

**TAXONOMIC CHARACTERS IN THE MORPHOLOGY
OF THE GENUS *EURYCOPE* (ISOPODA ASELLOTA),
WITH A REDESCRIPTION
OF *EURYCOPE CORNUTA* G. O. SARS, 1864**

by

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Résumé

Caractères taxonomiques du genre *Eurycope* (Isopoda Asellota), avec
une redescription de *E. cornuta* G. O. Sars.

Les Asellotes de la famille Eurycopidae dominent souvent dans les récoltes d'Isopodes de profondeur. Le principal genre de cette famille, *Eurycope*, renferme un grand nombre d'espèces morphologiques indiquant un besoin d'une révision générale. La présente note offre une méthodologie utile et une discussion des caractères taxonomiques, surtout de ceux qu'on a peu utilisés dans la littérature récente. *Eurycope cornuta* Sars (1864), type du genre, récolté en Norvège et dans l'Atlantique, loin des côtes des Etats-L'nis, est l'exemple central de ces descriptions morphologiques. Les données comparatives sont tirées de la grande collection d'Isopodes benthiques conservée dans notre laboratoire. La valeur systématique de la forme à trois dimensions du céphalon et de certains caractères somatiques est soulignée, un certain nombre de comparaisons étant très difficiles en l'absence de ces renseignements. La succession des variations morphologiques des groupes compris à l'heure actuelle dans le genre *Eurycope*, est discutée pour chaque caractère. En vue des révisions futures vraisemblables, *E. cornuta* est redécrit et sa distribution géographique est remise à jour.

Introduction

The Eurycopidae Hansen (1916) is an important taxon represented by a considerable number of deep-sea species and an interesting range of morphologies. This family is both taxonomically diverse and numerically abundant in deep-sea samples: 97 percent of those deep-sea epibenthic sled samples having more than 20 individuals yield eurycopids, and there may be as many as 25 species at a single station (unpublished data).

The current classification recognizes four subfamilies: Eurycopinae, Acanthocopinae, Bathyopsurinae and Syneurycopinae. Except for the Eurycopinae, these subfamilies are each morphologically restricted in breadth. Furthermore, all have been the subject of recent treatment: Acanthocopinae by Chardy (1972); Bathyopsurinae by Wolff (1962); Syneurycopinae by Haugness and Hessler (1980). The Eurycopinae contains six genera beyond the type genus: *Betamorpha*, *Lipomera*, *Munneurycope*, *Munnopsurus*, *Munnicope* and *Storlhyngura*. All six genera have narrow morphological

ranges and only *Storhyngura* has any number of described species, although new ones are gradually appearing for all of them.

In contrast to the condition of the above taxa is that of the central genus, *Eurycope* Sars 1864, which is a large, heterogeneous assemblage. Since establishment, it has accumulated 52 nominal species showing a broad range of morphologies. Although *Eurycope* cannot be regarded as completely neglected (Hansen, 1916; Menzies, 1962; Wolff, 1962), it still gives residence to important taxonomic problems. Historical review of the study of deep-sea isopods reveals a general reluctance to conduct super-specific revisionary work (e.g., see Menzies, 1962; Birstein, 1963; Menzies and George, 1972; Chardy, 1977) in spite of the morphological diversity that each of the traditional taxa is forced to subsume. As a result, some of the more important genera, such as *Eurycope*, have become ill-defined. One of the major causes for this situation is the frequent ambiguity of published descriptions (including some post-1970 papers).

In order to place future descriptions on a firm and non-ambiguous basis, the taxonomically important morphology of species of *Eurycope* is discussed, using *E. cornuta* as a model for comparison. The comparative data comes from a survey of all the species of *Eurycope* (*sensu lato*) in the collection curated by this laboratory (see Materials and methods below). These data clarify the critical need to introduce into eurycopine classification the use of detailed three-dimensional morphology, without which important taxonomic decisions cannot be made. Future papers will revise *Eurycope* and discuss problems of evolution, biogeography and interpopulation variation. As a first step toward the eventual revision of *Eurycope*, the last section provides a detailed redescription of *Eurycope cornuta* G. O. Sars 1864, the type species for the genus and the taxon around which all higher level taxa may be arranged in the family Eurycopidae.

Materials and Methods

The specimens of *Eurycope cornuta* used for this study came from the localities listed in Table 1. The Scandinavian specimens were collected by Robert R. Hessler with a Beyer net-sled.

TABLE 1
Eurycope cornuta localities of specimens used in this study.

Geographic area	Latitude	Longitude	Depth
Norway			
Hjelte Fjord	60°34.5'N	4°53'E	circa 250 m
Herdla Fjord	60°32.3'N	5°03'E	circa 250 m
Off New England, USA			
WHOI Sta. 96	39°55'N	70°40'W	498 m
105	39°57'N	71°04'W	530 m
207	39°51'N	70°55'W	808 m

The information on taxonomic characters came from a survey of the species of *Eurycope* (*sensu lato*) found in the collection curated by this laboratory. Much of this material was collected by the Woods Hole Oceanographic Institution (WHOI) deep-sea benthic sampling program directed by Howard Sanders, Robert Hessler and Frederick Grassle (Sanders *et al.*, 1965; Hessler and Sanders, 1967; Sanders and Hessler, 1969). This program has made a series of sampling transects throughout the Atlantic Ocean from shelf depths into the abyss of the following basins: North America (Gay Head-Bermuda transect), Guiana, Brazil, Argentina, Cape, Angola, Cape Verde, West Europe, Mediterranean. Additional samples have come from the Bay of Biscay (John Allen, Millport marine biological

Laboratories, Isle of Cumbrae, Scotland), Canaries Basin (J. Allen), the Weddell Sea (John Rankin, University of Connecticut). Species of *Eurycope* have been found at 117 stations (Fig. 1) with a total count of 7,495 individuals. 26 stations have more than 100 individuals and 41 stations

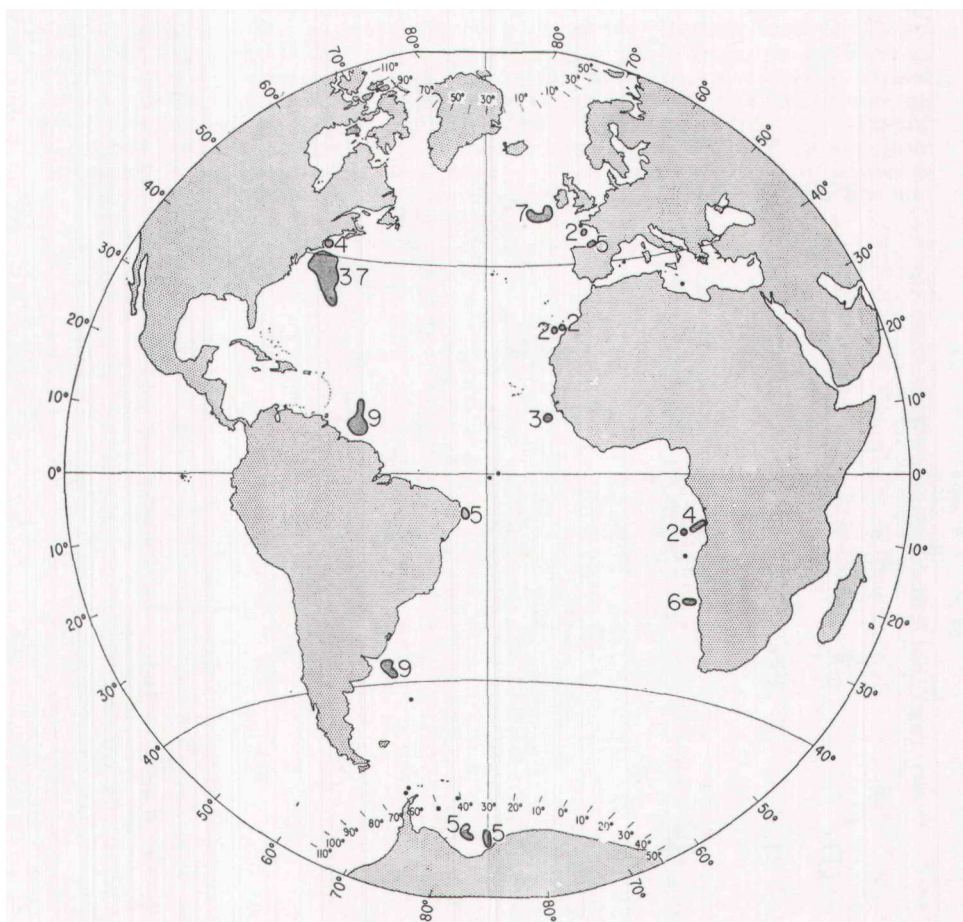


FIG. 1

Localities for specimens examined in this study. Closed circles are single samples.

Numerals indicate the number of samples from adjacent shaded areas.

have five or more species. The survey, which collected information on the diagnostic characters and variability in each species, yielded no less than 75 Atlantic species of *Eurycope*.

This study was conducted with a Wild M20 compound microscope and a Wild M5 dissecting microscope, both fitted with camera lucida drawing devices. Camera lucida drawings are preferred over those made using microprojectors because the latter technique often loses important three-dimensional detail as seen in several recent publications on eurycopids. For species comparisons during the survey, diagnostic characters were photographed with a Wild polaroid camera system. Specimens were immersed in ethylene glycol for illustration and photography. In order to avoid unnatural representations of morphology, care was taken to avoid crushing or distorting the specimen under the cover slip.

