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A NEW SPECIES OF NOTODELPHYID COPEPOD ASSOCIATED WITH *PTERYGASCIDIA LONGA* (VAN NAME, 1918) FROM THE BASILAN STRAIT, PHILIPPINES

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With 4 text-figures

In research on the two ascidians *Pterygascidia mirabilis* Sluiter, 1904, and *P. longa* (Van Name, 1918), Tokioka (1971a, b) found some copepods associated with both species. We were given the opportunity to examine these crustaceans. The copepod described below, *Goniodelphys tokiokai* n. sp., is a notodelphyid inhabiting the branchial sac of *P. longa*. The material was obtained from a few specimens among 20 ascidians which were collected by the Snellius Expedition on 5 September 1929, and deposited at the Rijksmuseum van Natuurlijke Historie, Leiden. As the copepods living in *P. mirabilis* belong to a family other than Notodelphyidae they will be reported in a future paper.

We wish to express our warm thanks to Dr. Takasi Tokioka, of the Seto Marine Biological Laboratory, for collecting the copepods from the ascidians and providing us the opportunity to examine the specimens, and for many other favors. We are indebted to the Rijksmuseum van Natuurlijke Historie, Leiden, for permission to study the material.

***Goniodelphys tokiokai* n. sp.**

Specimens examined: 6 females, all adult, from *Pterygascidia longa* (Van Name, 1918) preserved in formalin, Snellius Expedition, Station 60, 6° 58'N 121° 52.5'E, in the Basilan Strait between the islands of Basilan and Mindanao, 72-80 m deep, September 5, 1929.

Types. — The types are preserved in the collection of the Rijksmuseum van Natuurlijke Historie, Leiden. The holotype under no. Crust. F 793, a paratype under no. Crust. F 794.

Description. — Female (figs. 1-4). Body (fig. 1a) compressed, rigid from heavy cuticularization of integument. Three major body divisions, cephalosome, metasome, urosome, well-defined. In fixed specimens back of body (cephalosome plus metasome) slightly arched but not much expanded dorsally, and with relatively short urosome bent downward almost at a right angle. Separate lengths of trunk and urosome, measured along major axes, 2.3 mm, which also expresses greatest overall length of specimen, and 0.7 mm, respectively. Cephalosome (fig. 1a, b) produced in a relatively large triangular rostrum between antennules, posteriorly bearing appendages including maxillipeds. Rostrum (figs. 1b, 2f) with strong midventral keel, thus lateral margins 1.4 times as long as midventral. Metasome about 4.4 times as long as cephalosome and distinctly 4-segmented. Segments gradually increasing in size with proportional lengths about 2: 2.3: 4.3: 9, from anterior to posterior, measured along body axis. Proportional widths, anterior to posterior, increasing slightly as follows: 4.3: 4.7: 5: 5.6. Fourth segment posteriorly prolonged over urosome by its round posterior end, which extends slightly beyond caudal rami. Incubatory pouch occupying fourth segment, opening at extreme posterior dorsal margin of metasome. Fifth legs lying at ventral margin of metasome. Articulation between metasome and urosome just behind fifth legs. Urosome (figs. 1c, d, 2e) composed of 5 well-defined segments including modified anal segment, with approximate proportional lengths: 1.7: 2.8: 2.5: 1.4: 2, measured ventrally. Ventral side of first segment provided with genital apparatus, consisting of central vulval opening at proximal fourth of segment and diverging seminal tubes which end in seminal receptacles located dorsally on sides. Caudal rami projecting posterolaterally from dorsal side of anal segment. Body sparsely covered with cuticular hairs as well as transverse rows of fine denticles.

Antennule (fig. 2g) 8-segmented, gradually tapering distally. First segment longer than wide and larger than others, which form a unit bent laterally almost at a right angle upon first segment. Approximate proportional lengths of segments from first to eighth: 6: 2: 2: 1.6: 2: 1: 1: 1.4. All segments with heavy cuticle and with sclerotization of fifth segment suggesting origin in coalescence of 2 subsegments. Setal formula: I-7; II-11; III-8; IV-3; V-3; VI-1; VII-1; VIII-8. In general, setae long and slender; longest on segments I, II, IV and VIII; 3 setae on first segment plumose.

