his attention that BAINBRIDGE had described and figured the male of *B. confusus* (as *B. soleae*) some years before, and that CLAUS (1864), in his original description of *B. soleae* (with which WILSON considered his species identical), had succeeded in "die bisher von dieser Gattung noch nicht gekannten Männchen zu beobachten" (p. 374). In the sequel, CLAUS described the male completely, noting among others the structure of the legs, the shape of the genital segment and of the maxillipeds. The latter are pictured on Pl. XXXV fig. 17 of CLAUS' paper. In the same 1911 paper, WILSON drew up a key to the species of the genus, known that time. As many other parts of his paper, the key contains contradictions and errors, and has to be used with caution.

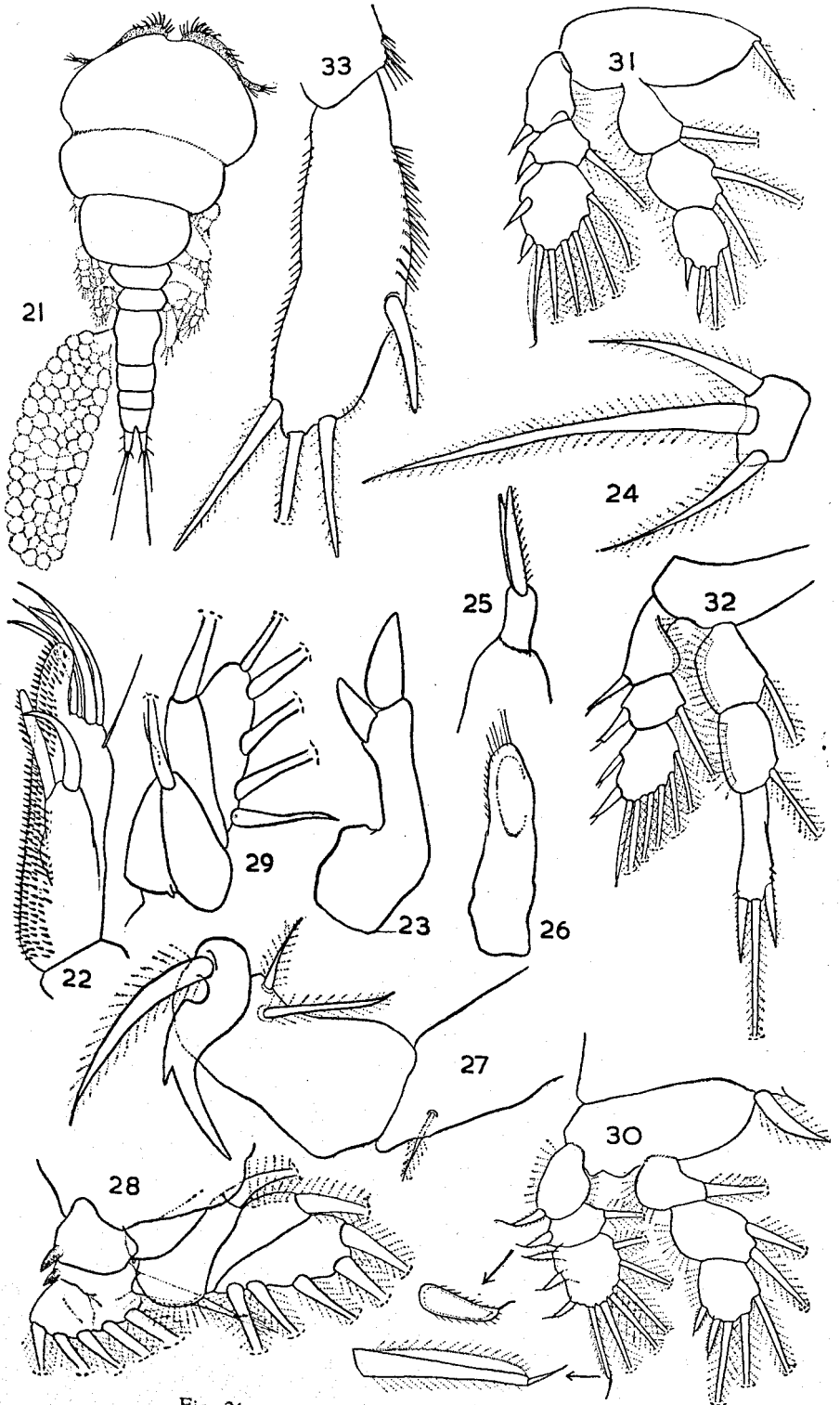


Fig. 21—33. *Bomolochus confusus* n.sp. (♀).

