

Marine Copepods of the Genus *Anthessius* from the Northeastern Pacific Ocean¹

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AMONG THE COPEPODS associated with invertebrates there is a remarkably homogeneous collection of species, predominantly associated with mollusks, comprising the genus *Anthessius* Della Valle 1880. The indications are strong that the mollusks will exclusively furnish the hosts of the members of the genus. Investigations of the invertebrate fauna of the Pacific Coast of the United States has resulted in the discovery of four species. One of these, *Anthessius navanacis* (Wilson, 1935), is known from California due to the fruitful ecological studies of Professor and Mrs. G. E. MacGinitie. From collections of the U. S. Steamer "Albatross," we have from Hawaii *Anthessius hawaiiensis* (Wilson, 1921). In the description of new species in a genus so anatomically consistent, it was necessary to invoke details not available in the original descriptions of these older species. Accordingly, they are redescribed below, with some emendations. For support of much of the research contributing to this paper I am indebted to Fund 171, State of Washington. The illustrations for three species are based on pencil renderings by Mr. R. U. Gooding. Other drawings and the writing of the paper have been completed during the tenure of a John Simon Guggenheim Memorial Foundation Fellowship. I am indebted to many colleagues for assistance in connection with this report, and am most particularly obliged to Mr. John E. Fitch for his considerable efforts in collecting for me the material of the species named for him below.

The genus *Anthessius* Della Valle dates from 1880, with two species described as associates of Mediterranean mollusks. A still earlier species is now included in the genus. This is *Boeckia arenicola* Brady 1872a, 1872b. As *Boeckia* is a preoccupied generic name, Brady subsequently

referred to this species as *Lichomolgus arenicolus* (1880: 46-47). It has been referred to in this combination by several authors, and also as *Herrmannella arenicola*, following T. Scott (1898). No host was known for this species until Bocquet and Stock (1958) demonstrated that *A. arenicolus* is an associate of *Dosinia exoleta* (L), and, further, clarified the systematic confusion of this species with their *A. teissieri* 1958 in much of the published record. Such reinvestigations as that of Bocquet and Stock of many of the known species are needed to solve bionomic problems and to expand anatomical descriptions for provision of a sound basis for the resolution of the discrepancies found in the literature on the systematics of the genus. The work of these authors added to the revisionary summary of Monod and Dollfus (1932) and the review of Sewell (1949) provide the basis for the present treatment of the group. In the published record so far, the genus is still referred to the family Lichomolgidae, although the appropriateness of this attribution has already been questioned (Illg, 1949: 393). Mycolidae Yamaguti 1936 is available in Cyclopoida Poecilostoma among the families in the complex containing Clausidiidae and Lichomolgidae. I follow de Vos in Korrynga and Lambert (1951: 18-19) in assigning *Lichomolgus spinosus* Raffaele e Monticelli 1885 not to *Anthessius*, but to the closely related genus, *Pseudomyicola* Yamaguti 1936. *Pseudomolgus* Sars 1916 is a synonym of *Anthessius* and the list of species so assigned must be transferred, as shown by Monod and Dollfus. The group of species now comprising *Anthessius* form a most coherent series of forms for which some morphological generalizations now can be made. Considerable emphasis has been laid by some authors on the importance of the condition of the segment of the first legs, relative to its alternative fusion with or separation from the cephalosome. Study of five species leads me to conclude that typically

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the cephalosome in the genus functionally includes the segment of the first legs. However, the legs themselves seem to function as part of the metasomal series of legs. The anterior part of the segment on the ventral side is involved in the formation of a posterior termination of the oral region. Functionally, then, the transition from cephalosome to metasome is strongly indicated as intrasegmental. In none of the species I have studied does the separation of the segment of the first legs from the anterior region seem to involve as free an articulation as that between successive pedigerous segments, although a well-developed inflected interruption of the integument may provide a conspicuous anterior boundary for the element. In the paratype material of *A. navanacis* this feature was found to vary, one female being found with a well-developed suture indicating the segmental boundary, a second female showing no interruption of the integument.

The structure and ornamentation of the antennule emerge as remarkably consistent throughout the species and it is strongly probable that a basic form as well as a characteristic ornamentation will be found consistently when details have been presented for all species. A very interesting dichotomy exists with regard to sexual dimorphism in the armature of this appendage. Bocquet and Stock were the first to point out the remarkable complement of aesthetes in the antennule of males of *A. arenicolus* and *A. teissieri*. As can be seen by comparing their findings and the descriptions below, there is apparently a typical distribution of aesthetes on the antennules of females, these occurring regularly on segments 5, 6, and 7. Bocquet and Stock described in the males of the species they studied this same complement of aesthetes with additional aesthetes found on segments 2 and 4. Exactly the same pattern was found in the new species described below, *A. lighti*. However, on the basis of careful study of equally favorable material of *A. nortoni* and *A. fitchi*, both new species, I can say that no such dimorphism exists in these species. It will be of interest to see how this feature is found to be distributed among the species of the genus. Unfortunately the type material of *A. navanacis* available to me was not sufficiently well preserved to make possible de-

termination of this feature, and for *A. hawaiiensis* I could not find males.

The antennae and the mandibles, maxillules, and maxillae are extremely similar throughout the species of the genus, so that a generic pattern might very soundly be said to exist, although there are minute details of specific variation. The maxillipeds, highly dimorphic in the sexes, are also somewhat more strongly specifically distinctive in details of ornamentation than are the other mouthparts. The swimming legs have a very consistent pattern of structure and ornamentation throughout the genus, with, however, fairly distinctive specific features of outline and proportion of segments and of fine details of minute ornamentation. Two major alternative patterns of armature appear through the series of species, some having three spines on the terminal segment of the fourth exopodite, some having four spines there. In all the species below in which I have been able to study both sexes (four of the five), I have found a sexual dimorphism of the first legs. On the terminal segment of the endopodite there is a spine and five setae in the female, two spines and four setae in the male. The species involved are sufficiently diverse in their other variable characteristics that I would venture to predict on the basis of these that such dimorphism will probably be found consistently throughout the genus.

The basic pattern of the fifth legs is consistent among the species, but there are distinctive variations in proportions and in the placement of the elements of the armature. There is a sexual dimorphism characteristically in this appendage, also, but the variation may be very subtle in degree in some species. Dimorphism of the caudal rami also seems substantially indicated, but for this feature additional investigation of the previously known species is required. Finally, with regard to sexual dimorphism it should be stated that in this group, where unusually large cyclopid species are included, there is remarkably little difference in size of males and females in many of the species. More information is needed on this feature, but the situation is particularly striking in such a distinctive species as *A. fitchi*, described below, which is gigantic and equipped with strongly developed epimerae. The male is slightly larger than the female, which is

unusual among poecilostome groups in general.

Reaching systematic conclusions in the genus *Anthessius* is difficult. The descriptions of many of the species are fragmentary or deal with details which are not readily comparable with those furnished in still other descriptions, so that the relatively subtly differentiated species become difficult to characterize as distinctive, although the information available convinces the taxonomic worker of the specific separation of the forms. Some characteristics which seem to serve for grouping species are discussed below. Finally a very rough key is presented to serve the function of demonstrating the specific separation of the new species described. As most of the features treated in the key are drawn from the literature, some of which is unsatisfactory for the details involved, it is to be regarded only as a synopsis, not as a reliable device for routine identification of species.

In general, the fifth leg of species is usually described and depicted with considerable detail and care. Grouping on the basis of this appendage should be fairly reliable. In *A. solecurti* Della Valle, the structure as figured and described is unique for the genus and readily serves to differentiate the species. Among the remaining species there are two general types of contour seen in the fifth leg of females. (The male of *A. investigatoris* Sewell 1949 has to be involved in this discussion, as the female of the species is not known.) In most species, the lateral margins of the free segment of the fifth leg are essentially parallel, although there may be some constriction at the base or toward the apex. In all, the appendage is narrow, so that the ratio of length to greatest width is much more than 3, ranging from about 3.2 to 4.5 or more. In the fifth leg of the remaining species the free segment is much broader and more platelike. The margins tend to expand and the armature may be concentrated on or near a broad distal margin. In such forms the ratio of length to width of the free segment is much less than 3, ranging from about 1.8 to 2.7, as discernible from figures accompanying descriptions in most cases. *A. navanacis* (Wilson), which is assignable to this group, is also readily separated from all members of the genus by the distinctive outline of the fifth leg, with marked basal constrict-

tion. Few anatomical details are available for *A. pleurobrancheae* Della Valle, but in the description the structure of the fifth leg is stressed, and this species is unique among those falling into the category just described by completely lacking marginal ornamentation of spinules on the free segment. As remarked above a useful dichotomy exists with regards to the armature of the fourth swimming legs, but this detail is not available from all species descriptions. Finally, there are readily determinable groupings available based on the ratio of length to width of caudal rami, and in most descriptions information on this feature or fairly good illustration is provided. The degree of variability of this character in any given species remains to be determined.

KEY TO SPECIES OF *Anthessius*

Based on adult females, but including *A. investigatoris* Sewell 1949 on the basis of the male. *A. pleurobrancheae* Della Valle 1880 has been included, after the treatment of Stock (1959), although the original description was very scanty and Claus' account (1889) does not extensively supplement Della Valle's. Species recently described (Humes, 1959; Stock, 1959) have been included in the key, but were not treated in the discussions in this paper.

- 1a. Body habitus very modified, cephalosome much expanded in outline, thoracic segments with widely extending epimera, caudal rami elongate, laminate.....*fitchi*, new species
- 1b. Body in general approaching typical cyclopid habitus 2
- 2a. Ratio of length to width of terminal segment of fifth leg more than 3..... 3
- 2b. Ratio of length to width of terminal segment of fifth leg less than 3.....12
- 3a. Terminal segment of exopodite of fourth leg with 4 spines..... 4
- 3b. Terminal segment of exopodite of fourth leg with 3 spines..... 9
- 4a. Ratio of length to width of caudal ramus about 1.....*brevifurca* Sewell 1949
- 4b. Ratio of length to width of caudal ramus much more than 1..... 5

- 5a. Maxilla bearing more than 10 external marginal teeth.....
.....*pleurobranchae* Della Valle 1880
- 5b. Maxilla bearing at most 6 external marginal teeth 6
- 6a. Ratio of length to width of caudal ramus about 2.6.....*lighti*, new species
- 6b. Ratio of length to width of caudal ramus about 4..... 7
- 7a. Interior margin of fifth leg bearing distal group of slender spinules at distal third and a group of slender spinules in the middle of the segment.....
.....*arenicolus* (Brady 1878)
- 7b. Interior margin of fifth leg bearing, with exception of distal group of slender spinules at distal third, no spinules or setae 8
- 8a. Ventral surface of last segment of urosome with 2 prominent rows of strong spinules.....*solecurti* Della Valle 1880
- 8b. Ventral surface of last segment of urosome with 2 rows of hardly discernible spinules.....
.....*teissieri* Bocquet and Stock 1958
- 9a. Ratio of length to width of caudal ramus about 1.5.....
.....*investigatoris* Sewell 1949
- 9b. Ratio of length to width of caudal ramus much more than 1.5.....10
- 10a. Ratio of length to width of caudal ramus about 3.....*nortoni*, new species
- 10b. Ratio of length to width of caudal ramus more than 3.5.....11
- 11a. Terminal segment of antenna at least twice as long as wide.....
.....*leptostylis* (Sars 1916)
- 11b. Terminal segment of antenna about 1.5 times as long as wide.....
.....*dilatatus* (Sars 1918)
- 12a. Terminal segment of fourth exopodite with 4 spines.....13
- 12b. Terminal segment of fourth exopodite with 3 spines.....16
- 13a. Maxilla with low apical sclerotized portion, not inclining anteriorly in marked angle to remainder of appendage.....*hawaiiensis* (Wilson 1923)
- 13b. Maxilla with apical portion erect, large, sharply angled14
- 14a. Exterior margin of fifth leg without spinules or setae.....
.....*groenlandicus* (Hansen 1921)
- 14b. Exterior margin of fifth leg with row of spinules or setae.....15
- 15a. Exterior margin of fifth leg bearing only about 5 short, stout, conical spinules
.....*minor* Stock 1959
- 15b. Exterior margin of fifth leg bearing many long, slender spinules or setules
.....*concinus* (A. Scott 1909)
- 16a. Second and fourth segments of antennule extremely elongate, over 4 times as long as wide
.....*navanacis* (Wilson 1935)
- 16b. Second and fourth segments of antennule of moderate proportions, less than 3 times as long as wide.....
.....*pinnae* Humes 1959

The literature contains references to species of *Anthessius* which have not yet received formal systematic characterization: *Pseudomolgus* sp. Wilson (1921: 15); *Pseudomolgus* sp. Wilson (1923: 4); and *Anthessius* sp. Humes and Cressey (1958: 935).