Antenna (figs. 1b, 2h) 3-segmented, with proportional lengths from basal to distal: 7.3: 5: 7. Basal segment bearing 1 well-developed plumose seta

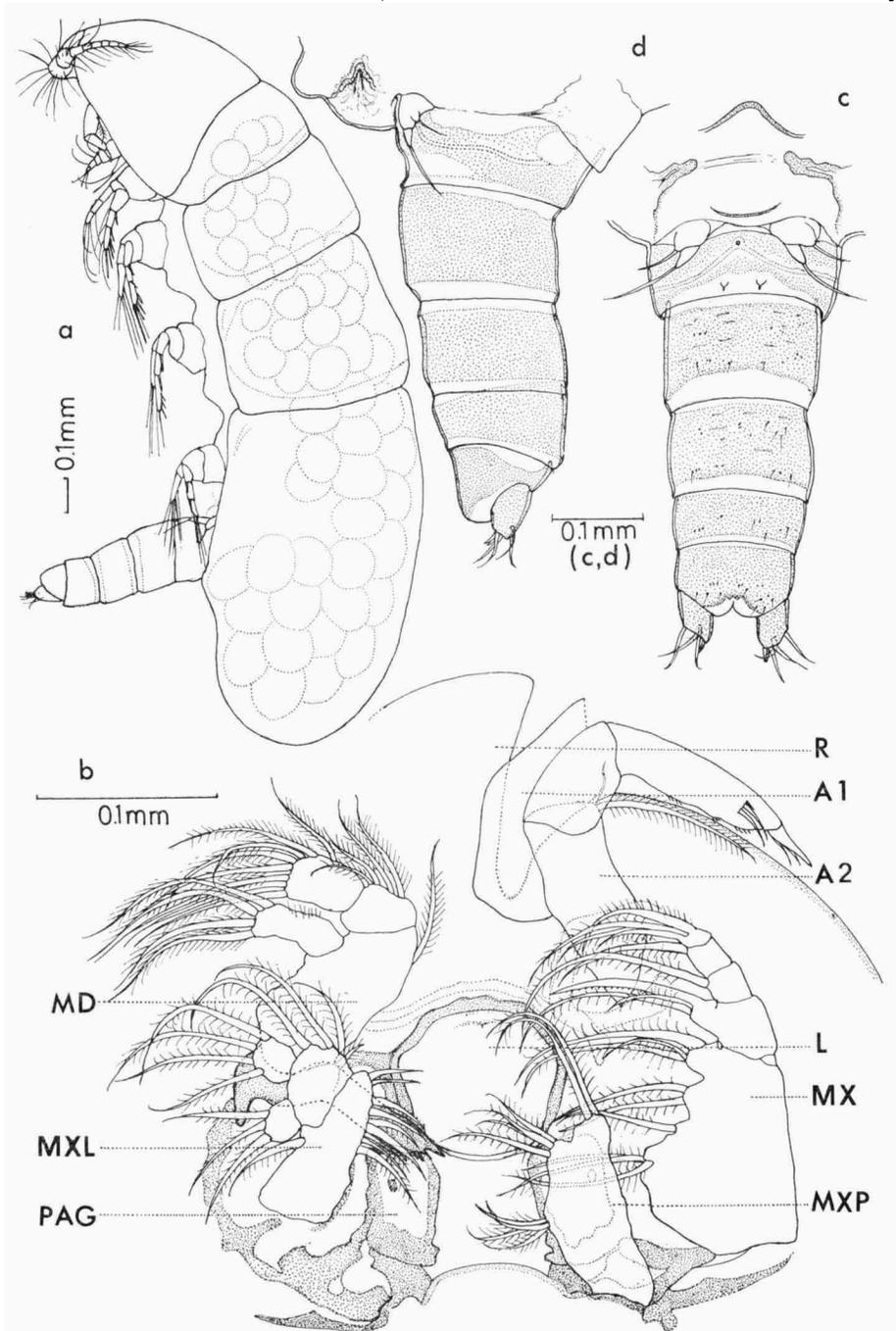


Fig. 1. *Goniodelphys tokiokai* n. sp., female. a, habit, lateral; b, cephalosome, ventral; c, urosome, ventral; d, urosome, lateral.

accompanied by 1 much shorter and non-plumose seta at inner distal corner and a minute setule near outer distal corner. Second segment with 1 short, non-plumose, slender seta at distal fourth on outer margin. Terminal segment provided with single seta at proximal fourth and trio of setae at distal fourth on surface. At apex 1 stout slightly curved, articulated hook, accompanied by 5 setae near base of hook. All setae on this segment non-plumose, short. Outer and inner margins with several rows of spinules.

Mandible (figs. 1b, 2i) consisting of bimerous protopod articulated with bimerous endopod and unimerous exopod. Medial margin of masticatory lamella of coxa (fig. 2j) cut into 1 distal strong tooth, array of 6 smaller teeth, accompanied by 7 spinules, which project from opposite side of tooth array, and 2 proximal plumose setules, the more proximal separated widely. Basis bearing 1 seta at about distal fourth of medial margin. First segment of endopod shorter than second, and bearing 4 short, slender setae at medio-distal corner. Second segment with 9 setae arranged along medial and distal margins; 5 setae of those on distal margin long, stout, remaining setae reduced to about half such dimensions. Exopod much longer than wide, with 4 subequal long setae on distal margin. All setae plumose.

Paragnath (figs. 1b, 2k) characteristic sclerotized, conical tubercle with a few terminal posteriorly-directed notches and hairy on medial side; located between mandible and maxillule, but closer to maxillule and nearer midline than mouthpart series.