Measurements were conducted according to Hessler (1970) with the following additions and amendments (Fig. 2). Total length measurements were made from the tip of the pleotelson to the frons or rostrum, whichever

is most anterior. Including the more flexible labrum into this measurement introduces unnecessary variability. Rostral lengths and widths were compared against cephalic width because the length is variable, depending on the flexion of the cephalon. Rostral width was measured anteriorly and the length was obtained as the sagittal distance from its most anterior point, whether medially or on the cephalic keels, to a line defined by the posteriormost extent of the cephalic anterior margin. Body depth measurements were made perpendicular to the body axis which is generally a curved line. The mandibular body length was obtained from the dorsal plan view as the linear distance between the incisor and the posterolateral projection. The female pleopod II depth is defined as the perpendicular distance between the apex and the plane which passes through the distal tip and the lateral points of articulation of the operculum.

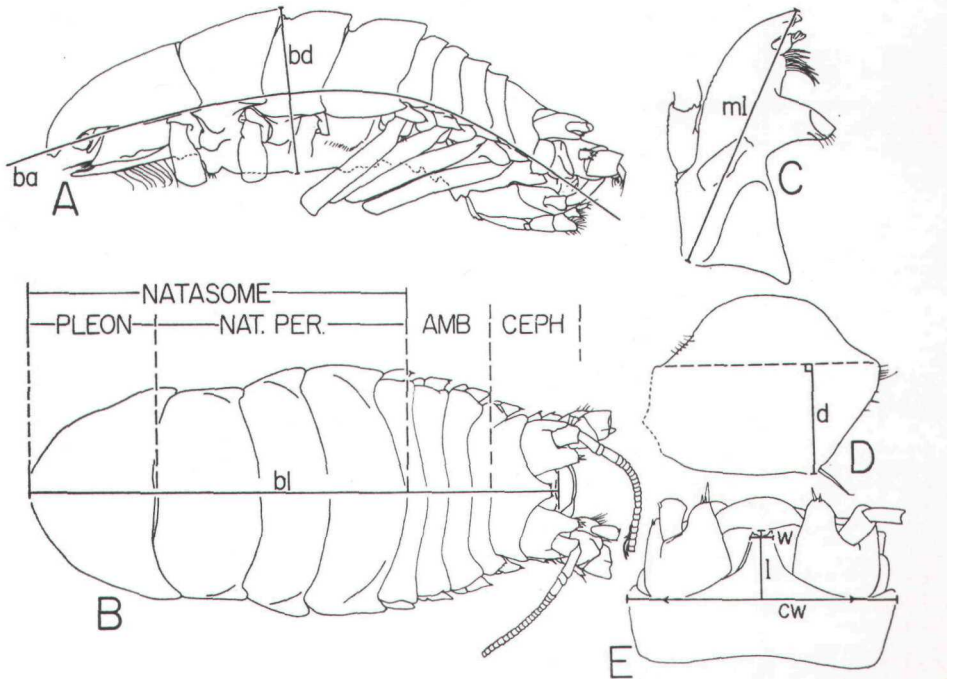


FIG. 2

Eurycopid body plan and various measurements.

A, body lateral view: body axis (ba), body depth (bd). B, body dorsal view illustrating divisions: cephalon (ceph.), ambulatory pereonites or ambulosome (amb.), natasome, natatory pereonites (nat. per.), pleon. C, mandibular body length (ml). D, female pleopod II depth (d). E, cephalic measurements: anterior rostrum width (w), rostrum length (l), maximum width of cephalon (cw).

MORPHOLOGY

Somatic characters

The organization of the eurycopid body is quite distinctive and represents a great evolutionary innovation in the Janiroidea which gave rise to the extant genera of this family as well as those of the Munnopsidae and the Ilyarachnidae (Kussakin, 1973; Hessler and Thistle, 1975). Four

separate tagma can be recognized (Fig. 2B): (1) the *cephalon* that bears the antennae, the cephalic mouthparts and the first thoracopod (maxilliped); (2) the *ambulosome* consisting of the first four pereonites (thoracic somites 2-5); (3) the *natatory pereonites* 5-7 (thoracomeres C-8) and (4) the *pleon* or *pleotelson*. The natatory pereonites and the pleon comprise the *natasome* (Hessler and Thistle, 1975) which functions as a unit to stream-

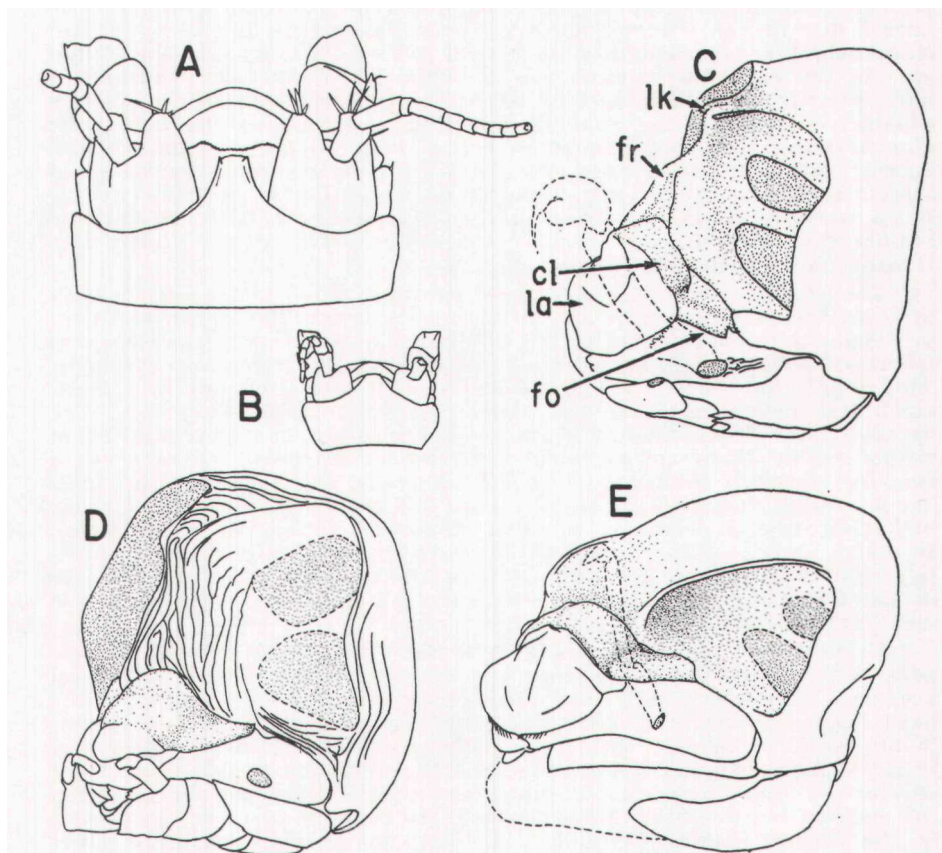


FIG. 3

Cephalic morphology.

A-C, *Eurycope cornuta*. A-B, adult female and manca stage 1, illustrating developmental changes. C-E, anterolateral oblique views of "face", antennules and antennae removed. C, cephalic keels (lk), frons (fr), clypeus (cl), labrum (la), fossa (fo). D, *E. phallangium*, cuticular ridges shown. E, *E. parva*.

line and propel the animal through the water. Because of the importance of hydrodynamic effects on a swimming animal, the shape of the body is likely to be subject to strong selective pressures. Bearing this in mind, one should suspect the rich morphological variability of eurycopid species as being lifestyle indicators. Most existing descriptions do not fully illustrate the three-dimensional morphology of these taxa; often only a simple dorsal view is offered. The following subsections emphasize the three-dimensional aspects of species of *Eurycope*.

Cephalon.—The head of *Eurycope* has a complex morphology but it is this feature that makes it valuable in discerning species (Fig. 3C-E), just as the human face is important in the recognition of individual people. Because the proximal portions of the antennae obscure facial features, it is often helpful to remove them on one side before making a careful examina-

tion. A simple dorsal view of this structure does not reveal much of the morphological diversity present in the genus, because vertical detail of the rostrum and the ventrally adjacent frons can be missed.

In addition to the mouthparts and antennae, there are several parts or areas of the head that are important (Fig. 3C). The *rostrum* is a projecting frontal area of the dorsal surface which is always present but extremely variable within *Eurycope* as has been noted by previous authors. The lateral margins of the rostrum sometimes have *cephalic keels*, vertical ridges which are extensions of the rostral surface. The frons is the frontal area of the cephalon between the antennae and below the rostrum. A narrow strip of cephalic surface below the antennal sockets can also be considered as part of the frons. Connecting the labrum to the frons is the *clypeus* which forms a supporting bridge between the mandibles. The lateral portion of the clypeus articulates with the mandible by means of a *fossa* or groove in the ventral surface on which the mandibular condyle slides (see description of the mandible below). Lateral to the clypeus are anterior projections of the lateral cephalic surface that are sometimes valuable in distinguishing various species.

The rostrum of *Eurycope cornuta* is rather small and quadrate with little overhang (the extent to which it projects beyond the frons), and with very small anterior cephalic keels. Other species can vary in the following features: width, length, cephalic keel development or spination, overhang, and/or anterior notch. The frons and the clypeus seem not to vary as much and may identify various groups of species within *Eurycope*. The height of the frons, degree of anterior projection and development of ridges on the frons are pertinent parameters. *Eurycope cornuta* has a rounded, inverted V-shaped ridge that projects anteriorly and occupies much of the anterior surface. In some species this ridge can become higher, broader and heavily calcified, somewhat similar to *Munnopsurus*. In others, such as *E. parva*, the distinctness of the frons is almost completely eliminated because the rostrum slopes down to the clypeus. Changes in the frons and clypeus sometimes correspond to modifications in the mandibular structure.