Anthessius Della Valle 1880

Boeckia Brady 1872a; Brady 1872b.

Lichomolgus Brady 1880 (pars); auctorum.

Anthessius Della Valle 1880; Canu 1891;

Monod and Dollfus 1932; auctorum.

Hermanella Thompson and Scott 1903

(pars); auctorum.

Pseudomolgus Sars 1916; auctorum.

The complete synonymy of the genus is not given here, although the basis for tracing all references is provided in the above and the bibliographies provided in the references cited. There are several systematic problems connected with the genus still to be clarified.

In many regards the diagnosis of the genus provided by Della Valle still holds, although some of his characters were erroneous. However the modern definition may well be based on the original description. The body is mostly cyclopid, but some considerable elaboration of body processes may occur. The segment of the first legs is functionally involved with the cephalosome in part and may be entirely anatomically

fused. The antennule is 7-segmented. The antenna is 3-segmented, the basal 2 segments each with 1 seta, the terminal segment with several setae and several characteristic articulated hooks. The mandible is an unsegmented flat plate tapering apically in a long setiform process. An equally well-developed accessory process is articulated on the anterior margin just proximal to the distal lash. Marginal ornamentation is strongly developed in both elements. The maxillule is a flat plate, with expanded and somewhat incised apical margin, with armature consisting of an articulated spine and seta. The maxilla has a greatly expanded basal segment, the flat apical segment tapering and bending anteriorly to form a heavily cuticularized element with right-angled outline, usually with 1 accessory articulated spine or seta, and with the margin developed as a series of conspicuous spinous processes. The maxilliped of the female is obscurely 3-segmented, with reduced armature. In the male the maxilliped is 3-segmented, the terminal 2 segments participating in a characteristic subchela. Hand of subchela inflated and with ornamentation of spinules and spines. Finger of subchela very elongate and bearing accessory seta. Legs 1 to 4 biramous, all rami trimerous. Armature well developed, the most characteristic pattern being that of the terminal segments of the third endopodite, bearing 4 spines and 2 setae; that of the terminal 2 segments of the fourth endopodite, bearing on segment two 2 setae, on three 1 seta and 4 spines; and that of the terminal segment of the fourth exopodite, this bearing 5 setae and alternatively 3 or 4 spines. The fifth leg has 1 free segment, the basal element being only a setiferous prominence of the body segment. The flat, elongate free segment bears four elements of armature, characteristically 3 spines and a seta. The sixth legs are not particularly distinctive among those of poecilostomes, and the caudal rami are variable in proportions, although the typical cyclopoid armature is consistently well developed.

Sars designated *Boeckia arenicola* Brady as the type of *Pseudomolgus*. The type for *Anthessius* has not yet been fixed, but must be selected from one of the two original species of Della Valle, *A. pleurobrancheae* and *A. solecurti*. On the basis of the redescription and ex-

tensive illustration of *A. solecurti* by Stock (1959), this species is herewith designated as the type of the genus.

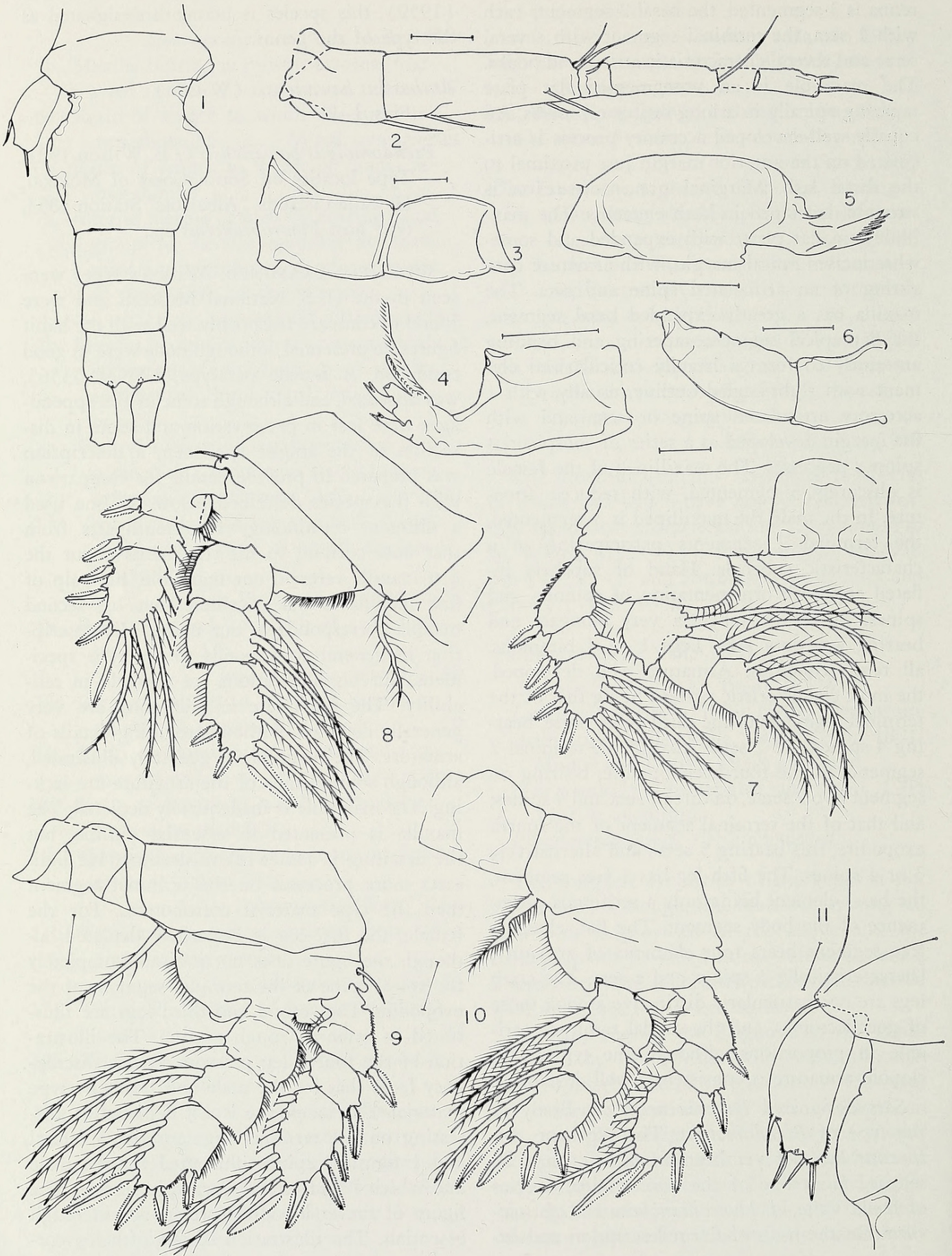
Anthessius hawaiiensis (Wilson)

Figs. 1-11

Pseudomolgus hawaiiensis C. B. Wilson 1921.

Type locality off South Coast of Molokai, Hawaiian Islands, "Albatross" Station 3853, type host *Pleurobranchus* sp.

SPECIMENS EXAMINED: Wilson's types were seen in the U. S. National Museum and were found to compare reasonably well with the habit figures he presented, although none were in good condition. A female paratype, USNM 53565, was dissected, and although some of the appendages were lost in preservation and some in dissection of the fragile specimen, a description was prepared to provide details for comparison with the species described below. Wilson used a different terminology for mouthparts from that now current, so his statements about the first maxilla refer to our mandible, his palp of first maxilla is our maxillule, but his second maxilla corresponds to our usage. His description in general corresponds to the type specimens, but his illustrations are variable in reliability. The antennule and antenna are very generally depicted, without providing details of armature. The mandible is generally illustrated, although some details of the armature are lacking. The maxillule is inadequately depicted. The maxilla is presented in essential outline, but the detailing is somewhat misleading. He indicates more processes on the terminal segment than the type material corroborates. For the female, the first leg is essentially depicted, although the figure does not indicate completely the apical spine of the terminal segment of the exopodite. The second and third legs are illustrated in essential rough outline. The illustration of the fourth leg presents serious discrepancy from that for the male and from the type material. The exopodite is not depicted as possessing on the terminal segment the 3 lateral and 1 terminal spines illustrated for the male and which I find on the paratypic female. The figure of the endopodite corresponds in rough essentials. The illustration of the fifth leg cor-



responds in rough essentials to the paratype, but the armature was incompletely represented. For the male, the third leg was represented as corresponding in rough essentials to the female, the fourth leg was illustrated so that the exopodite corresponds to what I found in the female paratype and serves to indicate a correction can be made in the illustration for the female. However the illustration of the endopodite does not represent the condition found in any *Anthessius* male I know of. This figure then is subject to question. The figures 55, 56, representing the fifth leg of the male, do not agree. I was unable to reinvestigate the appendage.

DESCRIPTION: Female (Figs. 1–11), body length 4 mm., greatest width 2 mm., based on Wilson's original description. Body of rather generalized cyclopid contours, but with most thoracic and abdominal segments distinct, so that regionalization is not emphatic. Cephalosome a fused complex bearing appendages through first swimming legs and comprising .34 of total body length, measured from apex of cephalosome to end of a caudal ramus. Segment of first legs not free, but strongly indicated by lateral indentations and surface grooves. Metasome including segments of second through fourth legs, with general body articulation between segments of legs 4 and 5. Urosome (Fig. 1) a complex including segment of legs 5, genital segment and 3 additional abdominal segments, considering element bearing anal opening and supporting caudal rami as terminal segment. Urosome comprising .41 of total body length. Genital segment expanded laterally.

Antennule (Fig. 2) essentially 7-segmented, but with complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment. Approximate proportional lengths of segments, basal to distal: Segment I, 3; II, 6; III, 1; IV, 3.5; V, 2; VI, 1; VII, 1. Setae varying in length; count per segment indeterminable in available material.