Maxillule (figs. 1b, 3l) composed of bimerous protopod and unimerous rami. Epipod represented by 1 long seta. Proximal major endite of coxa armed with a row of 9 elements consisting of 3 barbed spiniform setae and 6 graded setae on medial margin; second endite small, extending as a tapering seta. Basis bearing 3 distally-directed graded setae on terminal margin. Endopod and exopod provided with 4 and 3 long subequal setae, respectively. All setae plumose.

Maxilla (figs. 1b, 3m) 5-segmented. Basal segment occupying more than half of entire length, with 4 setiferous endites; first endite with 3, second with 1, third with 2 and fourth with 2 long setae and 1 slender, reduced proximal seta. Second segment produced medially into a relatively weak, slender, barbed, falcate process, from whose base a long and a short seta arise. Third and fourth segments each wider than long and with 1 long seta at mediobasal corner. Fifth segment smallest, with 4 setae along medial and terminal margins; proximalmost extremely short and slender.

Maxilliped (figs. 1b, 3n) unimerous, with integumentary fold between basal large portion and terminal small lobe. Basal portion armed on medial margin with 8 setae divided into 2 groups of 4 proximal and 4 distal; surface with

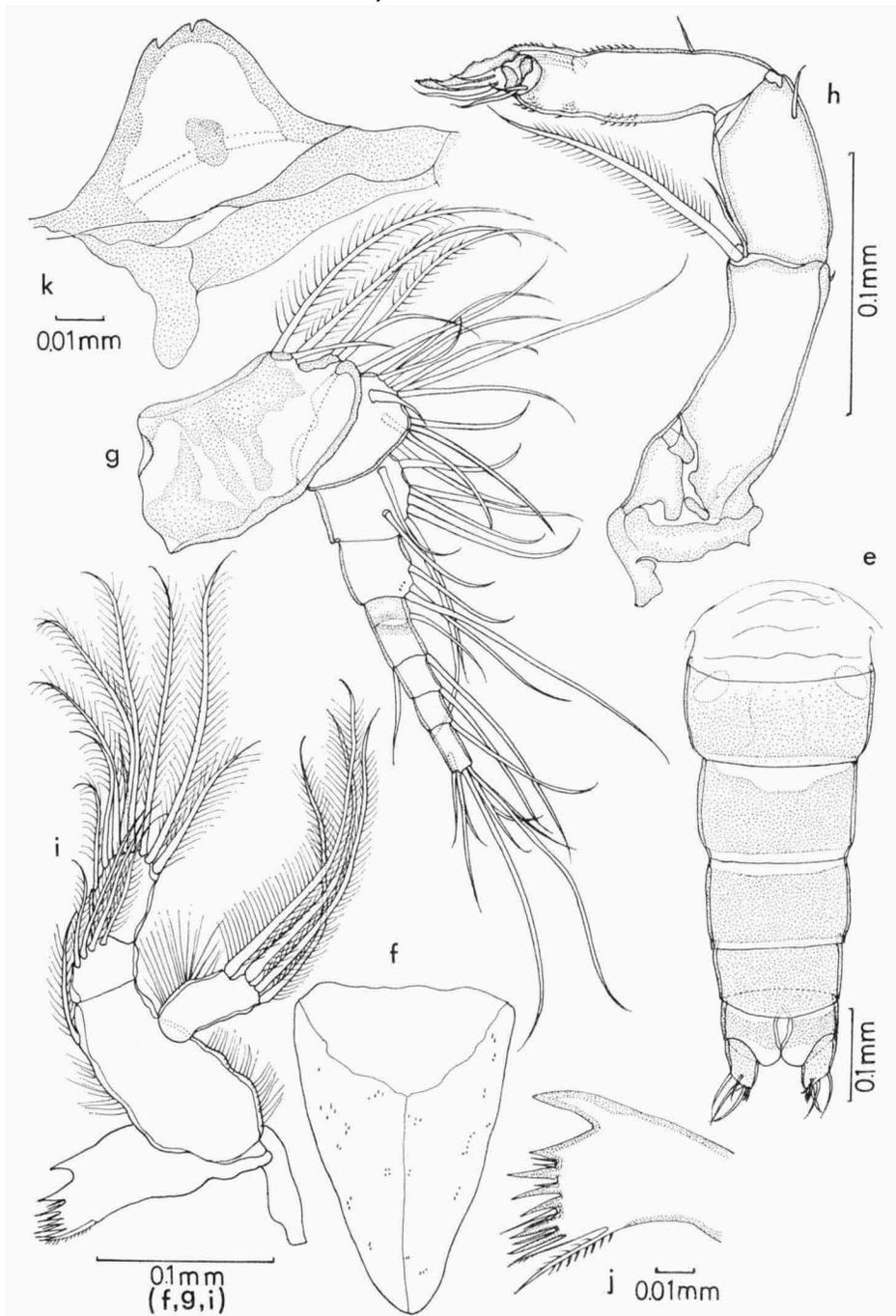


Fig. 2. *Goniodelphys tokiokai* n. sp., female. e, urosome, dorsal; f, rostrum, posterior; g, antennule, right, dorsal; h, antenna, right, posterior; i, mandible, left, posterior; j, masticatory lamella, left, posterior; k, paragnath, right, outer-lateral.

hairs. Terminal lobe tipped by 2 long setae at apex and with hairs on medial margin. All setae plumose.