Using the above characters it is possible to unambiguously identify practically all species of *Eurycope* and related genera. This is important because often a species will be represented in poor deep-sea samples by only head fragments. On the other hand, the face and rostrum of a species is not exactly the same in all individuals. There is often ontogenetic (Fig. 3A, B), sexual and individual variation within a definable range for a species that could conceivably cause taxonomic confusion. In *E. cornuta*, the rostrum is rather broad, rounded and lacking the small cephalic keels in the earliest stages. With age, the rostrum becomes narrower, more quadrate, and the keels appear. The rostrum of females is often longer with some overhang than in males which have no apparent overhang. This type of variation which had been noted by Hult (1941) is found in other species as well.

Ambulatory pereonites.—In most species of *Eurycope* the mid-sagittal length of the first four pereonites is much shorter than that of the natatory pereonites; they are also generally subequal to one another, as is the case in *E. cornuta*. A few species exhibit an enlarged first pereonite and/or a reduced fourth pereonite similar to *E. nodosa*. Most species have anterior pereonites that are transversely narrower than the posterior pereonites, but in those species that are related to *Munneurycope* and others, the fourth pereonite may be equal in width or slightly larger than the fifth pereonite.

Natatory pereonites.—The most characteristic feature of eurycopids is the enlargement and muscularization of pereonites 5, 6 and 7 to power the natatory appendages. Most typically pereonite 5 is the widest and pereonite 7 is the longest. However, these segments undergo much modification within the whole suite of *Eurycope* species. In a number of unrelated species, *E. megalura*, *E. frigida*, *E. parva*, for example, the seventh pereonite is reduced considerably. The last species also demonstrates a common condition: the partial fusion of the pereonites 5 and 6, at least medially.

A number of important characters are derived from the overall shape of the natatory pereonites. Dorsally one can see much variation in the width to length ratios of pereonites 5-7 (e.g., 0.96 in *E. cornuta*; 0.75 in *E. parva*), sometimes in conjunction with changes in the depth of the body. In *E. cornuta* the natatory pereonites are all equally deep, while in others, e.g., *E. parva*, there is a definite decrease in depth posteriorly. The dis-

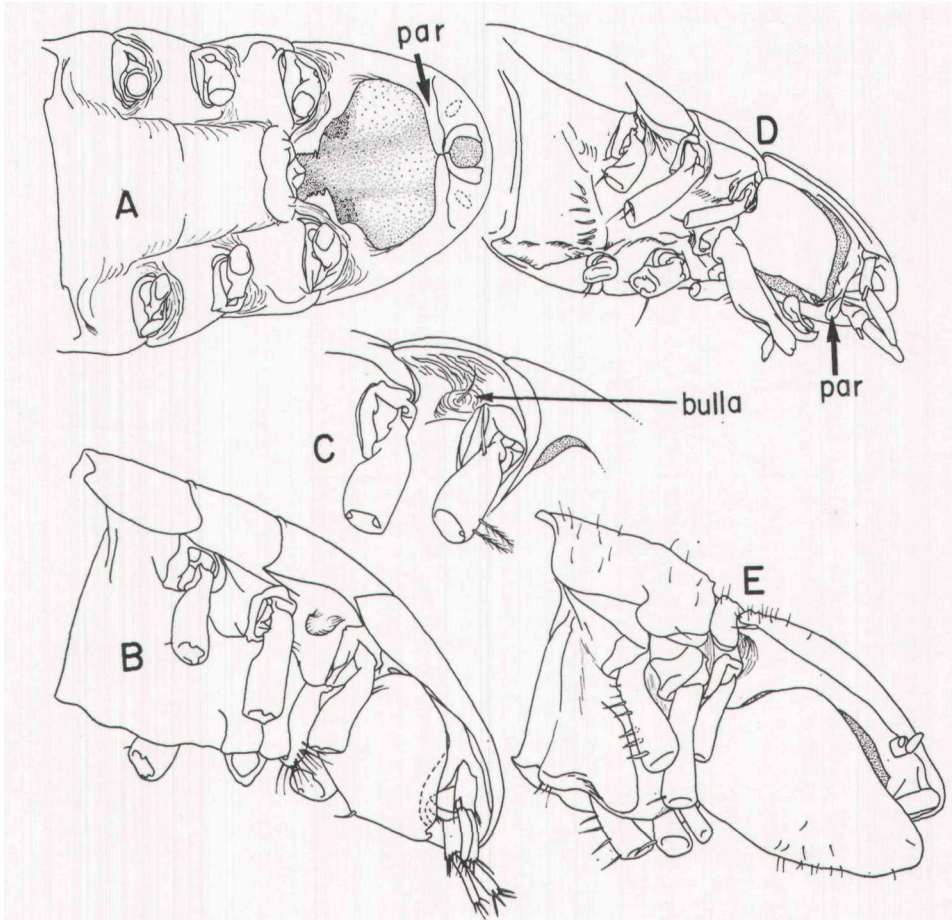


FIG. 4

Ventral surface of the natasome.

A, *Eurycope cornuta*, ventral view, distal parts of pereopod bases, pleopods and uropods removed: preanal ridge (par). B, D, E: ventrolateral oblique views of *E. cornuta*, *E. parva* and *E. rilegatura*. C, *E. complanata*, ventrolateral surface of pereonite 7 showing bulla and cuticular ridges.

tinctness and shape of the pereonites ventrally are useful in distinguishing species and groups of species (Fig. 4). In *E. cornuta* the natatory somites on the ventral surface are rather indistinctly separated and posteriorly there is a large transverse setose bump. *Eurycope cornuta*, *E. complanata* and related species also have enlarged bumps or *bullae* anterior to the coxal insertion of pereopod VII. *Eurycope parva* lacks either kind of bump as does *E. megalura*, although this latter species is protuberant ventrally on pereonite 6. All these modifications of the typical body plan exhibited by *E. cornuta* probably reflect substantial differences in swimming mode or life style. The associated pereopods on these somites also show corresponding modifications (see natatory pereopods below).

Pleotelson.—The pleon is basically shield-shaped in most eurycopids, but it is subject to relative variation among the species in the lengths and widths of the dorsal surface. These measurements are somewhat equivocal because of the very curved nature of the dorsal surface. Oftentimes the most stable and easiest measurement is to record simply the width and mid-sagittal length in dorsal view, even though (the true length is somewhat greater in plan view. Another interesting character is the angle between the pleon distal tip and lateral margin (see in lateral view, Fig. 5).

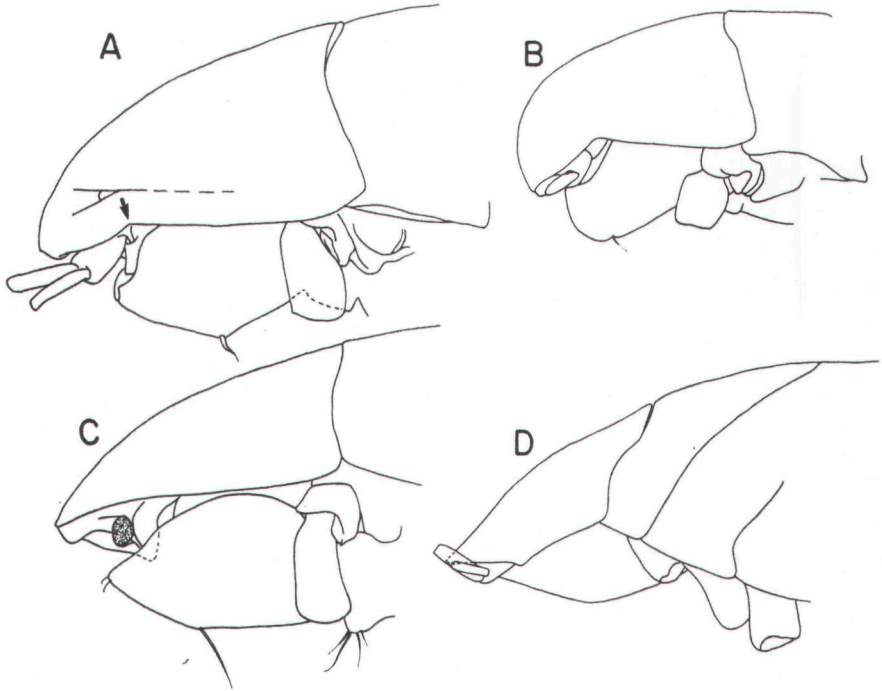


FIG. 5

Lateral views of pleon, illustrating distal angle in margin.

A, *Eurycope cornuta*, arrow indicates angle in margin. B, *E. gaussi*. C, *E. brevivirostris*, uropods missing. D, *E. furcata*. Note also the shape of female pleopods II.

The tip of *E. cornuta* exhibits a definite downward angle. This angle is even more pronounced in *E. gaussi*, slight in some species such as *E. brevivirostris*, and reversed in *E. furcata*.

Ventrally there is a *preanal ridge* separating the branchial (pleopodal) cavity from the anal plates and the uropods (Fig. 4B, D). In *E. cornuta* this ridge is quite small, but in a few special species (underscribed for the present), it is quite large and variously modified.

Appendage characters

The appendages are often the most sensitive indicators of specific differences and, if present, add strength to taxonomic descriptions. Unfortunately, in eurycopids, the distal portions of pereopods, antennae, maxillipeds, uropods and pleopods are often lost during sampling and processing because of their extreme fragility, length or both. However, the proximal portions of these limbs are more frequently retained and can be used to good effect.

Antenne I and II.—The most useful proximal character is the first article of the antennule (Fig. 6). This segment is practically always broad in species of *Eurycope* and has a complex morphology. Laterally the first article is thin and plate-like while medially it is thick and lobose. Setae may occur on the lateral edge or on the distal portion of the medial lobe. *Eurycope cornuta* illustrates the typical situation wherein the medial lobe is approximately the same length as the short second article. On other species the medial lobe ranges from extremely long to almost absent, while sometimes the position of the medial lobe may be seen to have shifted laterally behind the insertion of article 2.