Material and types :

- a) 24 females, one of which is made holotype, the remaining specimens being paratypes. Aberdeen, June 1900. From nostrils of *Cod. T.* Scott coll. Brit. Mus. coll. no. 1911.11.8.47686—700.
- b) Six females. British Coasts. Nasal fossae of *Gadus*. Brit. Mus. coll. no. 1913.9.18.1—6.

Measurements. Female, total length, excluding furcal setae : 1.5 mm. Male, total length, excluding furcal setae (according to BAINBRIDGE) : 0.8 mm.

Distribution. The distribution of *B. confusus* is not yet known with certainty. It has been recorded with certainty from Moray Firth, Aberdeen and North Shields (Northumberland), always from the nostrils of *Gadus callarias*. Future material may prove, whether the specimens from the nostrils of several other Gadoids, *Cyclopterus lumpus*, *Molva molva*, *Pleuronectes platessa*, and *P. flesus*, which have been referred by SCOTT (1913) to *B. soleae*, really belong to one species.

REDESCRIPTION AND TAXONOMIC STATUS OF *Bomolochus onosi* T. SCOTT.

Principal literature : *Bomolochus onosi* T. SCOTT, 1902 — Twentieth Ann. Rep. Fish. Board Scotland, part III, pp. 289—290, Pl. XIII figs. 19—22 ; T. & A. SCOTT, 1913—14 — Publ. Ray Soc. 1913—14, pp. 39—40, Pl. I, fig. 4, Pl. III figs. 5—7.

Female (figs. 34—44). External shape as figured by SCOTT, but abdomen 5-segmented. First thorax segment fused with the head. Thorax segments much less fleshy than in *B. soleae* and *B. confusus*. Furca much more slender than in the two preceding species. Outer-edge bristle at about $\frac{3}{5}$ on the way to the distal end.

First antennae : agreeing with SCOTT's description and figure. Second antennae resembling those of *B. soleae* CLAUS, though less powerful and roughened only by 1 row of spines and some few rows of squamose spinules.

Mouth-parts consisting of maxillary hooks, mandibles, first and second maxillae, and maxillipeds. Paragnaths lacking. The arrangement of the mouth-parts is totally different from that found in typical *Bomolochus* since the maxillipeds occur in normal position, behind the other oral parts (in typical *Bomolochus*, their position is abnormal, as they are attached outside of the other mouth-parts). The mandibles, and maxillae 1 and 2 are of the usual pattern (cf. figs. 36—37). The maxilliped, however, lacks the auxiliary tooth on the claw, which is not twisted or S-shaped, but simply curved, and armed with 2 setae (fig. 38). Near the base of the 1st antennae, the large maxillary hooks are found.

First leg a distorted structure ; exo- and endopod 3-jointed, armed with flattened setae. Terminal joint of endopod with 1 normal seta, terminal joint of exopod with 2 normal setae. Basal joint of endopod greatly enlarged. Exopod inserted laterally, terminal two joints of endopod directed laterally.

Second leg with both rami 3-jointed. Outer edge of exopod with compound spines ; the one on the 1st joint is of the same structure as in *B. soleae*. The 2nd joint has 1 compound spine, and the 3rd joint has 3 compound spines, which have a denticulated edge (cf. fig. 41). Endopod, inner edge with 1 spiniform process on the 2nd joint, and 2 processes on the 3rd joint.