First leg (fig. 3 o) composed of 2-segmented protopod and 3-segmented rami of unequal length. Intercoxal plate well-developed, trapezoidal. No seta on coxa. Basis bearing a barbed spine accompanied by basal spinules at medio-distal corner and 1 short seta on lateral margin. Endopod smaller than and about two-thirds as long as exopod, bearing 6 setae in all: no seta on first segment; 1 medial seta on second segment; 2 medial, 2 terminal setae and 1 lateral seta on third segment. Exopod provided with 4 setae, 1 setule and 6 spines in all: basal 2 segments each with 1 medial seta and 1 lateral spine; terminal segment 2 medial setae, 2 terminal spines (setiform), 2 lateral spines and 1 lateral setule. All setae plumose. Bases of all spines of exopod accompanied by a few denticles or spinules. Distal or medial margins of segments partially ornamented with rows of spinules.

Second leg (fig. 3 p) consisting of bimerous protopod and endopod and trimerous exopod. Intercoxal plate much smaller than in preceding leg. No seta on coxa. Basis with 1 short seta on lateral margin. Endopod about three-fourths as long as exopod, with 10 setae. Basal segment about as long as wide, with 1 medial seta at distal corner. Second segment 2.75 times as long as basal segment, with 6 medial, 2 terminal setae and 1 lateral seta. Exopod armed with 8 spines and 3 setae: basal 2 segments each with 1 lateral spine and 1 medial seta; terminal segment with 3 lateral, 2 terminal and 1 medial spine and 2 medial setae. All setae plumose. Spines grading toward setiform construction from basal to apical.

Third leg (fig. 3 q) resembles second, though reduced in armature of rami: second segment of endopod and third segment of exopod lacking 1 medial seta and 1 lateral spine, respectively. Thus, endopod with 9 setae and exopod with 7 spines and 3 setae in all.

Fourth leg (fig. 4 r) more reduced in armature and size in comparison with third leg. In general, setae showing tendency to lack plumosity and to be shorter. Endopod with 7 setiform spines and 3 setae (third segment lacking 1 medial seta but second segment with 1 seta).

Fifth leg (figs. 1 c, d, 4 s) 2-segmented. Basal segment wider than long, laterally projecting into small cone tipped with 1 long, non-plumose seta. Second segment subcylindrical, twice as long as wide, with 1 terminal seta, similar to but much longer than basal seta. Rows of setule-like elements ornamenting medial margin of second segment.

Caudal ramus (fig. 4 t, u) relatively short and truncated at apex. Armature of 2 claws and 4 setae: close-set ventral spiniform and dorsal setiform claws near inner distal corner and 2 more lateral setae articulated on terminal