If present, the distal articles of the antennulae are very useful in differentiating one species from another. This is easily seen in the various species of *Eurycope* illustrated by Sars (1899, pls. 64-69). When using an-

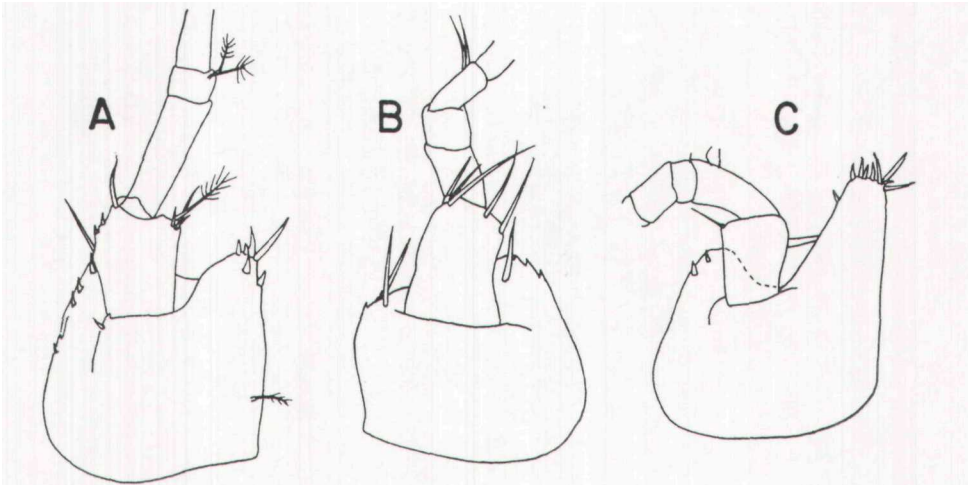


FIG. 6

Antennulae proximal articles, left dorsal views.

A, *Eurycope cornuta*. B, *E. phallangium*. C, *E. hanseni*.

tennular characters, it is necessary to note the sexual condition of the specimens. In comparison with females and juveniles, mature males have more robust and shorter proximal articles; the flagellum is variously elongated with numerous articles and prominent aesthetascs. The females and juvenile males have shorter and thinner antennulae.

The length and relative sizes of the articles of the antennae are useful, but this limb is practically always lost with the exception of the first four articles. The size and setation of the antennal scale may be of some value.

Mandible.—The mandibles have at least two important functions: ingestion of food and grooming of the antennae. This complex appendage can have numerous forms (Fig. 7) depending on the lifestyle and associated morphology of the species. The basic form, as seen in *E. cornuta* (Fig. 7A, 12B-E), is typical for most janiroideans. The basal article (coxa) of the mandible is most complex and has several structures of taxonomic value: the *incisor process*, the *lacinia mobilis*, the *spine row*, the *molar process* and the *dorsal condyle*.

The 3-toothed structure of the incisor is not symmetrical from side to side although the central tooth is generally the largest on both. In unmodified condition the left ventral tooth has a cuticular fold. In some species, such as *E. frigida*, the incisor is reduced and rounded. Wear on the teeth can also round them off. The lacinia is found only on the left side and can have a variable number of teeth depending on the species, seven in the case of *E. cornuta*.

While there is some within-species allometric variation in number, the spine row, made up of flattened, serrate spines, can be useful in terms of total number and shape. The most distal spine is most robust and strongly toothed with the more proximal spines decreasing in robustness. There are one or two more spines of heavier weight on the right side in place of the lacinia. Associated with the more robust spines are pairs of accessory setae that are extremely fine and difficult to see; because of this observational difficulty, it is not possible to evaluate the accessory setae as taxonomic characters until more information is collected on their distribution among *Eurycope* species.

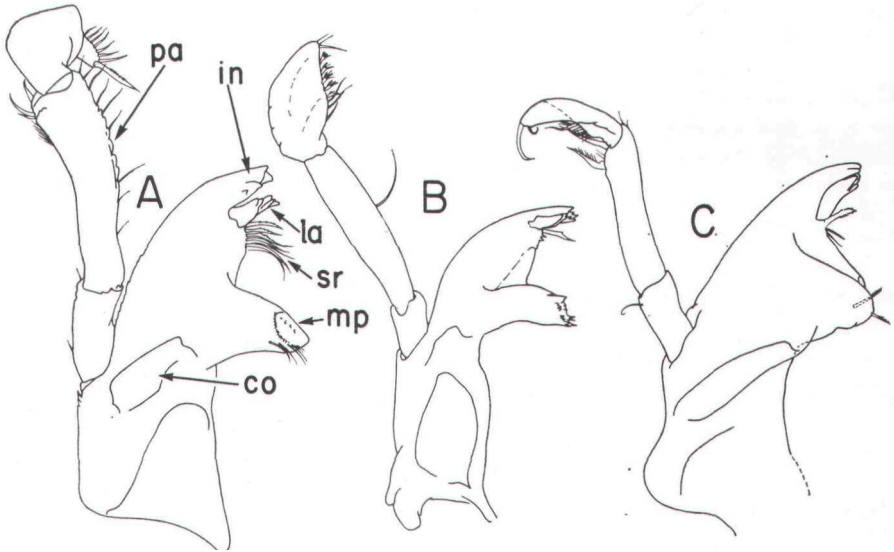


FIG. 7
Mandibles.

A, *Eurycope cornuta*: palp (pa), incisor process (in), lacinia mobilis (la), spine row (sr), molar process (mp), condyle (co). B, *E. phallangium*, condyle and molar process reduced. C, *E. frigida*, condyle and molar process enlarged and robust.

The molar process has a number of features that are taxonomically useful. The distal surface is usually broad with a tritulative area surrounded by a low ridge. On the ventral edge this ridge is enlarged into a flattened tooth while on the posterior edge, and sometimes on the other edges, the ridge can be bumped or multiply-toothed. Also on the posterior edge there is a row of thin compound setae. In *E. cornuta* these posterior bumps are small while in some species they can become large and sharp as in *E. phallangium*. The molar can vary from the normal condition as seen in *E. cornuta* to a rather thin process on *E. phallangium*, or to a robust, rounded crushing molar as in *E. frigida*. The molars are generally symmetrical from right to left.

The *dorsal condyle* is the curled ridge found on the dorsal surface of the mandibular body at the level of the molar process. Mastacatory motions are accomplished by the condyle sliding along the fossa of the clypeus and bringing the incisor or molar into contact. The size of the condyle tends to be correlated with the robustness of the molar process: if the molar is heavy and round for crushing, the condyle is long, and a small condyle will be associated with a reduced molar.

The major function of the mandibular palp is the grooming of the antennae, for which it shows a number of obvious adaptations, especially on the curled distal article. In *E. cornuta* (Fig. 12K) this latter article is provided with a large number of fine setae on the internal side of the curl.

Sometimes approaching a complete circle when viewed edge-on, the anterior edge of the curl has a row of compound setae which project radially inward. These setae have a finely setulate structure that may vary between taxa. On the distal end of the second article, two or three strong compound setae oppose the internal setae of the third article. The long second article of *E. cornuta* also has rows of long thin setae and spines and groups of tiny fine setae. The first palp article is generally very short and stout and often has the spination seen in *E. cornuta*. The palp is larger than the body of the mandible in the type species while in other species it can be smaller and sometimes reduced in setation and development of the distal article. Within a species there are some sexual differences in the palp; generally the male has a somewhat larger and more robust appendage than the female. This latter character probably correlates with the increased size of antennulae in mature males.

Maxillae I and II.—Endites of the basal segments of the maxillula and the maxilla seem to vary little from species to species. Comparative differences in the size of the lobes appear in some taxonomic descriptions, but lack of detail and consistency in these works make any generalizations difficult. At best one might suspect that there might be observable differences at the generic level, so as a rule, these two mouthparts should be illustrated for each type species. A number of variable setal types occur on the maxillae I and II (see Fig. 12M, N) which have often been inadequately illustrated in past publications. The above remarks apply as well to the paragnaths or lower lip.

Maxilliped.—The first thoracopod of *Eurycope* retains the conservative janiroidean structure as do the other mouthparts, although there are some relative dimensions, setae and spines whose variation is important. For example, the maxilliped of *Eurycope cornuta* is much like that seen in many species except that two adjacent flat spines occur on the lateral margins of the basis and the ischium (palp article 1), an unusual feature. Detailed characters of value revealed in this analysis are the comparative widths and lengths of the palp articles, the type of setation on the palp and the distal tip of the endite, the number of receptaculi (coupling hooks) and the form of the epipod. This latter character can be seen to vary considerably in species of *Eurycope*. In *E. cornuta*, the epipod has a distinctive lateral projection which in other species, can be almost quadrate (e.g., *E. complanata*) or absent (as in *E. phallangium* (see Fig. 8).

Pereopods I-IV.—An inspection of the monograph of G. O. Sars (1899, pls. 64-69) will show much species-level variation in the length of the anterior pereopods that may be correlated with antennal lengths. Regrettably these limbs are almost always lost in deep-sea samples. In *Eurycope cornuta* the first pereopod (Fig. 11B) is a simple reduced walking limb, not subchelate as is common for primitive janiroideans. This limb may be more robust and somewhat subchelate in other species. The remaining three ambulopods (Fig. 11A) are very elongate in all segments, even the dactyli. The walking limbs of eurycopids do not attain the lengths seen in munnopsids, so *E. cornuta* falls on the long end of the range of pereopod lengths. On other species, e.g., *E. pygmaea*, pereopods II-IV can be fairly short, such that the distal portions could possibly be folded entirely under the body. In lieu of the whole limb, the basis may be used for taxonomic comparisons because its length and robustness reflects the intact condition.