Antenna (Fig. 3) with segmental composition much obscured by additional flexures, involving integumental folds, and torsions of one region of appendage on adjoining regions, but probably essentially 3-segmented. Basal segment clear-cut, apical articulation transverse, no armature determinable. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; no armature determinable. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for elaborately articulated clawlike elements and setae. Details of armature indeterminable from available material.

Mandible (Fig. 4) a flat plate, with very cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Two most basal elements of ornamentation flat toothlike structures, compound apically and articulating with margin of appendage. Remainder of ornamentation a long row of graduated denticles. On anterior margin articulated a long lashlike auxiliary seta with conspicuous graduated row of cilia on outer margin. Between apical lash and auxiliary seta an articulated cuticular piece with some marginal ornamentation.

Maxilla (Fig. 5) with very long articulation with body surface, resulting in characteristic massive basal segment, on which articulates flattened apical segment with heavy cuticularization. Apex produced in sharp angle anteriorly with toothlike expansions of cuticle forming a medial saw-edge. Five marginal teeth, formed by flangelike protrusions of cuticle. Apex produced as short spinelike process. Inserted at base of angle of curvature of this segment and lying on its surface an articulated setule.

Maxilliped (Fig. 6) fairly long, 2-segmented. Basal segment a little over half as long as distal. Terminal segment with apical spinelike process. Margins somewhat cuticularized.

First legs (Fig. 7) with well-developed bimerous protopodites, yoked by substantial inter-

FIGS. 1–11: *Anthessius hawaiiensis* (Wilson). The scales accompanying certain figures represent 0.1 mm. Female: 1, urosome; 2, antennule; 3, base of antenna; 4, mandible (partial); 5, maxilla; 6, maxilliped; 7, first leg; 8, second leg; 9, third leg; 10, fourth leg; 11, fifth leg.

coxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Coxopodite seta very long, extending rather more medially than distally, its length slightly greater than width of intercoxal plate. Basipodite with row of cilia on curving medial margin. Armature of trimerous exopodite: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin and row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external hyaline flange and entire inner margin. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 2 apical setae, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. Every segment with row of cilia on lateral margin. Setae of coxopodite and rami with plumose ciliation.

Second legs (Fig. 8) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. Basipodite with tiny lateral seta; medial margin with dense row of cilia. Exopodite trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and very small internal flange. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spines of terminal segment subtended by such proc-

esses, but these somewhat less developed than those of basal segments. Spines of terminal segment with hyaline flanges. Each segment with row of cilia on lateral margin. Setae of coxopodite and rami with plumose ciliation.

Third legs (Fig. 9) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite, about equal to width of intercoxal plate, inserted on medial free portion of distal border of segment. Basipodite with small lateral seta; medial margin with row of cilia. Exopodite, extended almost directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, dense row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal margin entire. Trimerous endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 2 terminal spines, 2 medial setae. Each of 2 basal segments produced at distal lateral corners as small spinous cuticular processes. Spines of terminal segment subtended by such processes, but these even less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. Setae of coxopodite and rami with plumose ciliation.

Fourth legs (Fig. 10) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite inserted on medial free portion of distal border of segment; length about equalling width of intercoxal plate. Medial margin of basipodite with short row of cilia. Exopodite, extended with slight flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with

external hyaline flange and internal margin entire. Trimerous endopodite with slight flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines set in steplike emarginations, 2 apical spines, 1 medial seta. Medial setae of all segments reduced somewhat in length. Each of basal 2 segments produced slightly at distal lateral corner as small spinous cuticular process. Most proximal spine of terminal segment subtended by such process, and another apical on segment. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. Setae of coxopodite and rami with plumose ciliation.

Fifth legs (Fig. 11) with probably 2 segments represented, basal consisting only of expansion on body posteriorly and laterally to furnish articulation of distal segment, and with a small seta laterally, representing armature. Second segment broad, flattened with cuticularized medial and lateral margins. Length about 2.5 times greatest width. Armature 2 spines and 2 setae, spaced on lateral and terminal margins: 1 lateral seta at about distal .8 of lateral margin; 1 spine at lateral distal corner; 1 seta near medial distal corner; 1 apical spine at medial distal corner. Spines subtended by small groups of spinules, these continuing as short row on distal fifth of medial margin.

Caudal ramus about 2.5 times as long as greatest width and 1.15 times as long as anal segment. Setal armature not determinable from available material.

REMARKS: Due to the small amount of type material the male of this species could not be reinvestigated. According to the original description by Wilson the length of the male is 2.85 mm., the width 1.25 mm., and the usual features of anatomical dimorphism appear to occur. Attempts have been made to re-collect this species. The host, as indicated by the original description, quite possibly is a fairly common form in Hawaiian waters, but no further records of the copepod have come to light.

The species is differentiated from others of the genus in the key above. Many details of the anatomy should be reinvestigated when well-preserved specimens become available. The

species is one of the larger ones known for the genus.

Anthessius navanacis (Wilson)

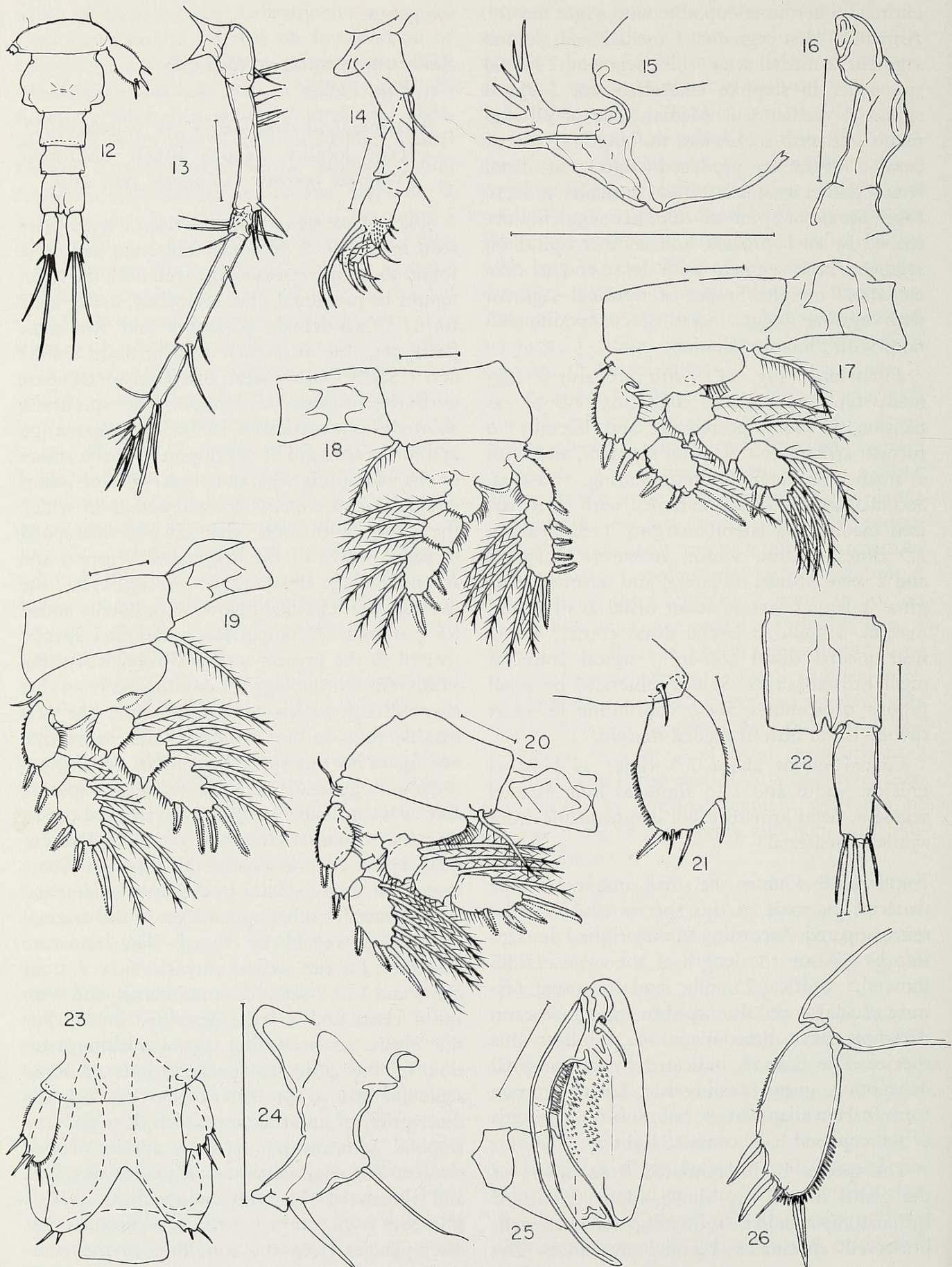
Figs. 12–26

Pseudomolgus navanacis, C. B. Wilson, 1935.

Type locality, Laguna Beach, California,

Navanax inermis (Cooper), type host.

SPECIMENS EXAMINED: Wilson's types were seen in the U. S. National Museum, and were found to compare reasonably well with the habit figures he presented (but see below, under body form). Two female paratypes and two male paratypes, one pair each from USNM 54082 and USNM 64062, were dissected to compare with the original description. The specimens showed some variation in body segmentation and in the strength of development of the spines of the swimming legs, but these were of minor grade. The specimens in some details in which they agree with each other do not correspond to some details of the original description and accompanying illustrations. Accordingly, the species is redescribed below, with details added for purposes of comparison with other species treated in the present study. Wilson was using a different terminology for mouthparts from that now current, so his statements about the first maxilla refer to our mandible. His description and figure for this appendage are in good agreement with generalities about *Anthessius* species, and, as I was unable to dissect out in good condition the mandible from the paratypes I examined, I can add no further information. Some important discrepancies in the descriptions and illustrations for other appendages in the original description should be noted. The armature described for the second antenna, 6 or 7 stout claws and 1 or 2 setae, does not correspond with the 4 claws and 7 setae described below. For the 4 pairs of swimming legs, a misinterpretation of the cuticular specializations of some segments led to presentation in the original description of an armature which does not correspond with any known for a species of *Anthessius*. The exopodites are adequately described and illustrated. For the endopodites, spinous processes were counted as spines and some other discrepancies from the condition in the para-



types occur. The illustration and description of the fifth leg in the female corresponds in rough essentials to the condition in the paratype, but one element of the armature was omitted. For the male, the maxilliped was described and figured in approximate correspondence with that of the paratypes, but Wilson overlooked a well-developed basal segment, so that the appendage was referred to as 2-segmented.

DESCRIPTION: Female (Figs. 12–22): Body length 2.0 mm., greatest width 1.40 mm., based on Wilson's original description. Body of rather generalized cyclopid contours, but with metasomal and abdominal segments distinct, so that posterior regionalization is not emphatic. Cephalosome a fused complex bearing appendages through first swimming legs and comprising .4 of total body length, measured from apex of cephalosome to end of a caudal ramus. Original description stated that segment of the first legs is fused with the cephalothorax and indicated so as an anatomical segment by slight marginal indentations. Paratypes (topotypic) from Laguna Beach (USNM 54082) showed the segment so clearly delimited as almost to justify considering it a free element. Paratypes from Anaheim Slough, California (USNM 64062) show fusion as in the original description.