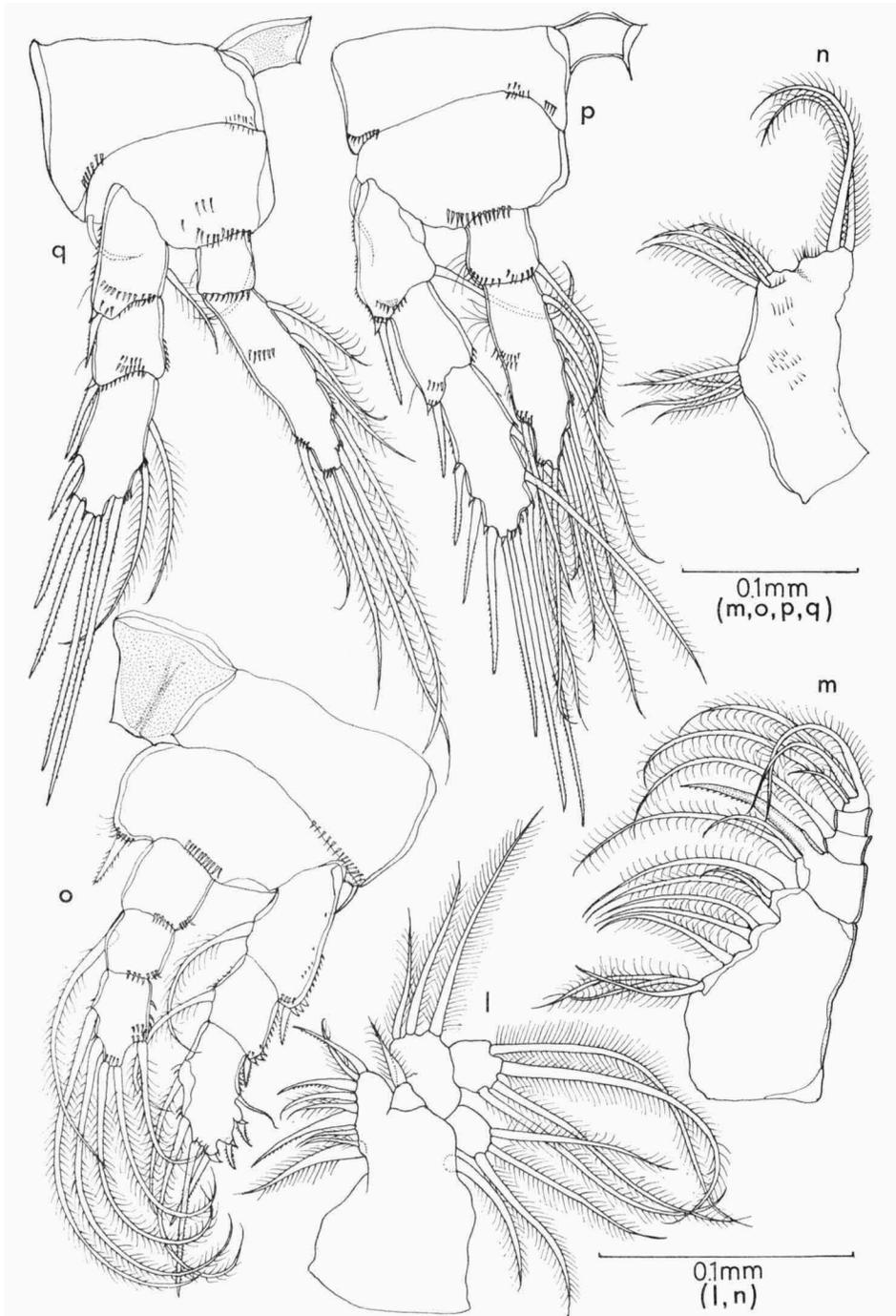


Fig. 3. *Goniodelphys tokiokai* n. sp., female. l, maxillule, right, anterior; m, maxilla, left, posterior; n, maxilliped, left, posterior; o, 1st leg, left, anterior; p, 2nd leg, right, anterior; q, 3rd leg, right, anterior.

margin; 1 lateral seta at distal fourth and 1 dorsal seta at same level inserted on surface. All setae subequal, non-plumose and twice as long as claws.

Remarks. — The new form has presented problems in generic assignment. Obviously related copepods have been described in the genera *Botachus* Thorell, 1859, *Goniodelphys* Buchholz, 1869, *Bonnierilla* Canu, 1891, *Notopterophoroides* Schellenberg, 1922, *Ustina* Illg, 1951 (see synonymies in Illg, 1958). Information on most of the species in these genera as so far published has been inadequate for developing a satisfactory taxonomic disposition of the whole series. A number of the species were proposed without definite knowledge of the host association, and all with very little information on the life history and sexual dimorphism. The distinguishing characters so far invoked can readily be seen also to have involved largely characteristics directly related to the dimorphic variation between the sexes or in a considerable number of instances to be actual sexual adaptations of the female. The male has not been described. Generic lines so far indicated have involved the very unsatisfactory bases of overall habitus of the female, segmentation of the swimming legs, and other features which are part of the exaggerated modifications of the female related to the habitat and the related specialized reproductive processes. For this and perhaps other reasons the taxonomy of the whole family of these copepods has been complicated by dependence on recurring convergent characters which are apparent upon very little reflection as stemming from the highly adaptive morphological features which have been invoked.

Botachus Thorell, 1859, is the oldest genus which by its characters is clearly related to the new species. There are many specific differences, however. In the treatment of Stock (1967) *Goniodelphys trigona* Buchholz, 1869, and *Notopterophoroides malacodermatus* Schellenberg, 1922, were added to the original species, *B. cylindratus* Thorell, 1859. The expanded generic concept was not diagnosed in Stock's presentation — except perhaps by implication in a key, which, however, is meaningless taxonomically. Such a definition of *Botachus* to include the species listed would present a generic diagnosis broad enough to encompass our new species, and also, surely, *Notopterophoroides armadillo* Schellenberg, 1922, and *Ustina clarki* Illg, 1951, which species Stock combined in the older genus *Notopterophoroides*. In several published papers one of us and a colleague (Illg, 1951; Illg & Dudley, 1961, 1965) pointed out difficulties of generic allocation of the species mentioned above. We emphasized the points now just repeated of deficiencies of morphological and bio-ecological information concerning most of the species. The treatment of Stock suffers from the disadvantage of this lack of information. His paper gives no indication that he had new data or that he