Pereopods V-VII.—The natatory pereopods of eurycopids are highly evolved, having numerous adaptations for swimming. In *Eurycope cornuta* (Fig. 11C-E, 13A) the articles of the three natapods are not equal in size. Pereopods V and VI are in total subequal, but the bases and ishia have complementary size differences: basis V is smaller than basis VI, but ishium V is larger than ishium VI. Lengths of the bases of all three natapods are less than half that of the ambulopods. Pereopod VII is smaller than the anterior natapods, but the coxa and basis are more robust, perhaps complementing the enlarged nature of the associated pereonite.

Pereopods V-VII tend to be preserved in deep-sea samples somewhat more often than I-IV, perhaps due to their more robust nature, but even these are absent with frustrating frequency. The bases may give some clue to the general sizes and development of the associated distal segments. In some species, such as *E. frigida*, there is a reduction in the seventh pereopod (paralleling that of ilyarachnids) which is reflected in the size of the basis. However, a lengthening of the basis is not reflected in a

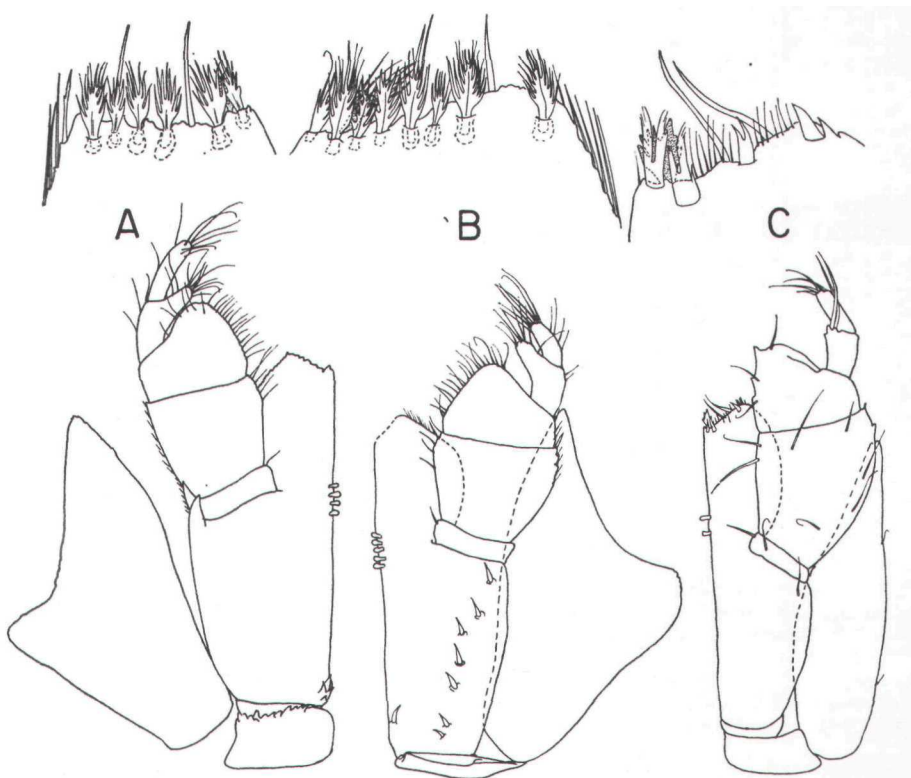


FIG. 8

Maxillipeds, ventral view and endite distal tip.

A, *Eurycope cornuta*. B, *E. complanata*. C, *E. phallangium*.

corresponding increase in the remainder of the pereopod for a number of species, such as *E. phallangium*. If the natapods are present, a number of characters may be of value in discriminating species of *Eurycope*: the relative shape of the paddle-like carpus and propodus, setation, degree of reduction of pereopod VII, shape of the dactylus and size of the bases. Sars (1899, pls 64-69) shows a number of excellent examples of these pereopods.

First pleopod, male.—This primary sexual character of the male is extremely valuable in distinguishing species of *Eurycope*. The pleopods join medially to form a funnel and tube which proximally receive the penes and distally, around two-thirds the length of the pleopod, open above the stylet of the second pleopod. Distal to this opening the pleopods are unfused and terminate in paired lobes. The size and shape of the first pleopod's medial and lateral lobes are often definitive in distinguishing groups of species and sometimes even closely related species (Fig. 9A, C, E, G). Because this feature varies ontogenetically it is critical that only fully mature males be compared, a caveat that has often been ignored.

Second pleopod, male.—The male second pleopod is also much modified for its sexual function (Fig. 13C). The basal article, homologous with the protopod, is enlarged and filled with muscular bands that attach to the

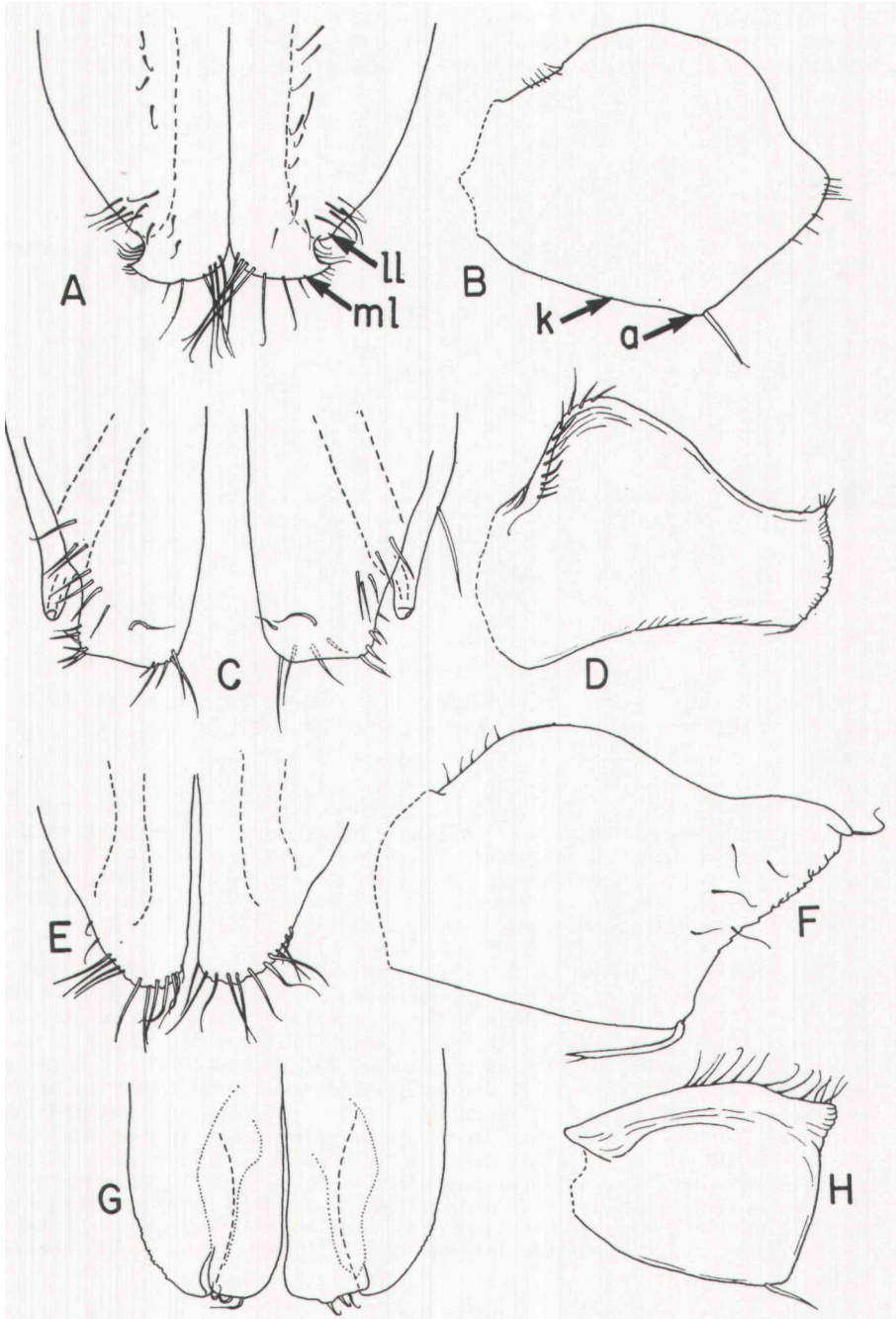


FIG. 9

Anterior pleopods: male pleopod I, distal tip ventral view; female pleopod II, lateral view.

A-B, *Eurycope cornuta*: medial lobe (ml), lateral lobe (ll), keel (k), apex (a).
C-D, *E. complanata*. E-F, *E. phallangium*. G-H, *E. parva*.

exopod. This ramus emerges on the distomedial edge of the protopod's dorsal surface; it is very setose and generally hook-like dorsally. The two-articled endopod is even further modified; the basal article emerges from the protopod on the medial edge anterior to the exopod, and extends anteromedially. The distal article is connected at an acute angle and extends posteriorly. Proximally it is expanded into the bulb of the stylet which tapers distally. On the ventral surface of the stylet, a chamber opens

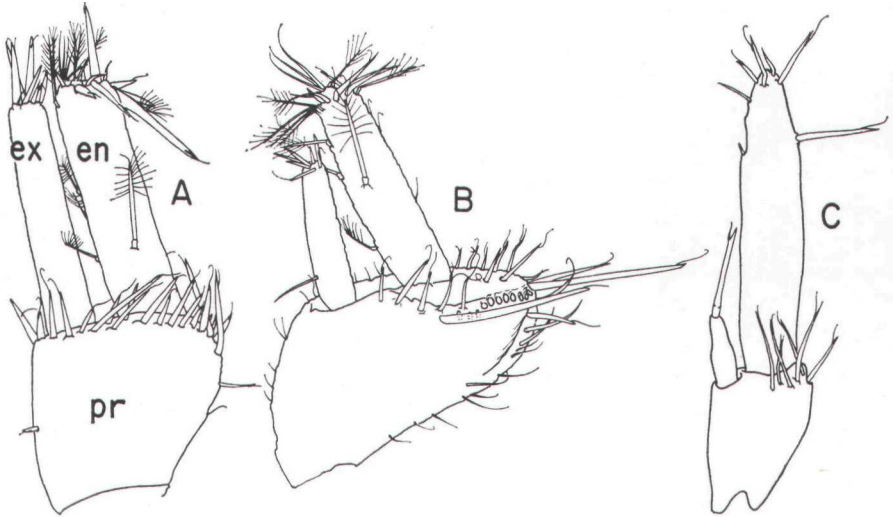


FIG. 10

Uropods, left ventral view.