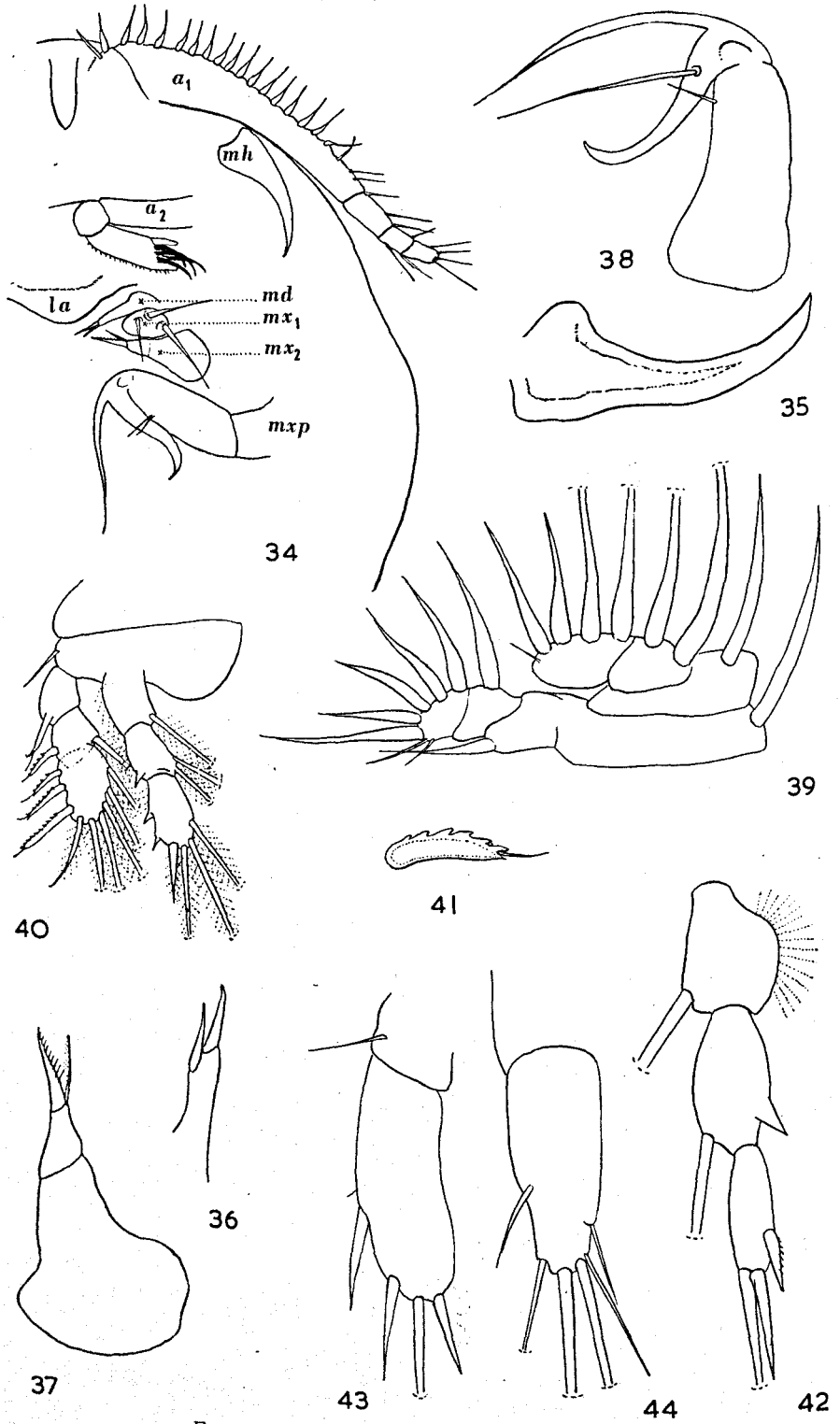


Fig. 34-44. *Anchistrotos onosi* (SCOTT), ♀.

Third leg in general resembling the 2nd leg, though it has a different spine formula : terminal joint of exopod with 2 compound spines, instead of 3 ; terminal joint of endopod with 2 setae, instead of 3.

Fourth leg : exopod resembling that of *B. confusus*. Endopod, terminal joint less slender ; second joint with a spiniform process on the inner edge ; spination of the terminal joint slightly different.

Fifth leg : terminal joint less slender, edges without spinules.

Colour : According to SCOTT, the animal is nearly colourless.

Measurements : The length of the female, excluding furcal setae, amounts to 1.2 mm.

Material : 2 females, both with fragments of ovisacs, erroneously identified as *B. soleae*, were sent to me by the British Museum, Natural History (catalogue numbers 1911.11.8. 47701—702). They are labelled "Bomolochus soleae, Claus. Syr Bay, Clyde, Nov. 1895"; another label reads : "Bomolochus soleae, Firth of Clyde. 1895. T. Scott."