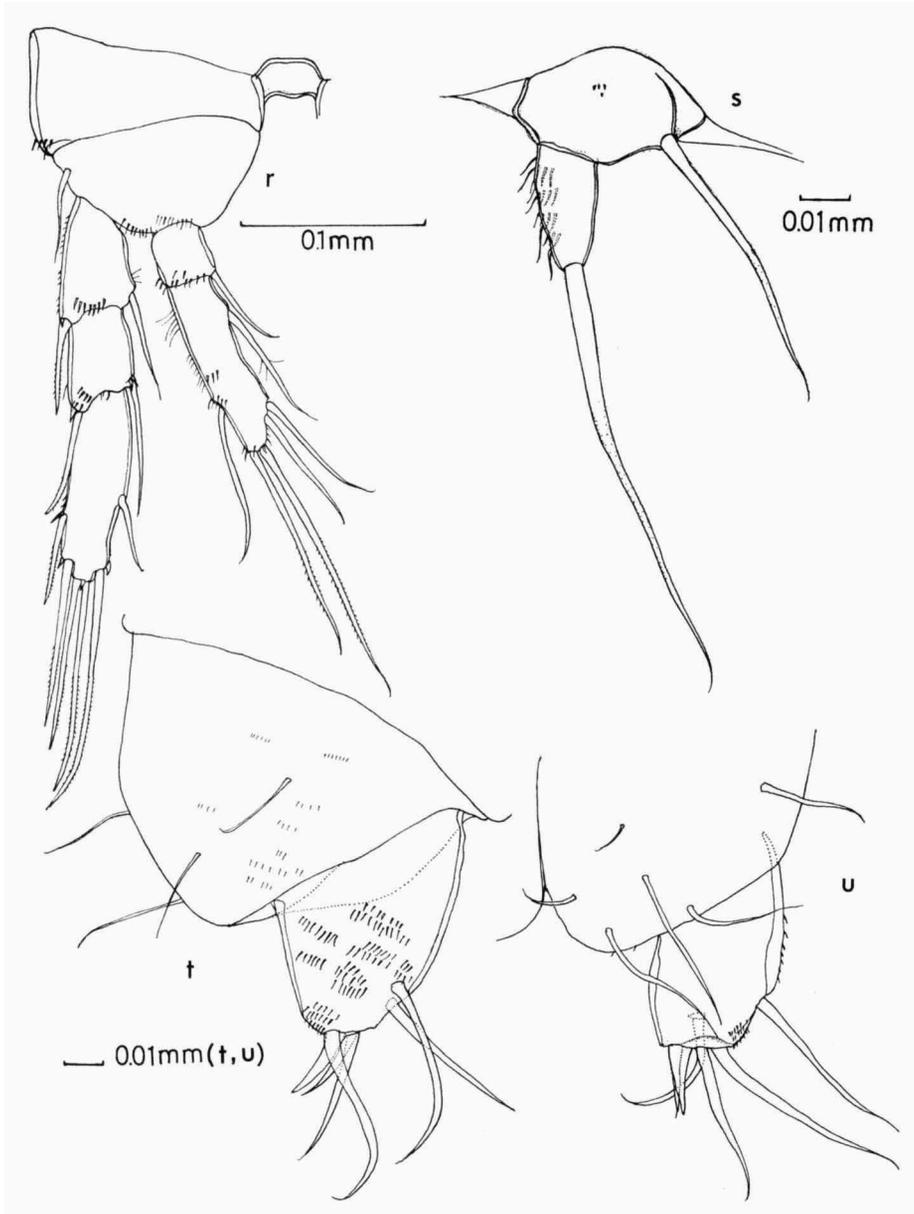


Fig. 4. *Goniodelphys tokiokai* n. sp., female. r, 4th leg, right, anterior; s, 5th leg, left, anterior; t, caudal ramus, left, lateral; u, caudal ramus, left, ventral.

studied actual specimens of any of the species concerned. We consider that his treatment does not resolve the taxonomic difficulties and so once again

reassign some of the species, although we are most hesitant to initiate further name-changing in such poorly known organisms.