A, *Eurycope cornuta*: exopod (ex), endopod (en), protopod (pr). B, *E. complanata*, only end members of protopod setal row shown. C, *E. parva*.

which connects distally with a fine tube continuous to the tip in mature individuals. The shape of the basis and the size and placement of the endopod are taxonomically useful. There is some neotenic tendency in some species, e.g., *E. complanata*, for the basal articles to remain partially fused proximally in the adult condition. This is often coupled with a reduction in the size and a more distal location of the endopod.

Pleopod II, female.—The three-dimensional structure of the opercular pleopod of the female has been much neglected in past descriptions; a lateral view as well as a ventral view is necessary for an adequate characterization of its form. Two features of importance are the shape of the *keel*, a ridge on the pleopod ventral midline, and that of the *apex*, a point or area of change in slope of the keel often ornamented with a single large seta. The depth and shape of the pleopod are also very useful taxonomically (Fig. 9B, D, F, H). In *E. cornuta* the apex is placed three-quarters the total length along the keel; the keel is thin ventrally, but broadens rapidly. The depth of the pleopod at the keel is 44 percent of the length. The distal tip is broad, rounded and does not protrude from the main part of the pleopod, as it does in some species, e.g., *E. complanata*. Other species, such as *E. phallangium* and *E. parva*, have much deeper keels.

Pleopods III-V.—The branchial pleopods (Fig. 13E-G), which G. O. Sars regarded as the only true pleopods (note their numbering in his figures), are morphologically very conservative within the Janiroidea. Their taxonomic utility seems limited, although there are some differences between several species in the length to width ratios and shape of the exopods of the third and fourth pleopods (e.g., compare *E. producta* and

E. phallangium in G.O. Sars (1899), pls. 65, 66). Like the maxillae and the paragnaths, it would seem best to illustrate them in generic descriptions for completeness.

Uropods.—The uropods are basically very simple structures, but in the Eurycopidae, their manifold variations can be very useful (Fig. 10). The protopod is particularly useful in this respect because it can be seen to vary from the simple sub-quadrate forms in *E. cornuta* to the broadly expanded shape in *E. complanata* or to a simple rod in *E. madseni*. A row of small, unequally bifid sensory setae is found on the distal margin of the *E. cornuta* protopod. In *E. complanata* these setae become extremely large, and with the medial extension of the protopod, cover the anal region. Species with a reduced protopod either lack or have few of these setae. The rami also vary considerably. In *E. cornuta* the exopod is nearly as long as the endopod but not as broad. In other species the exopod is generally much smaller than the endopod. Additional useful features of the rami are their relative size compared to the protopod, and their setation. There are three types of setae which are found on the uropodal rami: stout unequally bifid setae, sometimes occurring distally in a rosette; simple setae, usually long and thin at the distal tips; and broom setae, which often turn up anywhere. It is important to note the presence and elaboration of these setae; all three types occur in *E. cornuta* rami while other species may lack one or two types. Because eurycopids swim backwards (Hult, 1941; personal observation), the uropods probably function as sensory structures, as suggested by the setae described above.

TAXONOMY

The characters in the following diagnosis and description are explained in detail in the morphological section above. The generic and specific diagnoses for *E. cornuta* are not separated because a revision of *Eurycope* is beyond the scope of this paper. The additional description provides information on those non-key characters that nevertheless will be valuable in comparison with other eurycopine taxa.

EURYCOPE CORNUTA G.O. Sars, 1864 (Figs. 11, 12, 13)

Synonym: *Eurycope robusta* Harger, 1878.

Diagnosis

Body oval with light pigmentation at margins of body segments, length 2.2 width, depth 0.3 length. Rostrum narrowly quadrate with low cephalic keels anteriorly, little or no overhang; frons slopes abruptly to rounded, inverted-v ridge above clypeus. Pereonites 1-4 medially subequal, short, combined lengths one-half to one-third pereonites 5-7. Pereonites 5-7 free dorsally, pereonite 5 widest, pereonite 7 longest; fused ventrally, with setose rounded, transverse ridge anterior to insertion of pleotoelson; rounded bump anterior to pereonite 7 coxa. Pleotoelson length around 0.65 width, rounded posteriorly; distal end angles downward around 30° from pleonal plane just anterior to uropods. Antennula first article medial lobe length subequal to second article; mature male antennula greater than half body length; female antennula approximately 0.4 body length. Antenna longer

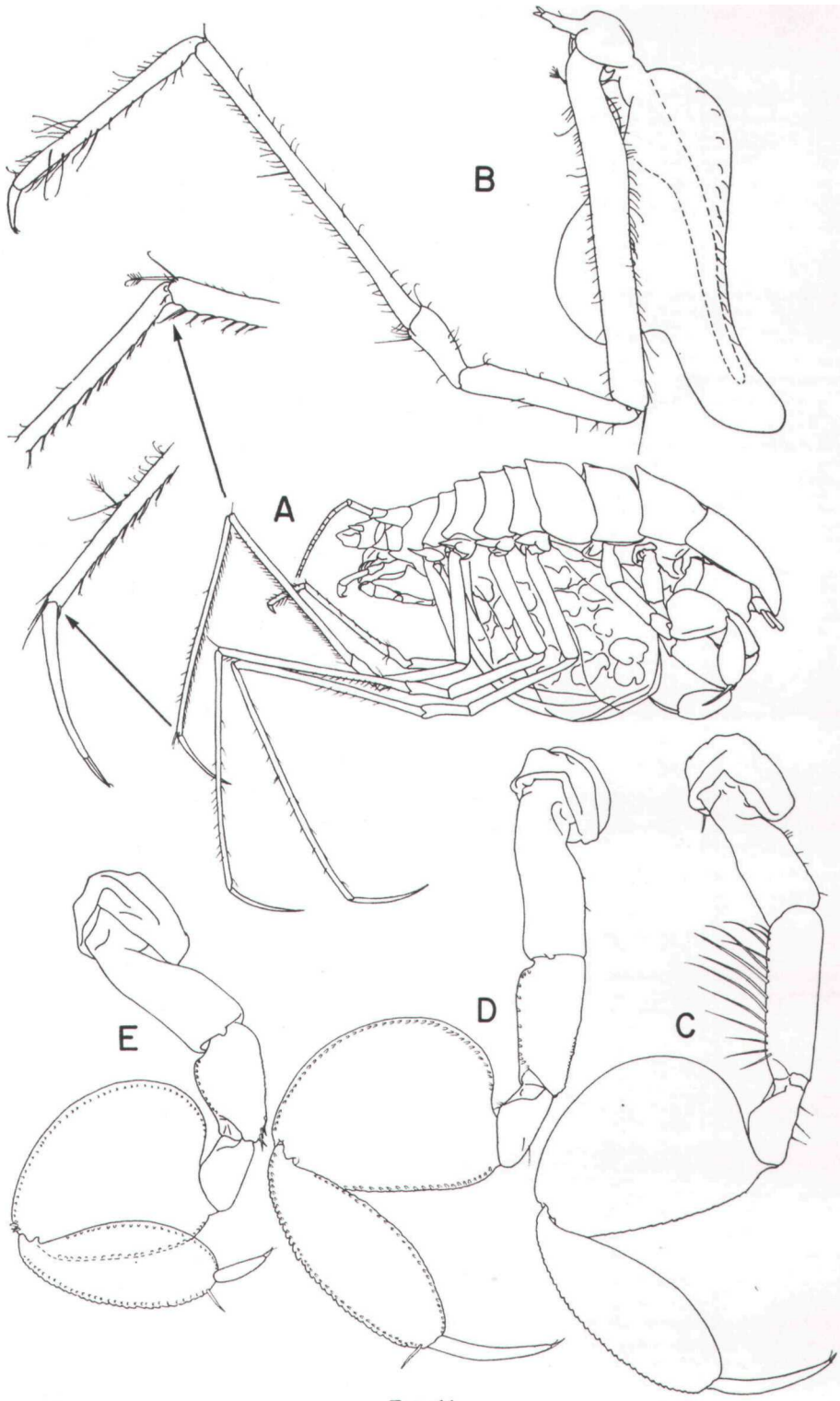


FIG. 11

than three body lengths. Mandibular molar broad oval with only tiny rounded denticles and five small setae on posterior edge, ventral edge flattened into sharp angular blade. Mandibular palp longer than body of mandible with denticles on first and second articles. Maxilliped with two large, flat spines on basis and ischium; epipod with angular lateral projection. Pereopods I-IV bases long, subequal; pereopods II-IV very long, 1.7-1.9 body length, increasing posteriorly. Natatory pereopods V-VII bases very short and robust; reduced pereopod VII size around 0.8 subequal pereopods V and VI. Pleopod I in mature male with lateral lobes broad, distally non-protruding, constricting and terminating short distance proximal to medial lobes; medial lobes around half pleopod width, distally rounded, laterally pointed. Male pleopod II stylet longer than protopod; endopod centrally placed on protopod medial edge. Female pleopod II width 1.4 length, distally rounded and non-protruding; keel deep, medially narrow, with obtuse apex around three-quarters length from insertion; lateral fields not recurved. Uropod robust, with subequal rami; protopod not distally broadened, basal fringing setae shorter than protopod; both rami with distal rosettes of stout unequally bifid setae.