Antennule (Fig. 13) essentially 7-segmented, but with complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment, which if present would raise number to 8. Approximate proportional lengths of segments, basal to distal: Segment I, 3; II, 6.5; III, 1.5; IV, 6; V, 3; VI, 1.5; VII, 1. Setae varying in length, count per segment undeterminable due to poor preservation of available specimens.

Antenna (Fig. 14) with segmental composition much obscured by additional flexures, involving integumental folds, and torsions of one region of appendage on adjoining regions, probably essentially 3-segmented. Basal segment without clear-cut, apical articulation, bearing 1

short external seta. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; 1 short seta distally and externally inserted. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements and 2 setae. Another seta near distal margin. A subapical group of 4 setae of diverse lengths. Total elements—4 claws, 7 setae.

Mandible a flat plate, with cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Two most basal elements of ornamentation flat structures compound apically and articulating with margin of appendage. Remainder of ornamentation a row of graduated denticles. On anterior margin of mandible articulated a long lashlike auxiliary seta with conspicuous marginal ornamentation.

Maxillule of characteristic type for genus, an elongate lobe with flaring apex. On apex a more medial spine and far lateral seta. More detailed description presented for male, below.

Maxilla (Fig. 15) with very long articulation with body. Characteristic massive basal segment, on which articulating flattened apical segment, with heavy cuticularization. Apex produced in sharp angle anteriorly, with toothlike expansions of cuticle forming medial saw-edge. Five large teeth formed by flangelike protrusions of cuticle. Apex produced as more elongate spinelike process, to total number of outgrowths 6. In some specimens there may be 1 more or 1 less tooth. Inserted at base of angle of curvature of distal segment, and lying on surface, an articulated, fairly long seta.

Maxilliped (Fig. 16) a prominent mouthpart, as seen in general habitus of mouth area, but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Terminal portion with folds and indentations of cuticularized surface, but with no elements of armature.

First legs (Fig. 17) with well-developed

FIGS. 12–26: *Anthessius navanacis* (Wilson). The scales accompanying certain figures represent 0.1 mm. Female: 12, urosome; 13, antennule; 14, antenna; 15, maxilla; 16, maxilliped; 17, first leg; 18, second leg; 19, third leg; 20, fourth leg; 21, fifth leg; 22, anal segment and caudal ramus. Male: 23, segments of fifth and sixth legs; 24, maxillule; 25, maxilliped; 26, fifth leg.

bimerous protopodites, yoked by substantial intercoxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Coxopodite seta relatively long, extending rather more medially than distally, and with its length slightly less than the width of intercoxal plate. Basipodite with small lateral seta proximal to insertion of exopodite and with row of stout cilia on curving medial margin. Exopodite held at angle to protopodite, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin, row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 2 apical setae, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as strong spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. Each segment with row of cilia on lateral margin. All setae of leg with plumose ciliation.

Second legs (Fig. 18) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. Basipodite with small lateral seta; medial margin with cilia. Exopodite trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal margin entire. Endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial setae. Each of basal 2 segments

produced at distal lateral corner as small spinous cuticular process. Proximal spine of terminal segment also subtended by such process. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 19) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite about as long as width of plate, inserted on medial free portion of distal border of segment. Basipodite with small lateral seta; medial margin with cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal margin entire. Trimerous endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in steplike emarginations, 1 terminal spine, 2 medial setae. Each of 2 basal segments produced at distal lateral corner as moderately long spinous cuticular process. Proximal spine of terminal segment subtended by such process, but this less developed than those of basal segments. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fourth legs (Fig. 20) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite inserted on medial free portion of distal border of segment. Basipodite with small lateral seta; medial margin with row of cilia. Exopodite, with somewhat medial flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 2 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 4 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal

margin, except for slight notch, entire. Trimerous endopodite with medial flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in steplike emarginations, 1 terminal spine, 1 medial seta. Medial setae of distal segment very short. Each of basal 2 segments produced at distal lateral corner as small spinous cuticular process. Basal spine of terminal segment also subtended by such process. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges, complete in lateral spines, only on lateral margin of terminal spine. All setae of leg with plumose ciliation.

Fifth legs (Fig. 21) with probably 2 segments represented, basal consisting only of expansion on body segment posteriorly and laterally to furnish articulation of distal segment, with 1 small seta representing armature. Second segment elongate, flattened, with cuticularized medial and lateral margins. Length about 1.8 times greatest width. Armature 3 spines and 1 seta, spines about equally spaced on lateral and terminal margins: 1 lateral spine at distal corner of lateral margin; 1 spine at about midpoint of broad apical margin; 1 spine at medial distal corner; 1 seta near medial distal spine. Seta and apical spine subtended by small groups of spinules. Spinules also forming short rows on distal half of medial margin and middle third of lateral margin.

Sixth legs probably represented by small setiferous knob in depression at aperture of oviduct, located dorsally on lateral expansion of genital segment. Two subequal setules forming armature.

Caudal ramus (Fig. 22) about 2.5 times as long as greatest width and about as long as anal segment. Armature 6 setae. Of apical quartet of setae, medial of central 2 longest, about 4 times as long as ramus; adjacent long seta 2 times length of ramus. Medial apical seta about .6 as long as ramus; lateral apical seta about .4 as long as ramus. Lateral marginal seta short, about .4 as long as ramus, inserted on lateral margin at about distal third. Dorsal medial seta very short, inserted just subapically.

MALE (Figs. 23–26): Body length 1.5 mm., greatest width .5 mm., based on Wilson's original

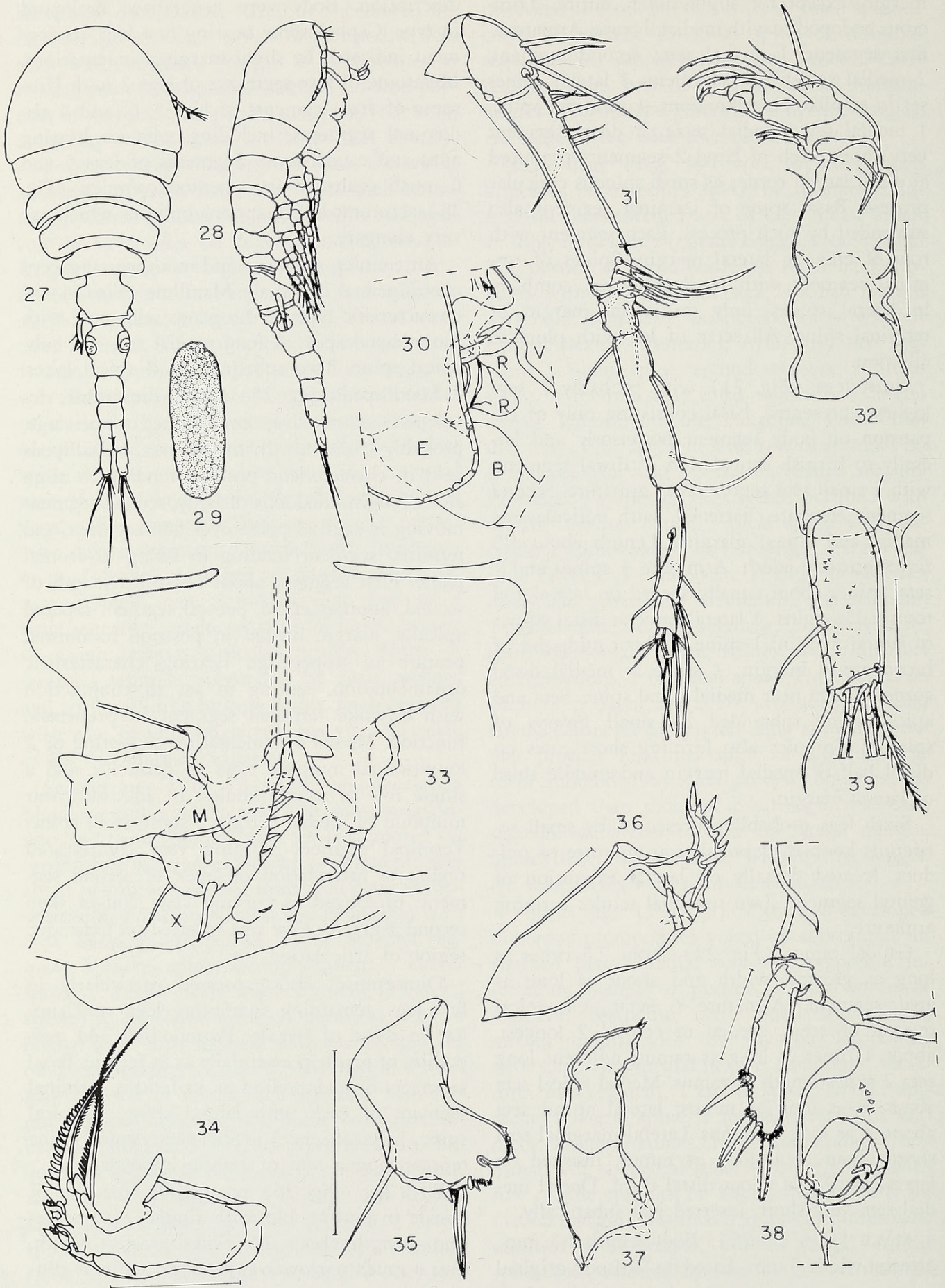
description. Body very generalized cyclopid in type. Cephalosome bearing first legs, its segment indicated by slight marginal indentations. Metasome of free segments of legs 2 to 4. Urosome of free segments of legs 5, 6, and 4 abdominal segments, including segment bearing anus and caudal rami. Segments of legs 5 and 6 much coalesced in a genital complex (Fig. 23) accommodating spermatophores which are very elongate.

Antennules, antennae and mouthparts, except maxilliped, as in female. Maxillule (Fig. 24) of characteristic type of the genus; elongate, with shoe-shaped apex. A long medial seta and subapical spine. Two subequal small apical lobes.

Maxilliped (Fig. 25) highly dimorphic, developed as massive, complicated appendage, probably trimerous. In mouth area, maxillipeds held in characteristic posture, tending to align along longitudinal axis of body, second segment moving in sagittal plane over first segment, and terminal segment tending to swing in frontal plane. First segment about one-third length of second, unornamented. Second segment tapered apically, margin medial in position in normal posture of appendage bearing characteristic ornamentation, serving to act in conjunction with clawlike terminal segment in prehensile function. Medial ornamentation consisting of 2 longitudinal multiple rows of denticles, and a single row of long spinules. In addition, near midpoint of medial margin a short, stout spine. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, longer than second segment. One seta inserted on expanded region of articulation.

Dimorphism also expressed particularly in first legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs essentially as in female. Basal segments of endopodites as in female, terminal segment of each with lateral spine, 1 apical spine, 1 apical seta, 3 medial setae, apical spine representing a seta of female appendage.

Fifth leg (Fig. 26) not greatly like that of female in outline, but with similar ornamentation. Length about 2.5 times greatest width, thus a much narrower appendage, without con-



spicuous basal constriction. Medial row of spinules more extensive, reaching apex.

Sixth legs (Fig. 23) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 setae, the more medial about half as long as lateral.