The copepods most closely related to the new form on the bases of overall similarities of females would be *Gomiodelphys trigona* Buchholz, 1869, and *Ustina clarki* Illg, 1951. The original description of the former was lacking in details of the structure of the appendages, but a very good overall idea of the habitus of the female and male was developed. Comparison on the basis of the very primitive original description, which also did not identify the host ascidian, would not be significant. Our considerations in this connection have been made possible by the development of fuller information. In 1965 Illg & Dudley described an immature specimen of *G. trigona* and determined the host, for the first time, at Naples, as *Ascidiella aspersa* (Müller). Our material now includes adults from *A. aspersa* from the Gulf of Trieste, in the vicinity of Portorož, Yugoslavia. Specimens were collected directly by one of us (P.L.I.) by use of facilities furnished through Dr. Jože Štirn; additional specimens and the identifications of the tunicate were supplied by M. and Mme. C. Monnot, from collections of Dr. Štirn. We have restudied the original description of Buchholz and now for the first time since his paper have been able to observe adult males and females. Our survey demonstrates that the individual described by Illg & Dudley (1965) was a fifth-stage male copepodid. It differs from the adult condition in several features. There is relatively little dimorphism, other than size, in the species, so the emended information in comparison to the subadult is relatively minor, but significant for our taxonomy in several particulars. The antennule of stage V and adult males is roughly equivalent in segmentation; in the adult female the segmentation is the same but the appendage is stouter and in general more developed. A number of setules of the young male are replaced by substantial setae in the adults. The adult male has about the same setation as the female but the setae are shorter and less ornamented. The other head appendages are approximately similar throughout except in relation to absolute size differences, but in the maxilliped there is a major alteration from the subadult to the adult condition. In the stage V the two groups of setae on the medial margin of the proximal portion of the appendage consist of three each; in the adults there are 4 setae in each of these groups. In the stage V male the first legs have both rami trimerous. There is a slightly differentiated segmentation of these rami in the adults. The adult male has the same condition as the stage V. The adult female has the exopod trimerous, with the endopod modified by suppression of the basic trimery to a functional bimery, although faint articulative lines persist to demarcate the elements. The second to fourth legs of the female are segmented as in the stage V but

the segments tend to greater elongation and the setae are more developed. The segmentation and the setation of these appendages correspond very closely in the adult and stage V males. The fifth legs are reasonably similar in the subadult and adults, allowing for overall size differences. The adult female lacks sixth legs. In the adult male the terminal plates of the sixth legs are perhaps even more elongate than in the stage V male. In the urosome the adults differ considerably from the subadult. In both sexes segments are added; the terminal element becomes cuticularized and expanded in a plate-like development, strongly suggesting that of *Ustina clarki*, but not quite so exaggerated. Interestingly, this element of the subadult resembles much more closely our new species than do either of the adults of *G. trigona*. In the latter the caudal rami are inserted very proximally on the terminal element, just at the point of its articulation with the next anterior segment. In both sexes the rami develop strong cuticularization and the two terminal claw-like elements become much heavier than in the subadult. In the female there are two major claws, terminal and subterminal, and two more proximal setae. There is perhaps an auxiliary terminal setule. In the male there are the two terminal and subterminal claws, terminal setule, and more proximally two setae. In addition we have found a most unexpected confirmation of Buchholz' remarkable observation of the similarity in general habitus of the male to the female, including posterior prolongation of the last metasomal segment, simulating to a degree the prolongation of the brood sack of the female.

A copepod which has been pointed out (Illg & Dudley, 1961, 1965) as related to *G. trigona* and *U. clarki* was described as *Bonnierilla arcuata* by Brément (1909). Stock proposed a genus *Periproctia* (1967) to which we hereby assign the species of Brément. We discuss below bases of separation of this genus from the genus including our new species.

The species described by Schellenberg in *Notopterophoroides* (1922) continue to be a problem. They are distinguishable from each of the genera discussed above and our new species on some basis or other, as given in Schellenberg's original descriptions. However, they associate only very tenuously with each other. Details of mouthparts and legs are lacking or need re-examination. Using the statements of Schellenberg as indications there are perhaps reasonable bases to maintain these species in his genus. Alternatively the species would be assignable to *Goniodelphys* with only slight emendation to the generic diagnosis we propose here, and with still very substantial bases for maintaining the separation of *Botachus* and *Goniodelphys* in such a wide sense. However, we feel re-allocation of the *Notopterophoroides* species must be left to the future when more information on them becomes available.

The description of *Ustina clarki* Illg (1951) was minimal for current com-

parisons, but essential information was presented, and the features of the male at least indicated. In the present study the type material was re-examined for comparison with the new species. At this time it is pertinent to record that the name of the host can now be furnished by courtesy of Dr. Tokioka. The material is from the collections of the United States National Museum, Catalogue Number 11780, *Herdmania momus* (Savigny), collected by the Steamer "Albatross" off Honshu Island, Japan, May 5, 1900. From the specimens of this number additional topotypes were extracted for our study. Our reference of the species to *Goniodelphys* constitutes a new combination.

As is mainly indicated above, we conclude on the basis of the literature and our restudy of the material available to us the following. *Botachus* should be re-established as monotypic. *Goniodelphys* receives *Ustina clarki* Illg and the new species here described. *Notopterophoroides* reverts to the two species originally included by Schellenberg. *Bonnierilla arcuata* Brément is transferred to *Periproctia*, a new combination.