Additional description

Length of adults between 3.6 and 4.9mm, males tend to be smaller than females. Body widest at pereonite 5, deepest at pereonite 7. Pereonite 7 length 1.3 pereonite 5, latter only slightly longer than pereonite 6. Pereonite 6 curves medially, forming slight constriction in natasome dorsum; in lateral view margins of pereonites 5 and 6 curve slightly downward, pereonite 7 curves slightly upward. Preanal ridge of pleotelson venter not significantly enlarged, covered by opercular pleopods.

Rostrum length 0.23-0.24 cephalon width, anterior width 0.1 cephalon width.

Antennula first article with around five stout short setae on medial lobe; third article length 1.2 second article; fourth article very short, 0.27 second article length; male flagellum with single row of aesthetascs placed ventrally, one per **segment**, each being as long as three flagellar articles, females with few distal aesthetascs.

Antenna flagellum over half total appendage length; scale (or squama) shorter than third article, pointed distally with three or four setae.

Left mandible incisor with three teeth, median tooth largest. Lacinia mobilis with seven teeth, ventral tooth largest. Spine row with around seven thin, dentate or setulate spines; distal robust spines with pairs of accessory setae. Mandibular condyle at base of molar approximately same length as molar process. Mandibular palp second segment length 0.51-0.56 mandible body, shorter and less robust in females; third article proximal part of fold larger than distal part, anterior edge setal row with broad single-branched setulate setae in opposing part of fold.

Right mandible incisor with three teeth, central tooth largest; spine row with nine members, distally very robust and broad, proximally very thin.

Maxilliped with denticles on medial proximal edge of basis and distal edge of coxa; endite with four coupling hooks (receptaculi) medially and six subequal palmate setae distally; palp only 1.3 wider than endite at second article, latter is only slightly wider than third article; medial margins of second and third articles with row of simple setae; epipod width 0.56 length, slightly longer than inside margin of endite and basis.

FIG. 11

Eurycope cornuta brooding female.

A, left lateral view with sections of pereopod II. B, pereopod I with coxa and oostegite. C, pereopod V, setae shown only on ischium. D-E, pereopods VI-VII, only attachment points of plumose setae shown.

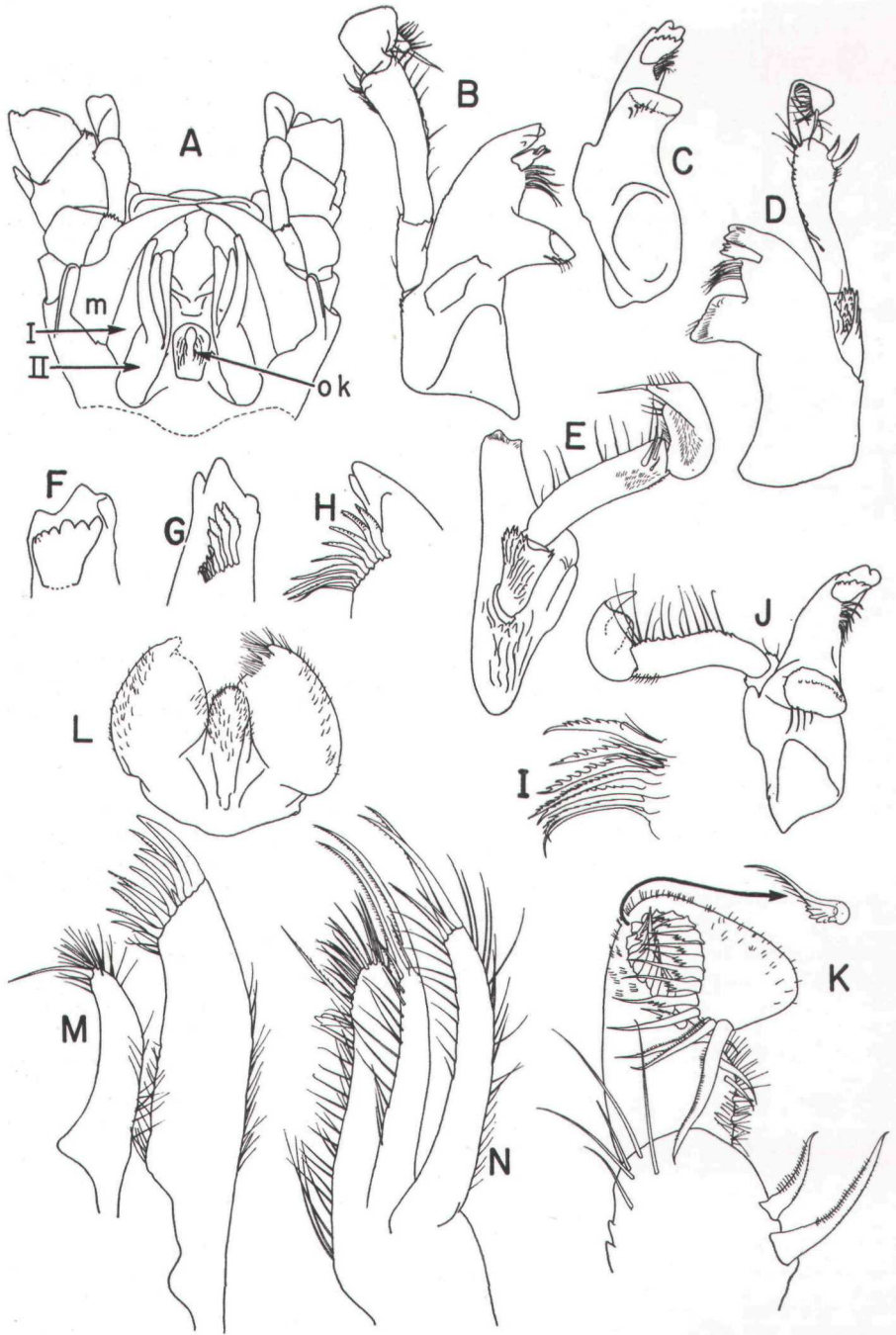


FIG. 12

Eurycope cornuta mouthparts.

A, ventral view of cephalon with maxillipeds removed: mandible (m), maxillule (I), maxilla (II), oral surface plate with projecting knob (ok). B-E, left mandible, copulatory male, views respectively: dorsal, posteromedial, ventral, lateral. F, left mandible incisor process and lacinia mobilis. G-H, right mandible incisor and spine row, posterior and dorsal views. I, right mandible spine row, ventral view. J, left mandible, preparatory female, showing smaller palp, setae omitted from distal article. K, left mandible palp, distal article with cleaning seta shown. L, paragnaths. M, maxillule. N, maxilla.

Pereopods I-IV coxae visible in dorsal view, bilobed laterally, anterior lobes triangular, tipped with small stout seta. Pereonite lateral margins lack any such setae. Pereopods I-IV bases subequal to body depth, lenti-

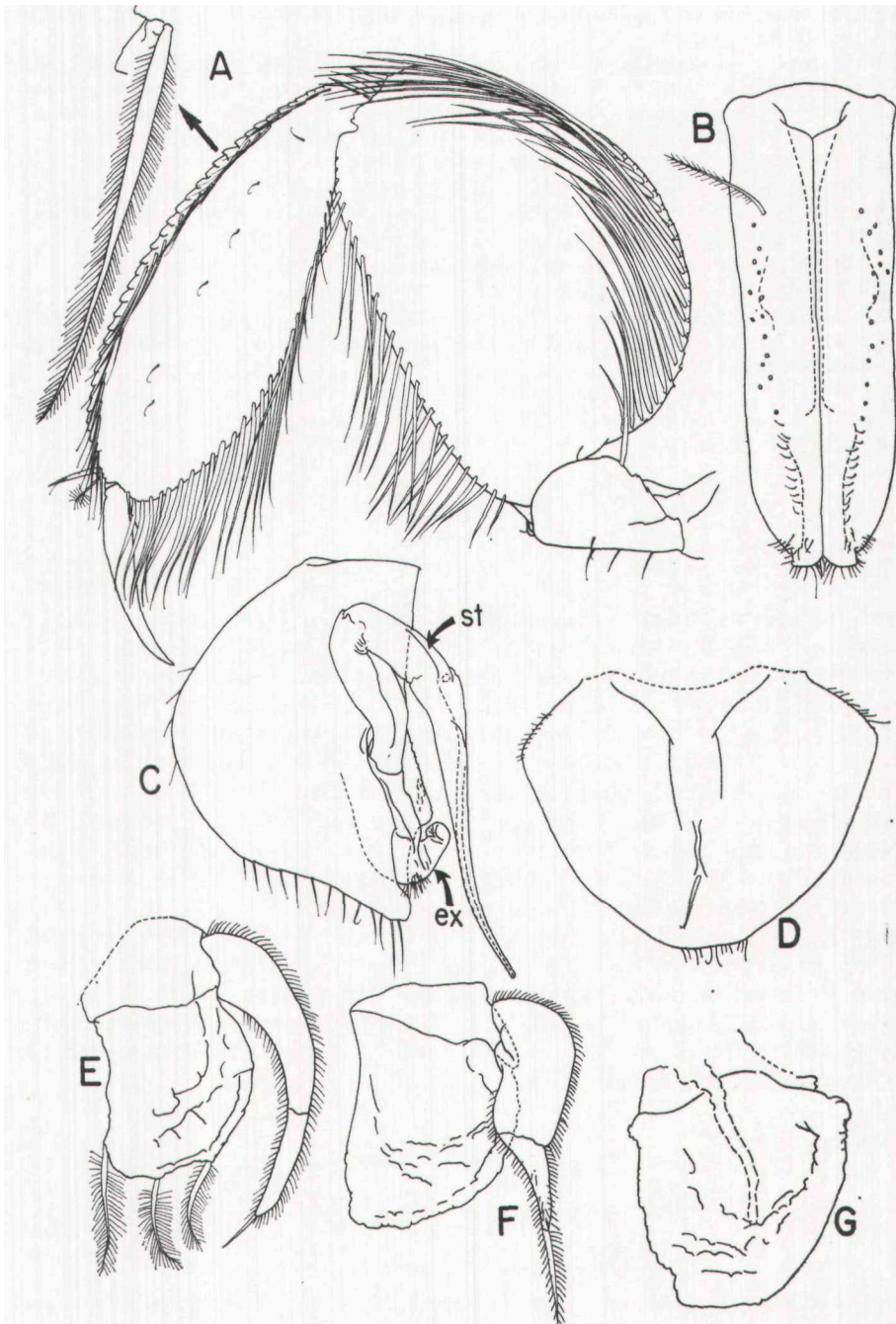


FIG. 13

Eurycope cornuta.