REMARKS: The species seems to belong to a southern California fauna, as it was collected from at least two localities, Anaheim Slough and Laguna Beach, by the MacGinities. In considerable exploration and study of marine zoology on the West Coast no collections from further north have yet come to my attention, although the host is recorded as ranging very widely on the coast of California and has been closely observed frequently. Details of the antennules should be reinvestigated on freshly collected specimens.

Anthessius lighti, new species

Figs. 27-58

TYPES: Holotypic female, USNM 103307, allotypic male, USNM 103308, paratypes, USNM 103309; additional paratypes in Alan Hancock Foundation, University of Southern California, and in author's collection. Type locality, Bodega Bay, California, from *Aplysia californica* Cooper.

SPECIMENS EXAMINED: Several lots of this species are included in the material studied, but as far as can be determined they represent a single collection from *A. californica*, from Bodega Bay, California, June 1, 1941, O. Hartman and E. C. Dougherty, many specimens, males and females. The descriptions below and the illustrations are based on a number of specimens, some unmounted, some whole mounts, some temporarily mounted dissections, some permanently mounted dissections. Two of the latter have been selected as holotype and allotype.

DESCRIPTION: Female (Figs. 27-43): Body

length 2.67 mm., greatest width 1.14 mm., averages for 10 specimens. Body (Figs. 27, 28) of rather generalized cyclopid contours, but with most thoracic and abdominal segments distinct, so that regionalization is not emphatic. Cephalosome a complex bearing appendages through first swimming legs and comprising .33 of total body length measured from apex of cephalosome to end of a caudal ramus. General contour and internal structure strongly indicating segment of leg 1 a part of cephalosome, but this segment clearly demarcated dorsally and anteriorly by continuous articulationlike groove and well-developed marginal indentations. Ventrally segment of leg 1 apparently contributing to cephalosome in forming massive midventral bulge between mouthparts and leg 1. First legs situated on posterior edge of segment, directed posteriorly, obviously behaving functionally as part of metasomal group of legs. On anterior margin apex of head protruded in a slight bulge between bases of widely separated antennules. No rostrum, apical ventral region of head a wide flattened expanse between bases of antennules and antennae. Metasome including pedigerous segments of second through fourth legs, with general body articulation between segments of legs 4 and 5. Segment of fourth legs with distinctive bilateral, ventral structures. Fourth legs borne on anterior end of ventral surface of segment. At each side on posterior region of ventral surface two subequal lobes extending posteriorly. Lobes visible in dorsal view (Fig. 30) of intact animal, as lying between segments of legs 4 and 5 and medial to the fourth legs. Urosome a complex including segment of legs 5, a genital segment and 3 additional abdominal segments, considering element bearing anus and supporting caudal rami as terminal segment. Segment of fifth leg, as in other pedigerous segments, with dorsal epimeralike lateral expansions. Urosome comprising .45 of total body length. Genital segment expanded laterally, dorsally with dis-

FIGS. 27-39: *Anthessius lighti*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 27, habit, dorsal; 28, habit, lateral; 29, egg sack; 30, lateral part of segment of fourth leg and adjoining structures, dorsal view; 31, antennule; 32, antenna; 33, oral area; 34, mandible; 35, maxillule; 36, maxilla; 37, maxilliped; 38, fifth leg and lateral portion of genital segment; 39, caudal ramus. Legend: B, base of fourth leg; E, epimeron of segment of fourth leg; L, labrum; M, mandible; P, maxilliped; R, protuberance of unknown significance at base of fourth leg; U, maxillule; V, segment of fifth leg; X, maxilla.

tinctive structures marking apertures of oviducts and sites of attachment of egg sacks (Fig. 38). Egg sack (Fig. 29) about .35 of total body length, containing several hundred small eggs.

Antennule (Fig. 31) essentially 7-segmented, but with complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment. Approximate proportional lengths of segments, basal to distal: Segment I, 3; II, 7; III, 1.5; IV, 5; V, 3.5; VI, 1; VII, 1. Setae, varying in length and count per segment: Segment I, 4 setae; II, 7 setae near base of segment, 8 around distal end; III, 5 setae, 1 belonging to section suggesting a free segment; IV, 3 setae; V, 4 setae, 1 aesthete; VI, 2 setae, 1 aesthete; VII, about 5 setae, 3 on basal prominence of segment, apparently 2 setae and 1 aesthete apical.

Antenna (Fig. 32) with segmental composition obscured by flexures, involving integumental folds, and torsions, probably 3-segmented. Basal segment with partial distal articulation, 1 short external seta apically. Second segment with very complicated distal articulation, 1 short seta distally and externally inserted. Terminal segment short, with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements and 2 large setae. Another larger seta inserted midway between group of claws and apical setae. Small seta at external distal corner. A subapical group of 4 small setae of diverse lengths. Total elements: 4 claws, 8 setae.

Mouthparts compactly and intricately arranged in oral area (Fig. 33). Labrum of 2 conspicuous lobes, overlying entirely blades of mandibles, and much of distal parts of maxillae.

Mandible (Fig. 34) a flat, unsegmented plate, with cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Two most basal elements of ornamentation flat platelike structures, compound apically and articulating with margin of appendage. Remainder of ornamentation a long row of graduated denticles, about 15 of them of conspicuous size. On anterior margin articulated a long lashlike auxiliary seta with conspicuous marginal ornamentation. All of outer margin bearing graduated

row of spinules, distal two-thirds of inner margin with short spinules. Between apical lash and auxiliary seta a small articulated cuticular piece, subtriangular in outline.

Maxillule (Fig. 35) of characteristic type for the genus, an elongate lobe with flaring apex. On apex a spine and far laterally a seta. A medial apical indentation setting off a blunt median subapical lobe. Margins of appendage much sclerotized. Apical spine subtended by cuticular spinous processes and spinules.

Maxilla (Fig. 36) with very long diagonal articulation with body surface, resulting in characteristic basal segment, on which articulates flattened apical segment, with heavily cuticularized margins. Apex produced in sharp angle anteriorly with toothlike expansions of cuticle forming a medial saw-edge. Four large teeth formed by flangelike protrusions of cuticle. Apex produced as very small spinelike processes, 1 on each side of most distal tooth. Inserted at base of angle of curvature of this segment and lying on surface, an articulated, short, stout spine.

Maxilliped (Fig. 37) fairly long, a prominent mouthpart, as seen in general habitus of mouth area (Fig. 33), but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Basal 2 segments not ornamented. Terminal segment with 2 apical setules.

First legs (Fig. 40) with well-developed bimerous protopodites, yoked by substantial intercoxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Small spinules forming ornament on lateral distal corner of coxopodite. Coxopodite seta relatively long, extending medially, and with its length equal to width of intercoxal plate. Basipodite with lateral seta proximal to insertion of exopodite and with dense row of cilia on curving medial margin. Exopodite, extending directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin, dense row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate

hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 2 apical setae, 3 medial setae. Each segment with row of cilia on lateral margin. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. All setae of leg with plumose ciliation.

Second legs (Fig. 41) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. A few spinules at lateral distal corner of coxopodite. Basipodite with lateral seta, medial margin with dense row of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, a few cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spines of terminal segment subtended by such processes, but these less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 42) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite, about as long as width of plate, inserted on medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with small lateral seta; medial margin with dense row of cilia. Exopodite, extended directly, without notable flexure, trimerous.

Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, dense row of cilia on medial margin. Second segment with a few cilia on proximal part of medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in steplike emarginations, 1 terminal spine, 2 medial setae. Each of 2 basal segments produced at distal lateral corners as moderately spinous cuticular process. Spines of terminal segment subtended by such processes, but these less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fourth legs (Fig. 43) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite small, inserted on somewhat diagonally directed medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with small lateral seta; medial margin with short, dense row of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite with very slight medial flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in steplike emarginations, 1 terminal spine, 1 medial seta. Medial setae of all segments reduced, that of distal segment very short. Each of basal 2 segments produced moderately at distal lateral corner as small spinous cuticular process. Spines of terminal segment subtended by such proc-



esses, these less well developed than those of basal segments. Each segment with dense row of cilia on lateral margin, distal 2 segments with medial cilia. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fifth legs (Fig. 38) with probably 2 segments represented, basal consisting only of expansion on body segment posteriorly and laterally to furnish articulation of distal segment, but with 1 small seta representing armature. Second segment elongate, flat, with cuticularized medial and lateral margins. Length about 4 times greatest width. Armature 3 spines and 1 seta, spines about equally spaced on lateral and terminal margins: 1 lateral spine at about distal three-fourths of lateral margin, 1 lateral spine at about distal .9 of margin; 1 seta inserted close to lateral distal spine; 1 apical spine at medial distal corner. Spines subtended by small groups of spinules and cuticular spinous processes. Spinules of apical spine extending briefly on medial margin to form short row.

Sixth legs probably represented by small setiferous knob (Fig. 38) in depression at aperture of oviduct, located dorsally on lateral expansion of genital segment. Two subequal setules forming armature.

Caudal ramus (Fig. 39) about 2.6 times as long as greatest width and nearly as long as anal segment. Margins with conspicuous cuticular development and some surface ornamentation. Armature consisting of 6 setae. Of apical quartet of setae, medial of central 2 longest, about 3.5 times as long as ramus, adjacent seta 2.2 times length of ramus. Medial apical seta about .73 times as long as ramus; lateral apical seta about .55 times as long as ramus. Lateral marginal seta about .5 as long as ramus, inserted on lateral margin at about distal .6. Dorsal seta short, not quite as long as width of ramus, inserted medially just subapically.

MALE (Figs. 44–58): Body length 2.53 mm., greatest width 0.94 mm., based on 6 specimens. Body (Figs. 48, 49) very generalized cyclopoid in type. Cephalosome bearing first legs, segment

of these appendages strongly indicated by indentations. Metasome of free segments of legs 2 to 4. Segment of leg 4 lacking auxiliary lobe-like elements seen in female. Urosome of segments of legs 5, 6, and 4 abdominal segments. Segments of legs 5 and 6 much coalesced in a genital complex containing elongate spermatophores. Segment of leg 5 without epimera.