We offer some points here to substantiate our maintenance of *Botachus* as a separate genus. It is a most distinctive copepod type. There is so far a single known species, although Hesse (1869 — see synonymies in Illg, 1958) proposed other names, which remain indeterminable species. Many of the characters of *B. cylindratus* Thorell are similar to those of the species of *Goniodelphys* but there remain substantial differences. The habitus of adult females is different, *Botachus* being very fusiform, with a tendency to depression rather than compression. The species of *Goniodelphys* show strong compression, as do all the species discussed above, except perhaps the very modified forms in the genus *Periproctia*.

The antennule of *Botachus* is 7-segmented; in the species of *Goniodelphys* the antennule is 8-segmented. There is a difference between the genera in the disposition of setae and aesthetes on the appendage, with a strong suggestion that there are two lines of different basic segmental composition. Although *Botachus* has one less clearly articulated segment, the appendage bears a substantially greater number of setae and aesthetes than in any *Goniodelphys* species, and with different distribution by segments. The basal segment is distinctive in bearing 4 setae in *Botachus*, 7 in *Goniodelphys*.

The mandible is distinctive in *Botachus* in the degree of suppression of the endopodite, although there is a strong trend toward this condition in the species of *Goniodelphys*. However, there is no doubt that in *Botachus* the element is unimerous; in *Goniodelphys* the bimery is complete or very slightly suppressed, with full indication retained.

The maxillule of *Botachus* is highly characteristic, with few cases of similarly arranged appendages known among other notodelphyids. The

endopod bears 3 setae, the exopod 4 setae. The *Goniodelphys* species have endopods with 4 setae, exopods with 3.

In the swimming legs *Botachus* and *Goniodelphys* share in a trend of coalescence of endopod segments and in the absence of a seta on the first (and some other) coxopodites. *Botachus* is highly exceptional in lacking a medial spine on the basipodite of the first legs. This feature is almost always present in other notodelphyids, except where the legs are extremely degenerated.

The fifth legs vaguely suggest a somewhat different basic anatomy in the two genera, but in any case are so reduced that the comparison is not very informative in the absence of details of the course of development. The caudal ramus is a completely distinctive structure in *Botachus*; it serves to identify the copepod at a glance. The ramus is drawn ventrally into a peculiar finger-like process, this ornamented terminally with fine spinules and supporting subterminally on its lateral surface a relatively elongate seta. The dorsal portion of the apex of the ramus supports two hooks, usually subequal, but the ventral hook may be only two-thirds as long as the dorsal. There are additional setules and setae. This very specific pattern in this genus remains merely a modification within the consistent pattern of prehensile adaptation of the caudal rami occurring in all the forms discussed here.

Periproctia is distinctive among the genera accepted here in the feature of the female incubatory sack. It encompasses the segments bearing the second through the fifth legs. In all the other genera the incubatorium occupies principally the segment of the fourth legs. The mandible is probably differentiated in the advanced degree of reduction of segmentation and setation of the endopod. The swimming legs have a characteristic pattern of fusion of segments of endopods — in all they are 2-segmented. The posterior pairs of legs are asymmetrical. The hosts are compound ascidians, mostly of the family Didemnidae; there is one known occurrence from a botryllid. All the other copepods dealt with here are associated with simple ascidians.

Goniodelphys is characterized by a rigid body form of the female, deriving from very heavy overall cuticularization of the integument. The feature is shared only with the species of *Notopterophoroides* among the forms dealt with in our discussion. The antennular composition, in segmentation and setation is probably distinctive. We have pointed out above a definite difference from *Botachus*. A somewhat comparable tendency to fusion of segments is pronounced in *Periproctia*, thus differing in degree, and furthermore, the indications from setation counts are that the appendage is basically different anatomically.

The mandible is perhaps the least modified among those of the related

genera, particularly expressed in the retention of more substantial endopod development. The swimming legs 1-4 participate in the trend to modification seen in our whole series and the characters seem to emerge only at the specific level. The fifth legs are reduced and offer differences from the other forms only at the specific level. The same differentiation would extend to the terminal abdominal segment and the caudal rami.

The only particular characters emerging for diagnostic separation of the genus *Notopterophoroides* would be in difference of brood pouch from *Periproctia*; in overall habitus from *Botachus*, and also in the many specific details mentioned above as distinctive for the latter genus; separation from *Goniodelphys* by segmentation of the antennule, differing proportions of the segments of the antennae, perhaps in some details of the mouthparts, and of the swimming legs, although these and the above features would have to be substantiated by restudy of specimens when they become available.

It remains to be seen how discovery and description of the males of all the species will affect the generic disposition. As in so many other cases, the male of *Goniodelphys tokiokai* remains unknown.

G. tokiokai is immediately distinguishable among the species of the genus now known by many features. Particularly salient are the 4 setae of the mandibular exopod, contrasting with the usual 5; the very feebly developed prehensile character of the circumanal ring, the caudal ramus, and its terminal claws. In this feature the species is by far the least specialized among species so far described in *Botachus*, *Goniodelphys*, *Notopterophoroides*, and *Periproctica*, and indeed offers a transitional condition to some of the less modified notodelphyids.

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