A, pereopod V distal articles, propodal seta enlarged. B, pleopod I, small circles mark positions of plumose setae. C, male pleopod II: exopod (ex), stylet (st). D, female pleopod II. E, pleopod III. F, pleopod IV. G, pleopod V.

cular in cross-section. Pereopod I long and thin, not distinctly prehensile, with rows of fine setae on edges, carpus as long as basis, 1.5 longer than propodus. Pereopod II with row of small unequally bifid setae along ventral margins of carpus and propodus; setation of pereopod III and IV not as dense.

Natatory pereopods V-VII with rows of plumose setae on one edge of ischium and both edges of carpus and propodus; only one or two plumose setae on merus and none on basis. Pereopod V subequal to pereopod VI, but size relations between bases and ischia reversed: pereopod V complementary basis/ischium length ratio 0.75; pereopod VI 1.2.

Pleopod I in mature male slightly tapering from insertion, constricting abruptly distally; paired longitudinal rows of plumose setae on ventral surface; ventral surface flat.

Male pleopod II protopod length 1.4 width. Female pleopod II length 0.73 width; one large seta at apex.

Uropod protopod length 0.76 width, lacking angular medial lobe; endopod 1.5 protopod length, with numerous broom setae and several terminal simple setae.

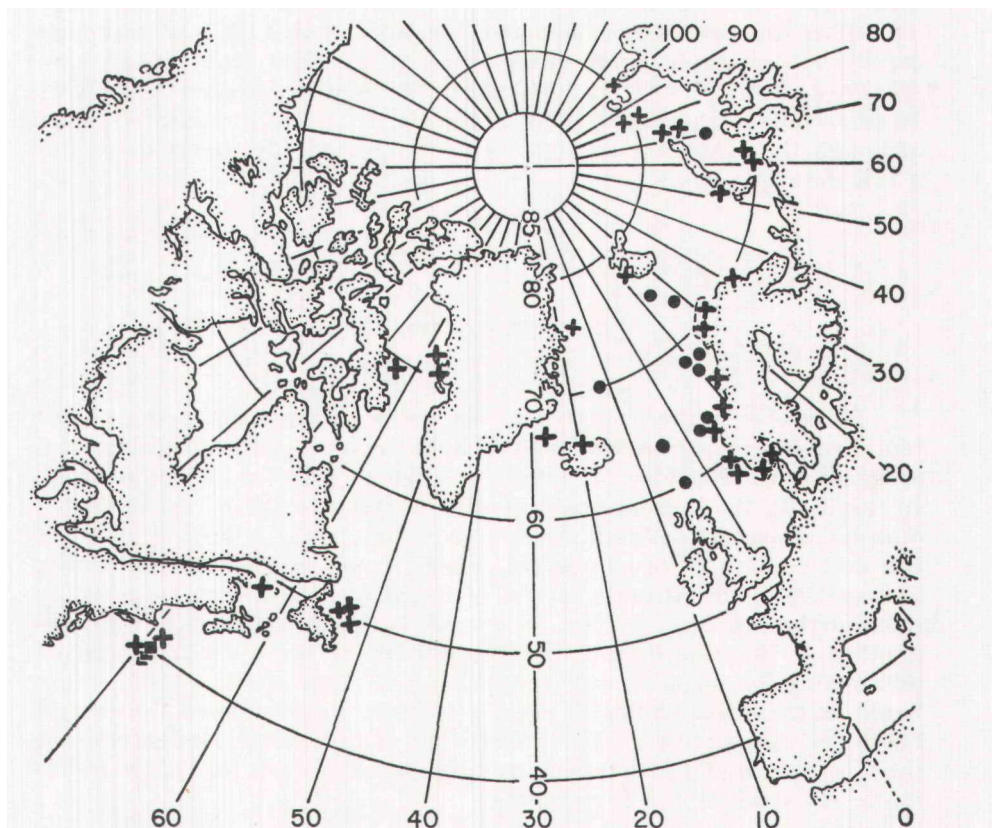
DISTRIBUTION

All records before 1941 are listed in Hult (1941). The distributions are also summarized in Wolff (1962) for more than 105 localities to which the present work adds three new localities, but with no change in the overall distribution (Fig. 14). *Eurycope cornuta* is common and very well known from the Skagerrak and the west coast of Norway. The primary material for the present study was collected by Robert R. Hessler in these areas. It also has been shown to occur in the eastern Arctic Ocean and off western Greenland. In the North American area it has been taken in the Gulf of St. Lawrence, off Newfoundland and New England. The Woods Hole specimens from stations 96, 105, and 207 (Table 1) reaffirm the New England records mentioned vaguely by Richardson (1905). Vertically, Wolff (1962) lists *E. cornuta* as occurring between 55-2207 meters, although most of the records are in the upper half of this range. Hult (1941) observes that it is taken most commonly below 400 meters, while there are frequent records below 100 meters. Off New England the depth range is 498-808 meters (WHOI samples) while Harger's (1878) record is 220 fathoms (400 meters) in the Gulf of St. Lawrence.

GEOGRAPHIC VARIATION

An examination of older material from the Zoological Museum in Copenhagen (kindly lent by Dr. Torben Wolff) has brought to light some geographic variation, mostly in body size. The Hjelte and Herdla Fjord specimens used in this study reached maturity at around 3.6mm and the largest individuals were no greater than 5mm. Some specimens identified by G. O. Sars from the "Cristiania

Fjord" (no other data) were slightly larger: three brooding females were 5.3mm long. The WHOI specimens from off New England, USA were somewhat smaller in all life stages by a few tenths of a millimeter: maturity was reached by 3.2mm and the largest individual, a preparatory female, was 3.9mm Wolff (1962) reported body lengths of females from Thor station 26 (58°01'N, 9°49'E, 250m) to be between



Recorded localities for *Eurycope cornuta*: + — from Hult (1944) ■ = WHOI stations; ● uncertain records.

8.7 and 12.9mm, but it is suspected that these numbers were the untransformed readings from an ocular micrometer. A remeasurement of these specimens yielded a range of 4.2-6.2mm for undamaged adult males and females, which is larger than that seen for Sars' specimens.

All the specimens reported above showed only slight variability in the rostrum and other characters, while three arctic individuals were much more different. A preparatory female collected by the Svenska Expedition of 1871 from Baffin Bay (71°10'N, 58°56'W, 364m) was rather large (5.5mm) and had a very unusual projecting rostrum, much like *Eurycope hanseni*: anterior rostrum width 0.25 length; length 0.29 cephalon width. Two preparatory female specimens supplied by Gurjanova from the northern part of the Kara Sea (no other data) were very unusual, both being slightly larger than 7mm.

In addition they differed in a number of important characters. The lateral flattened edge of the antennula first article was wider and the medial lobe was smaller. The rostrum was slightly longer with more overhang than is typical. The uropod rami were longer compared to the protopod and the pleotelson was smaller with respect to the rest of the body. Hult (1941) noticed the different rostrum on the latter specimens but considered them as variations of the main form. The other differences were not mentioned. Oldwig (1917) also reports three approximately 7mm examples of *E. cornuta* from Spitzbergen (Eisfjord, 78°11'N, 14°2'E, 277-313m). It is possible that these very large arctic specimens are sufficiently distinct to be a separate species although there are not enough well-documented specimens to justify a full description.

CONCLUDING REMARKS

Because it is the first step in the study and understanding of our biotic environment, taxonomy must help the biologist, ecologist or biogeographer to recognize important differences between groups of taxa. In this light, the critical problem with eurycopine taxonomy is that it does not presently define a discrete group of closely related species but can best be thought of as a supra-generic taxon in a non-formal sense. The survey of the Atlantic species of *Eurycope* reveals several possibly monophyletic groups of species morphologically separated from one another by definite gaps. The recognition of these groups is made possible by the use of the morphologies described above. A taxonomy based on these morphologies must use *Eurycope cornuta* as the central taxon for comparisons. This discussion of taxonomic characters and the description of *E. cornuta* introduces a framework for future systematic revisions of the Eurycopidae.

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Summary

The natatory asellotes of the family Eurycopidae often dominate collections of deep-sea isopods. The central genus of this family, *Eurycope*, contains a large number of morphologically diverse species, thus indicating a need for an extensive revision. This paper presents the necessary methodology and a discussion of taxonomic characters, many of which have often been ignored in recent literature. *Eurycope cornuta* Sar  (1864), the type species collected from Norway and off New England, is used as the main example of these morphologies. Comparative data comes from a large collection of deep-sea isopods curated by our

laboratory. The value of three-dimensional shape of the cephalon and other somatic features is emphasized because some types of comparisons are very difficult without this information. The range of morphological variation among the taxa presently included in *Eurycope* is discussed for each character. In order to introduce a framework for future systematic revisions, *E. cornuta* is redescribed and its known distribution is brought up-to-date.

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