Distribution : Firth of Clyde, and (according to SCOTT): Firth of Forth, Moray Firth, and Bressay Shoal, east of Shetland, on the inner surface of the gill-covers of *Onos mustellus* (L.), and *O. cimbricus* (L.).

Remarks : SCOTT's description is complete enough for recognizing the species, though he did not describe in detail the structure of mandible, maxillae and legs ; neither did he notice the normal position of the maxillipeds, nor the presence of maxillary hooks.

The position of the maxillipeds, their structure, and the presence of maxillary hooks, requires moving SCOTT's species from the genus *Bomolochus* (family Bomolochidae) to the genus *Anchistrotos* BRIAN, 1906 (= *Eucanthus* CLAUS, 1864, preocc.), belonging to the family Taeniocanthidae.

THE STATUS OF THE GENUS *Artacolax* WILSON, 1908.

WILSON, 1908 (Proc. U.S. Nat. Mus. 35, no. 1652) gives a diagnosis of a new genus, *Artacolax*, which he described in detail in 1911 (Proc. U.S. Nat. Mus. 39, no. 1788). According to the diagnosis, 1908, the genus is distinguished from *Bomolochus* by the body segmentation ("third and fourth segment fused"), the structure of the mouth-parts (especially the maxillipeds), and the structure of the first leg. In 1911, he distinguished *Artacolax* from *Bomolochus* by the body segmentation ("fusion and overlapping of the third and fourth segments"), by the greater width of the rami of the 1st and 2nd legs, and by the structure of the mouth-parts (especially the 2nd maxillae).

In fact, none of these characters justifies generic separation. In typical *Artacolax*, the 3rd and 4th body segments are not really fused, but the 3rd segment is overlapping the 4th, so that there seem to be but 3 free segments in front of the genital segment, instead of 4. The degree of overlapping may vary : fourth segment completely covered by the 3rd (e.g. *A. saetiger* WILSON); 4th segment partly covered by the 3rd (e.g. *B. confusus* n.sp.); 3rd segment without any overlapping part (e.g. *B. soleae* CLAUS).

The legs (female) show the same variation : (1) rami of all legs

scarcely narrowed (e.g. *B. albidus* WILSON*); (2) rami of 1st leg flattened (e.g. *B. confusus* n.sp., *B. eminens* WILSON); (3) rami of 1st and 2nd leg flattened (e.g. *B. nitidus* WILSON, *B. soleae* CLAUS, *A. saetiger* WILSON); (4) rami of 1st to 3rd legs flattened (e.g. *A. palleucus* WILSON). If the widening of the joints of the inner rami of the legs supplied a good generic character, all the above combinations would deserve generic rank.

The mouth-parts too, do not justify separating *Artacolax* from *Bomolochus*. The structure of the maxilliped of one *Artacolax* or another may be somewhat different from that in typical *Bomolochus* (e.g. the lack of plumose setae in *A. ardeolae* (KRÖYER)), the 2nd maxilla of *A. saetiger* WILSON may show some differences if compared with that of typical *Bomolochus*, on the whole those differences are of specific, but not of generic, importance.

WILSON himself, apparently has a vague conception of the characters distinguishing *Artacolax* from *Bomolochus*, since he described (1935, Pap. Tortugas Lab. XXIX, no. XII) a new species as *Bomolochus scutigerulus*, though the structure of the maxillipeds, and legs 1 to 3 completely agrees with that found in typical *Artacolax*. Segments 3 and 4 of the body do not overlap each other, like in *Bomolochus*, whereas the general shape of the body strongly recalls certain *Artacolax* species. But what is the generic value of body shape in Cyclopoids?

There cannot be any doubt that *Artacolax* does not deserve generic rank, and that the genus may be considered identical with *Bomolochus*.