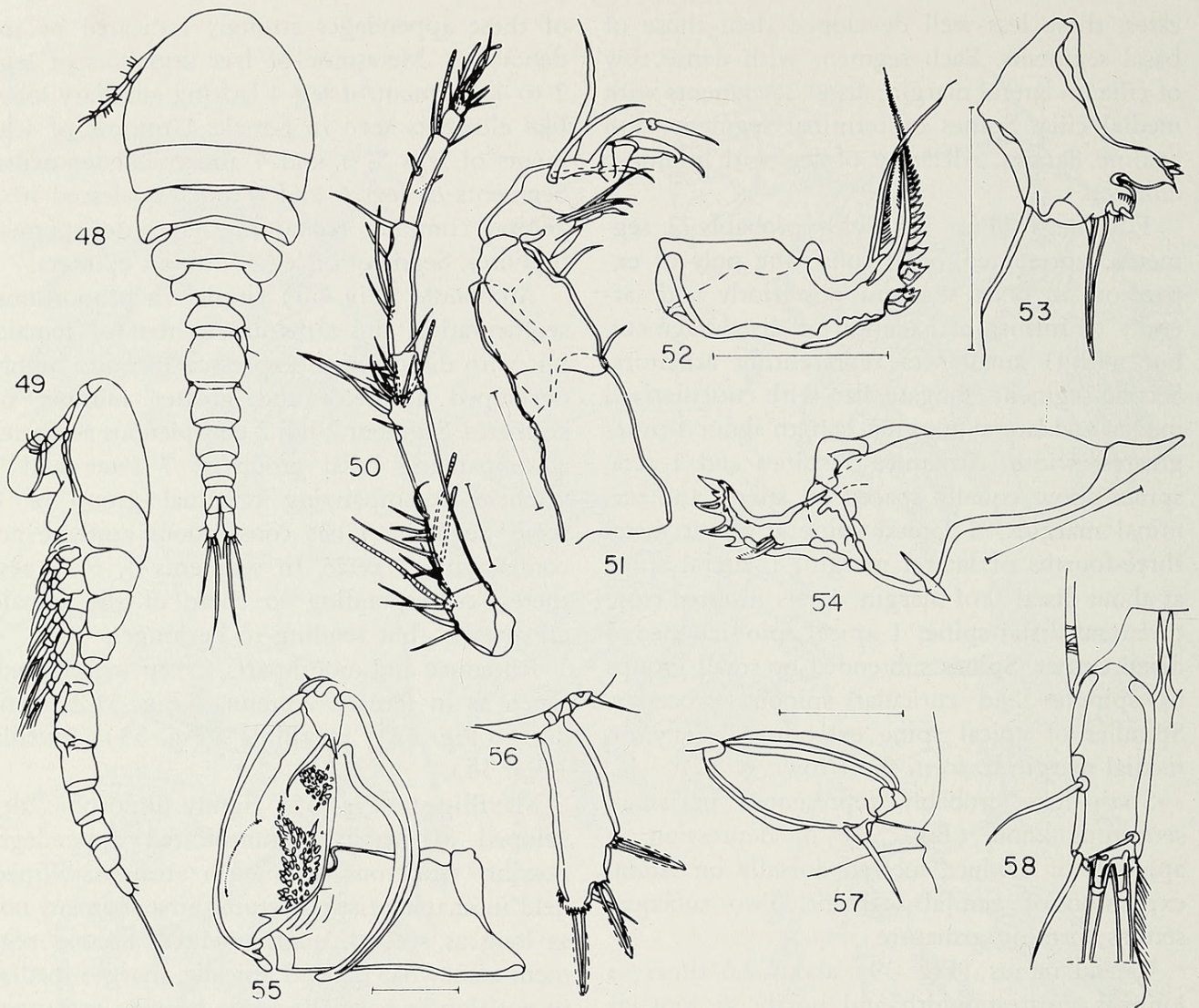
Antennule (Fig. 50) similar in proportions, segmentation and armature to that of female, but with dimorphism expressed in more highly developed aesthetes and greater number of aesthetes. Segment 2 has 2 conspicuous aesthetes accompanying basal group of 7 setae and 1 aesthete accompanying terminal group of 8 setae. Segment 4 has conspicuous aesthete accompanying 3 setae. In segments 5, 6, 7, aesthetes, corresponding to those of the female are present, but tending to be longer.

Antennae and mouthparts, except maxilliped, much as in female. Antenna (Fig. 51); mandible (Fig. 52); maxillule (Fig. 53); maxilla (Fig. 54).

Maxilliped (Fig. 55) highly dimorphic, developed as massive, complicated appendage, possibly trimerous. In mouth area, maxilliped held in characteristic posture. First segment not as long as second, unornamented. Second segment somewhat tapered apically, margin medial in position in normal posture bearing ornamentation serving to act in conjunction with claw-like terminal segment in prehensile function. Medial ornamentation consisting of patches of denticles. In addition, near midpoint of medial margin a short, stout spine. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, longer than second segment. One seta, accompanied by 1 setule, inserted on expanded region of articulation.

Dimorphism also expressed particularly in first legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs (Fig. 44) essentially as in female. Basal segments of endopodites as in female, terminal segment of each with 1 lateral

FIGS. 40–47: *Anthessius lighti*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 40, first leg; 41, second leg; 42, third leg; 43, fourth leg. Male: 44, first leg; 45, second leg; 46, third leg; 47, fourth leg.



FIGS. 48-58: *Anthessius lighti*, new species. The scales accompanying certain figures represent 0.1 mm. Male: 48, habit, dorsal; 49, habit, lateral; 50, antennule; 51, antenna; 52, mandible; 53, maxillule; 54, maxilla; 55, maxilliped; 56, fifth leg; 57, sixth leg; 58, caudal ramus.

spine, 1 apical spine, 1 apical seta, 3 medial setae, apical spine representing a seta of the female appendage. Leg 2 (Fig. 45), leg 3 (Fig. 46), leg 4 (Fig. 47) in general aspect and ornamentation essentially similar to female.

Fifth leg (Fig. 56) very similar to that of female in general structure and ornamentation. Shorter in proportion to width, length equalling about 3 times greatest width.

Sixth legs (Fig. 57) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 setae, the more medial with an articulating base.

Caudal rami (Fig. 58) with no striking differences from those of female.

REMARKS: This species is named for S. F. Light. The species is distinguished from others of the genus in the key above. Some of its distinctive features may turn out to occur in other species when more anatomical details are known in the genus. The complement of aesthetes on the antennule of the male does not occur in *A. nortoni* and *A. fitchi*, also West Coast forms, but is found in *A. arenicolus* and *A. teissieri* of Europe. The accessory protuberances of the fourth pedigerous segment have not so far been reported from any other species.

Anthessius nortoni, new species

Figs. 59-91

TYPES: Holotypic female, USNM 103304, allotypic male, USNM 103305, paratypes, USNM 103306; paratypes in author's collection. Type locality, San Juan Island, Washington, from *Diadora aspera* (Eschscholtz).

SPECIMENS EXAMINED: From *D. aspera*: Culver's Point, San Juan Island, Washington, intertidal, July 5, 1952, many specimens, females, males, developmental stages, including holotype, allotype. Off Reed Rock, San Juan Channel, Washington, dredged, 92 m., July 2, 1953, many specimens, females, males, developmental stages. Salmon Beach, Tacoma Narrows, Washington, intertidal, May 14, 1953, many specimens, females, males.

The description below and the illustrations are based on a number of specimens, some unmounted, some whole mounts, some temporarily mounted dissections, some permanently mounted dissections. Holotype and allotype are permanently mounted dissections.

DESCRIPTION: Female (Figs. 59-75): Body length 1.28 mm., greatest width .63 mm., averages from 10 specimens. Body (Fig. 59) broad, of rather generalized cyclopid contours, with thoracic and abdominal regionalization fairly emphatic. Cephalosome a complex bearing appendages through first swimming legs and comprising .34 of total body length, measured from apex of cephalosome to end of a caudal ramus. Segment of first legs strongly indicated by indentations and grooves, but mass of segment firmly coalesced with more anterior mass of body. Cephalosome and metasome together comprising a forebody of almost circular outline. On anterior margin, apex of head protruded as slight bulge between bases of widely separated antennules (Fig. 60). No rostrum, apical ventral region of head a wide flattened expanse between bases of antennules and antennae. Metasome including pedigerous segments of second through fourth legs, with general body articulation between segments of legs 4 and 5. Urosome a complex including segment of legs 5, genital segment and 3 additional abdominal segments, considering element of anal opening and supporting caudal rami as terminal segment.

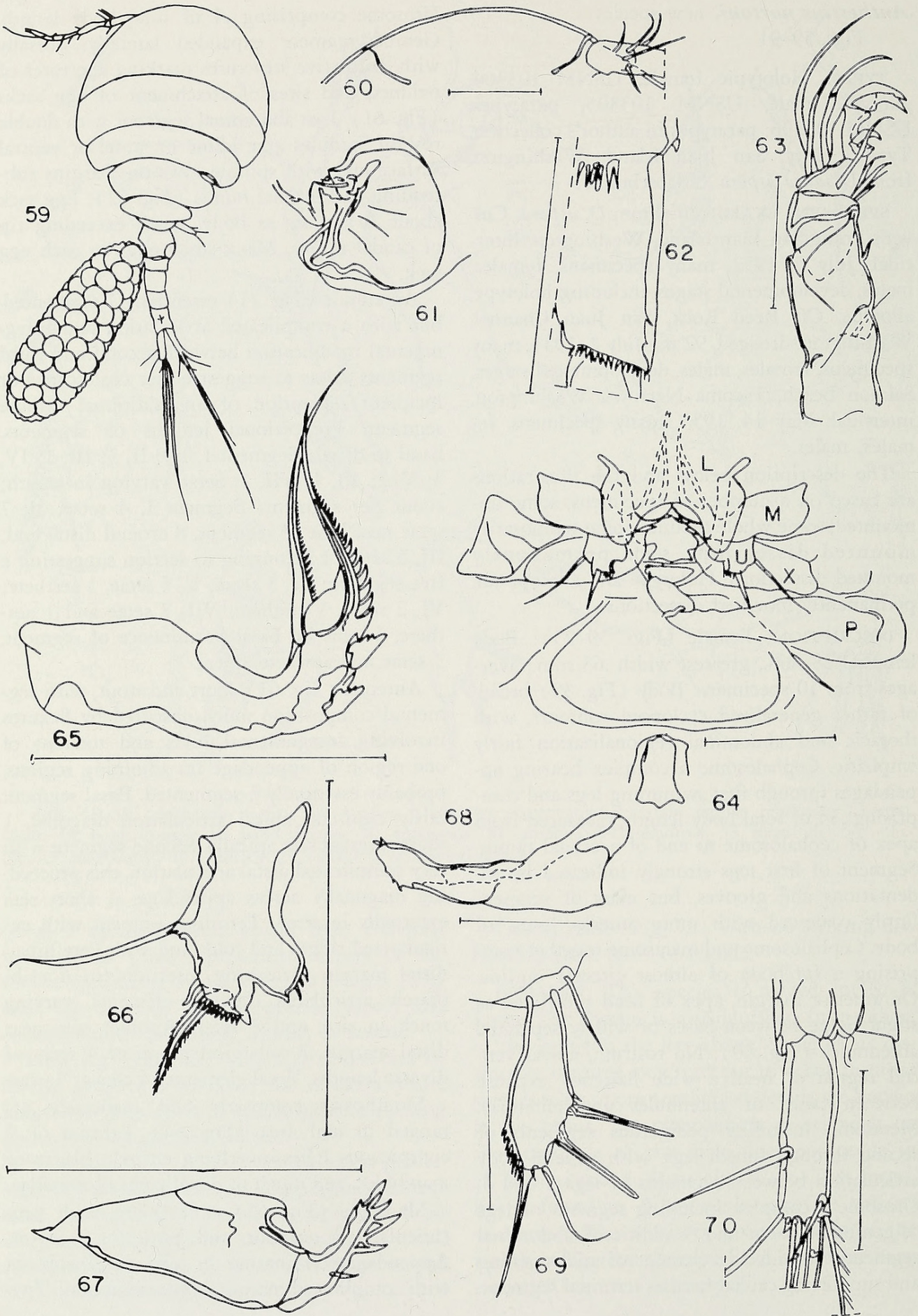
Urosome comprising .4 of total body length. Genital segment expanded laterally, dorsally with distinctive structures marking apertures of oviducts and sites of attachment of egg sacks (Fig. 61). Last abdominal segment with double row of spinules at midline on anterior ventral surface and with spinule rows on margins subtending each caudal ramus (Fig. 62). Egg sack about .6 as long as body, much exceeding tip of caudal ramus. Many small eggs in each egg sack.