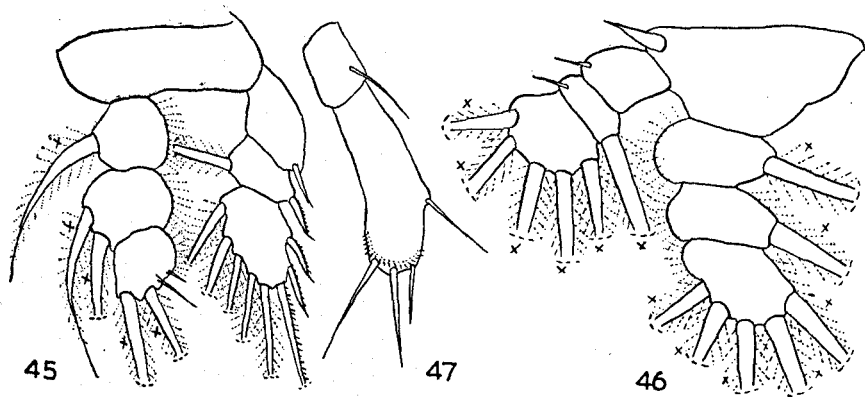


Fig. 45—47. *Bomolochus albidus* WILSON (♀).

*) The first and third leg in this species have been figured again (figs. 45—46), from paratypes, obtained in exchange from the United States National Museum (now: Zoological Museum Amsterdam coll. no. Co. 100, 140—100, 141) to show the scarcely widened rami of the endopod. The setae marked with X are more flattened than the remaining setae. WILSON's description of *B. albidus* needs some correction. The 5th leg is not 3-jointed, as stated, but quite normally 2-jointed (fig. 47). The endopod of the 3rd leg is not "quite slender, with elongate terminal segments", but is shaped like the endopod of the 2nd leg (fig. 46). The structure of the 2nd antennae differs somewhat from the description. The 2nd antennae are 3-jointed; 3rd joint with foot-shaped process, which bears a claw, and a membranous joint similar to that of *B. like* in *B. soleae*.

ACKNOWLEDGEMENTS.

The author is indebted to the Trustees of the British Museum (Natural History), for lending some *Bomolochus* material, and for permission to publish this paper, partly based on that material.

The authorities of the United States National Museum, especially Dr. Paul L. ILLG, kindly arranged the exchange of paratypes of *Artacolax palleucus* WILSON and *Bomolochus albidus* WILSON, for which thanks are due.

Thanks are also due to the Director of the Zoological Station, Den Helder, Dr. J. VERWEY, for putting at my disposal the facilities of the Station during a visit in summer 1950, thus enabling me to collect topotypes of *Bomolochus soleae* CLAUS.

EXPLANATION OF THE FIGURES.

Fig. 1—8. *Bomolochus soleae*, female. 1, Dorsal view. 2, Furca. 3, First antenna. 4, Second antenna. 5, Mandible, maxilla 1, and maxilla 2. 6, Maxilliped. 7, Basal segments of endopod of first leg. 8, Fifth leg.

Fig. 9—14. *Bomolochus soleae*, female. 9, Furca. 10, First leg. 11, Second leg. 12, Third leg; one of the compound spines is figured on enlarged scale. 13, Fourth leg. 14, Sixth leg.

Fig. 15—20. *Bomolochus soleae*, male. 15, Dorsal view. 16, Maxilliped. 17, First leg. 18, Second leg. 19, Fourth leg. 20, Fifth leg.

Fig. 21—33. *Bomolochus confusus*, female. 21, Dorsal view. 22, Distal part of second antenna. 23, Mandible. 24, First maxilla. 25, Second maxilla. 26, Paragnath. 27, Maxilliped. 28, First leg. 29, Endopod of first leg, fine setae omitted. 30, Second leg; two of the compound spines are figured on enlarged scale. 31, Third leg. 32, Fourth leg. 33, Fifth leg.

Fig. 34—44. *Anchistrotos onosi*, female. 34, Arrangement of the mouth-parts, semi-diagrammatic. 35, Maxillary hook. 36, Mandible. 37, Second maxilla. 38, Maxilliped. 39, First leg. 40, Second leg. 41, Compound spine of second endopod joint of second leg. 42, Endopod of fourth leg. 43, Fifth leg. 44, Furca.

Fig. 45—47. *Bomolochus albidus*, female. 45, First leg. 46, Third leg. 47, Fifth leg.

The following letters apply to all figures: A₁, first antenna; A₂, second antenna; mh, maxillary hook; md, mandible; la, upper lip; mx₁, first maxilla; mx₂, second maxilla; mxp, maxilliped.