Antennule (Fig. 71) essentially 7-segmented, but with a complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment. Proportional lengths of segments, basal to distal: Segment I, 1.5; II, 3; III, 1; IV, 3; V, 2; VI, 1; VII, 1. Setae varying in length; count per segment: Segment I, 4 setae; II, 7 setae near base of segment, 8 around distal end; III, 5 setae, 1 belonging to section suggesting a free segment; IV, 3 setae; V, 4 setae, 1 aesthete; VI, 2 setae, 1 aesthete; VII, 7 setae and 1 aesthete, 4 setae on basal prominence of segment, 3 setae and aesthete apical.

Antenna (Fig. 63) short and stout, with segmental composition much obscured by flexures involving integumental folds and torsions of one region of appendage on adjoining regions, probably essentially 3-segmented. Basal segment fairly clear-cut, apical articulation diagonal, 1 short external seta apically. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; 1 short seta externally inserted. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements, varying much in size, and 2 setae. Another seta near distal margin. A subapical group of 4 setae of diverse lengths. Total elements: 4 claws, 7 setae.

Mouthparts compactly and intricately arranged in oral area (Fig. 64). Labrum of 2 conspicuous lobes, overlying entirely blades of mandibles, and much of distal parts of maxillae.

Mandible (Fig. 65) a flat plate, with very cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation: Two



most basal elements of ornamentation flat tooth-like structures, compound apically and articulating with margin of appendage; remainder of ornamentation a long row of graduated denticles, about 15 of them of conspicuous size. On anterior margin articulated a long lashlike auxiliary seta with outer margin bearing graduated row of spinules on proximal third; inner margin without spinules. Between apical lash and auxiliary seta a subtriangular cuticular piece, flat and platelike.

Maxillule (Fig. 66) of characteristic type of the genus, an elongate plate with lobed apex. On apex a spine; at midpoint of lateral margin a seta. An apical indentation setting off a blunt median subapical lobe. Margins of appendage much sclerotized. A few spinules on median lobe and row of graduated spinules subtending apical spine.

Maxilla (Fig. 67) with very long articulation with body, resulting in characteristic basal segment, on which articulates flattened apical segment, with heavily cuticularized margins. Apex produced in sharp angle anteriorly with tooth-like expansions of cuticle forming a medial saw-edge. Four large teeth formed by flangelike protrusions of cuticle. Inserted at base of angle of curvature of this segment and lying on surface, a small, articulated spine.

Maxilliped (Fig. 68) fairly long, a prominent mouthpart, as seen in general habitus of mouth area, but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Terminal segment with 2 apical setules. Margins cuticularized and produced into 2 spinulelike protrusions.

First legs (Fig. 72) with well-developed bimerous protopodites, yoked by substantial intercoxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Small spinules forming ornamentation on lateral corner of coxopodite. Coxopodite seta very long, extending rather medially

and distally, and with its length more than width of intercoxal plate. Basipodite with long lateral seta proximal to insertion of exopodite and with row of cilia on distal margin. Exopodite with slight medial flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with large spinules on lateral margin, row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 1 lateral seta, 1 apical seta, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. Each segment with row of cilia on lateral margin. All setae of leg with plumose ciliation.

Second legs (Fig. 73) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. A row of spinules at distal lateral corner of coxopodite. Basipodite with short lateral seta; terminal margin with rows of cilia. Exopodite trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of stout spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in step-like emarginations, 1 terminal spine, 3 medial

FIGS. 59–70: *Anthessius nortoni*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 59, habit, dorsal; 60, ventral apical region of cephalosome; 61, structures at genital aperture; 62, one side of anal segment showing ornamenting spinules; 63, antenna; 64, oral area; 65, mandible; 66, maxillule; 67, maxilla; 68, maxilliped; 69, fifth leg; 70, part of anal segment and caudal ramus. Legend: L, labrum; M, mandible; P, maxilliped; U, maxillule; X, maxilla.

setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spines of terminal segment subtended by such processes, but these much less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 74) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite, slightly longer than width of plate, inserted on medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with lateral seta; terminal margin with rows of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in steplike emarginations, 1 terminal spine, 2 medial setae. Each of 2 basal segments produced at distal lateral corner as moderately small, spinous cuticular process. Spines of terminal segment subtended by such processes, but these less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

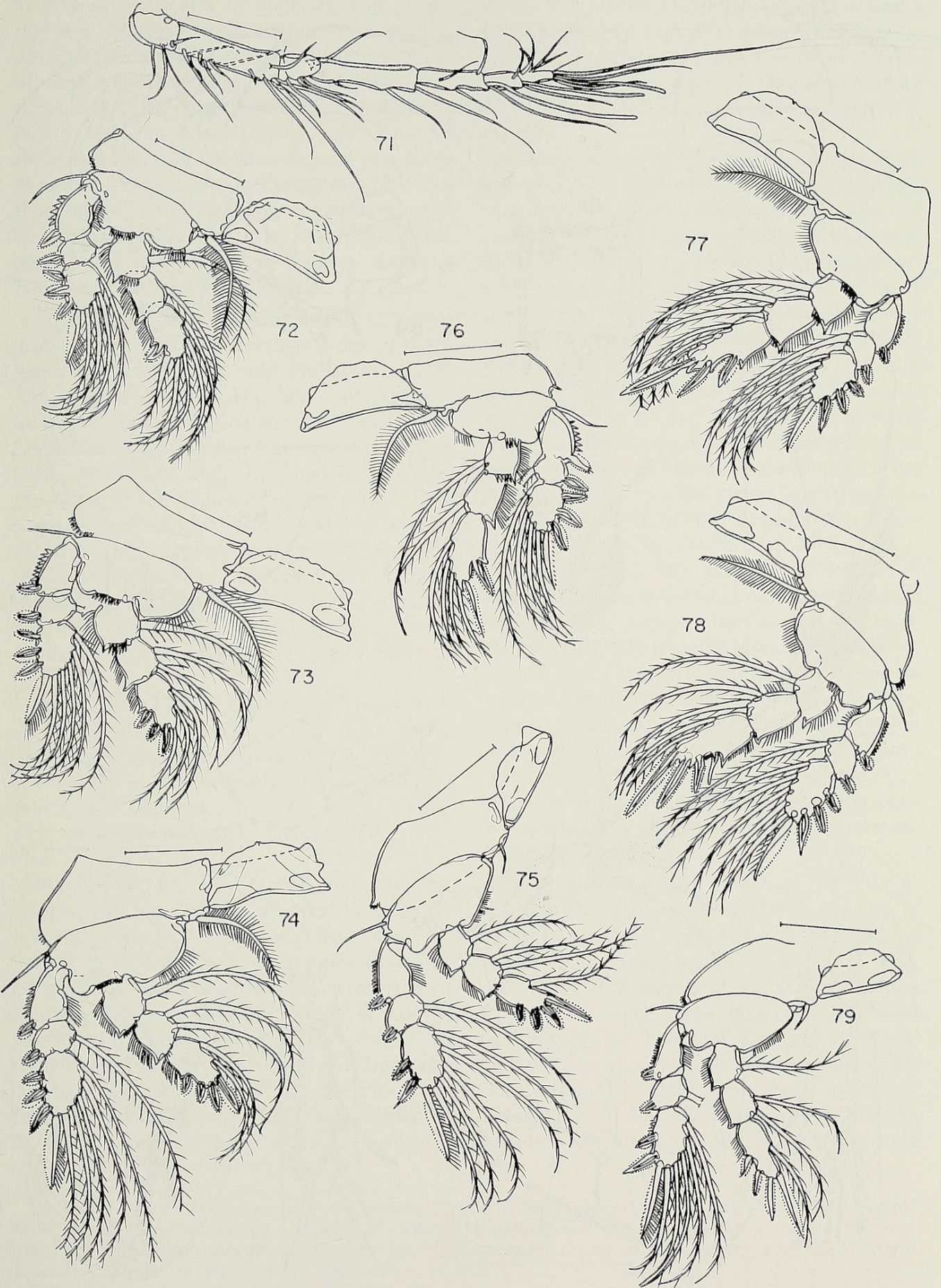
Fourth legs (Fig. 75) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite very small, inserted on somewhat diagonally directed medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with small lateral seta, medial margin with row of cilia. Exopodite, extended

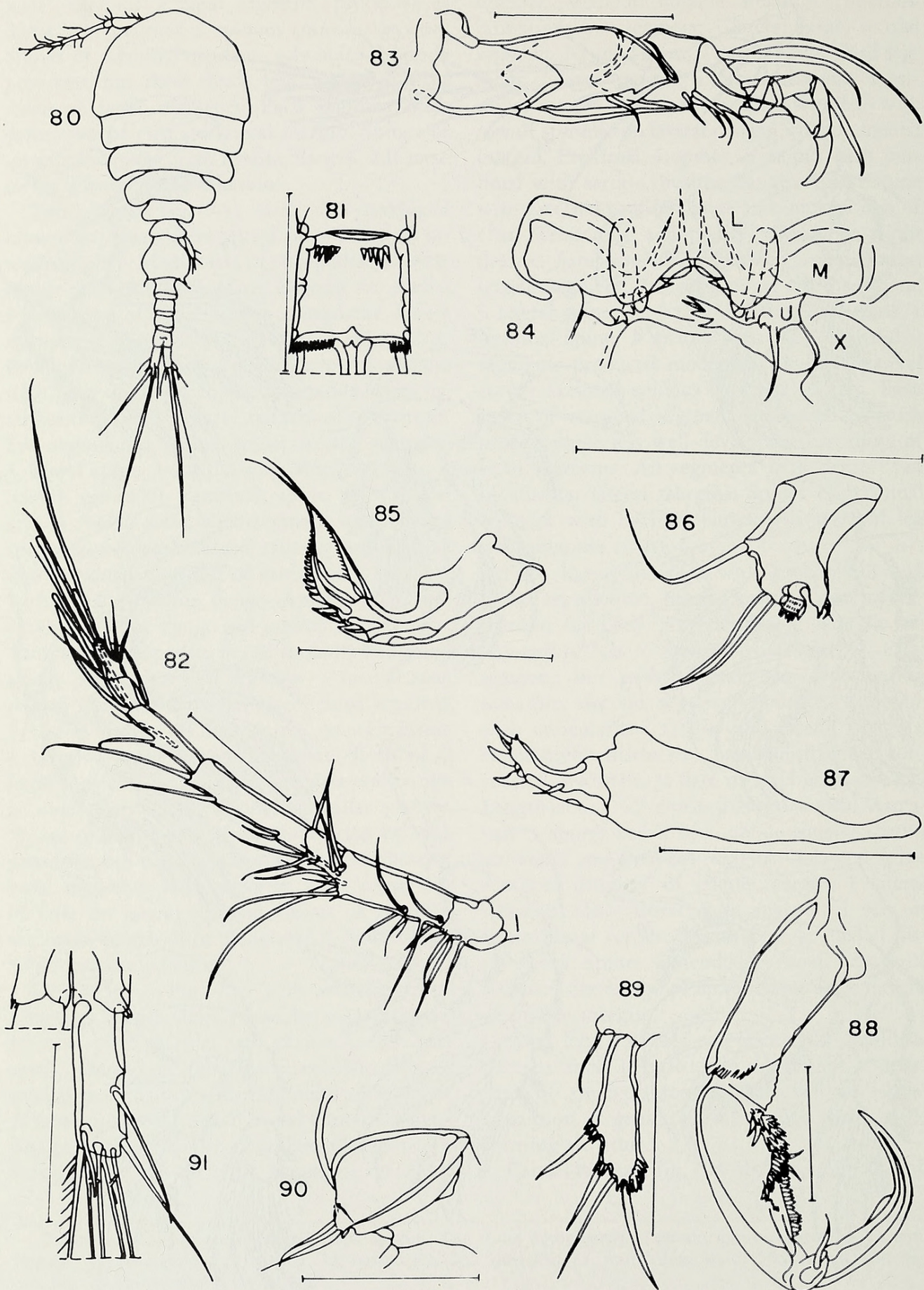
directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 2 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, cilia on medial margin. Proximal 4 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite with very slight flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in steplike emarginations, 1 terminal spine, 1 medial seta. Each of basal 2 segments produced moderately at distal lateral corner as small spinous cuticular process. Each spine of terminal segment subtended by such process, these less well developed than those of basal segments. All segments with dense rows of cilia on lateral margins. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fifth legs (Fig. 69) with probably 2 segments represented, basal consisting only of expansion on body posteriorly and laterally on segment of legs to furnish articulation of distal segment, but with 1 small seta representing armature. Second segment elongate, flattened, with cuticularized medial and lateral margins. Shape highly distinctive, basal fourth much constricted, with abrupt flare to level of first spine. Length about 3.2 times greatest width. Armature 3 spines and 1 seta, about equally spaced on lateral and terminal margins: 1 lateral spine at about distal .7 of lateral margin, 1 lateral spine at about distal .8 of margin; 1 seta at lateral distal corner; apical spine at medial distal corner. Spines subtended by small groups of spinules. Short row of spinules on distal fourth of medial margin.

Sixth legs probably represented by small setiferous knob (Fig. 61) in depression at aperture of oviduct, located dorsally on lateral expansion of genital segment. One small setule forming armature.

Caudal ramus (Fig. 70) about 3 times as long





as greatest width and 1.2 times as long as anal segment. Margins with conspicuous cuticular development. Armature 6 setae. Of apical quartet of setae, medial of central 2 longest, about 6.3 times as long as ramus, adjacent seta 3.5 times length of ramus. Medial apical seta about 1.6 times as long as ramus; lateral apical seta about .8 times as long as ramus. Lateral marginal seta short, about .7 times as long as ramus, inserted on lateral margin about at distal .6. Dorsal medial seta short, about as long as width of ramus, inserted just subapically.

MALE (Figs. 76–91): Body length 1.25 mm., greatest width .56 mm., averages from 10 specimens. Body (Fig. 80) very similar to that of female in size and aspect, but approaching a little more closely to generalized cyclopid type. Cephalosome bearing first legs, segment of these indicated by very slight marginal indentations. Metasome of free segments of legs 2 to 4. Urosome of segments of legs 5, 6, and 4 abdominal segments, including element bearing anus and caudal rami. Segments of legs 5 and 6 much coalesced to form a genital complex, through which extend elongate spermatophores. Ornamentation of anal segment (Fig. 81) much as in female.

Antennule (Fig. 82) similar in proportions, segmentation and armature to that of female, no particular dimorphism expressed.

Antennae and mouthparts, except maxilliped as in female. Antenna (Fig. 83); oral area (Fig. 84); mandible (Fig. 85); maxillule (Fig. 86); maxilla (Fig. 87).

Maxilliped (Fig. 88) highly dimorphic, developed as massive, complicated appendage, probably trimerous. First segment about as long as second, with row of fine spinules on distal margin. Second segment somewhat tapered apically, margin medial in position of normal posture of appendage bearing characteristic ornamentation serving to act in conjunction with clawlike terminal segment in prehensile function, this consisting of patches of long denticles. In addition, near midpoint of medial margin 2

short, stout spines. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, longer than second segment. One seta inserted on expanded region of articulation with segment 2.

Dimorphism also expressed particularly in first and third legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs essentially as in female. Basal segments of endopodites as in female, terminal segment of each with lateral spine, 1 apical spine, 1 apical seta, 3 medial setae, very long apical spine representing a seta of female appendage (Fig. 76). Leg 2 (Fig. 77) in general aspect and ornamentation essentially similar to that of female. Leg 3 (Fig. 78) showing slight dimorphism in that most proximal lateral spine of terminal segment of endopodite has characteristic shape, a basal knob, angled posture, and lacks outlining hyaline flange of other spines of rami. Leg 4 (Fig. 78) as in female.

Fifth leg (Fig. 89) very similar to that of female in general structure. Length about 3 times greatest width. Accessory ornamentation of spinules more highly developed than in female.

Sixth legs (Fig. 90) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 unequal setae, the more medial with a well-developed articulating base.

Caudal rami (Fig. 91) very similar to those of female.

REMARKS: This form is named for John R. Norton. The species occurs very commonly in association with its typical host in Washington Sound, Puget Sound, and also on the outer rocky ocean coast of Washington, in the Cape Flattery Region. The usual infestation consists of fair numbers of the copepod, ranging to several dozen. They wander freely in the rather capacious respiratory cavity of the host, sometimes emerging from the dorsal aperture or moving over the foot and other fleshy parts. They are

FIGS. 80–91: *Anthessius nortoni*, new species. The scales accompanying certain figures represent 0.1 mm. Male: 80, habit, dorsal; 81, anal segment; 82, antennule; 83, antenna; 84, oral area; 85, mandible; 86, maxillule; 87, maxilla; 88, maxilliped; 89, fifth leg; 90, sixth leg; 91, part of anal segment and caudal ramus. Legend: L, labrum; M, mandible; U, maxillule; X, maxilla.

usually readily detected if the host is held in sea water for observation. There has been no interaction so far detected between the copepod and the other extremely commonly occurring associate of *D. aspera*, the polynoid worm *Arctonoe vittata* (Grube). The large limpets of the genus *Acmaea*, living in the same environment as the host, sometimes will be found to have a specimen of *A. nortoni* in the respiratory cavity, but I feel that present evidence does not justify considering this as a regularly occurring association. The typical host should be further explored for this associate over its considerable range; I suspect the copepod will be found to have a wide distribution. This is one of the very small species of *Anthessius*, and in many regards it shows resemblance to the common European *A. arenicolus* and *A. teissieri*. However, it is distinctive anatomically, as expressed in part in the key to species above. It is the first member of the genus so far reported in association with an aspidobranch gastropod.

Anthessius fitchi, new species

Figs. 92–125

TYPES: Holotypic female, USNM 103301, allotypic male, USNM 103302, paratypes, USNM 103303; paratypes in author's collection. Type locality, Carpinteria, California, from *Chaceia ovoidea* (Gould).

SPECIMENS EXAMINED: From *C. ovoidea*: Carpinteria, California, November 11, 1954, J. E. Fitch, many specimens, females, males, including holotype and allotype.

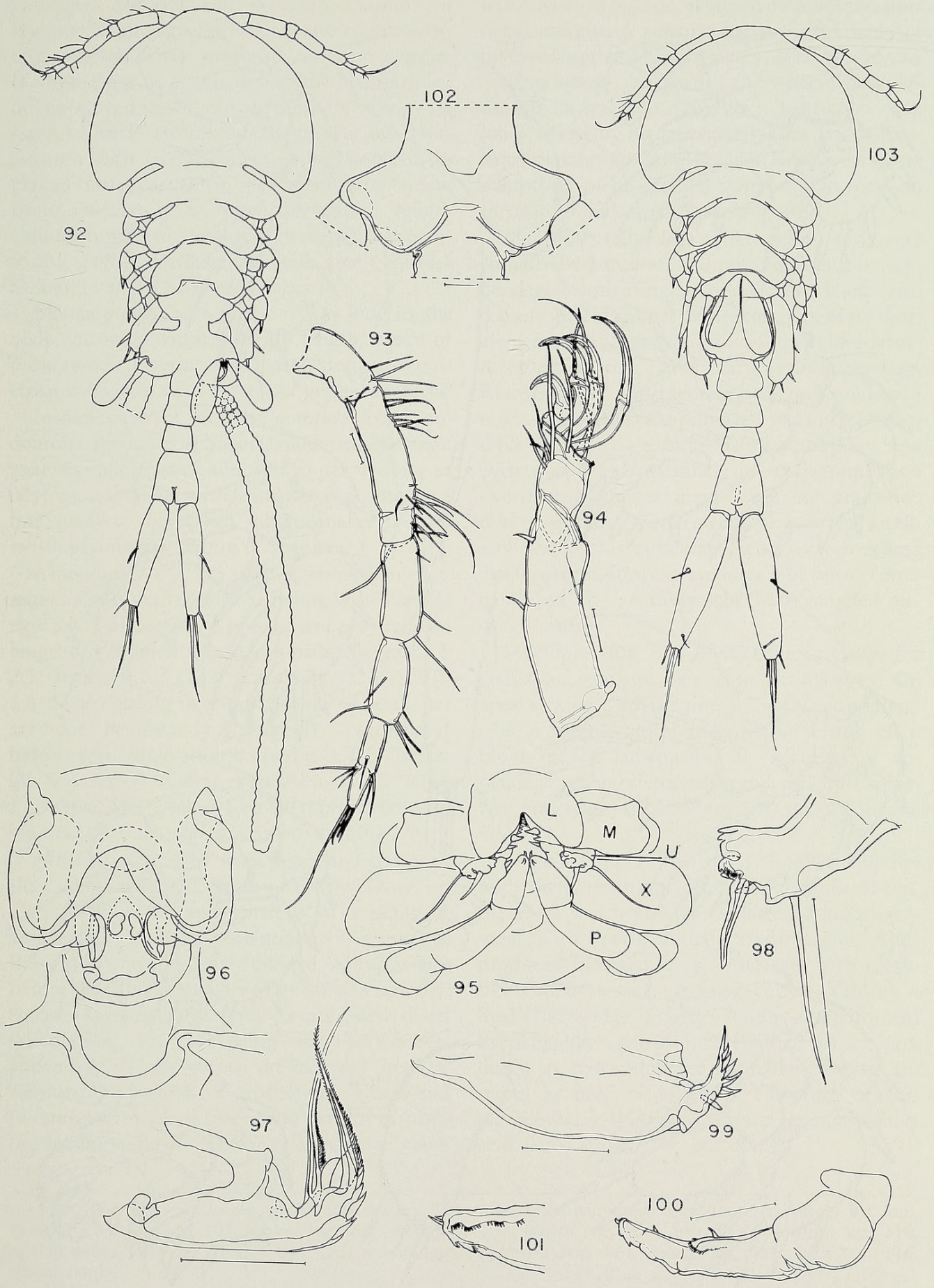
Carpinteria, California, January 1, 1956, J. E. Fitch, 50 + specimens.

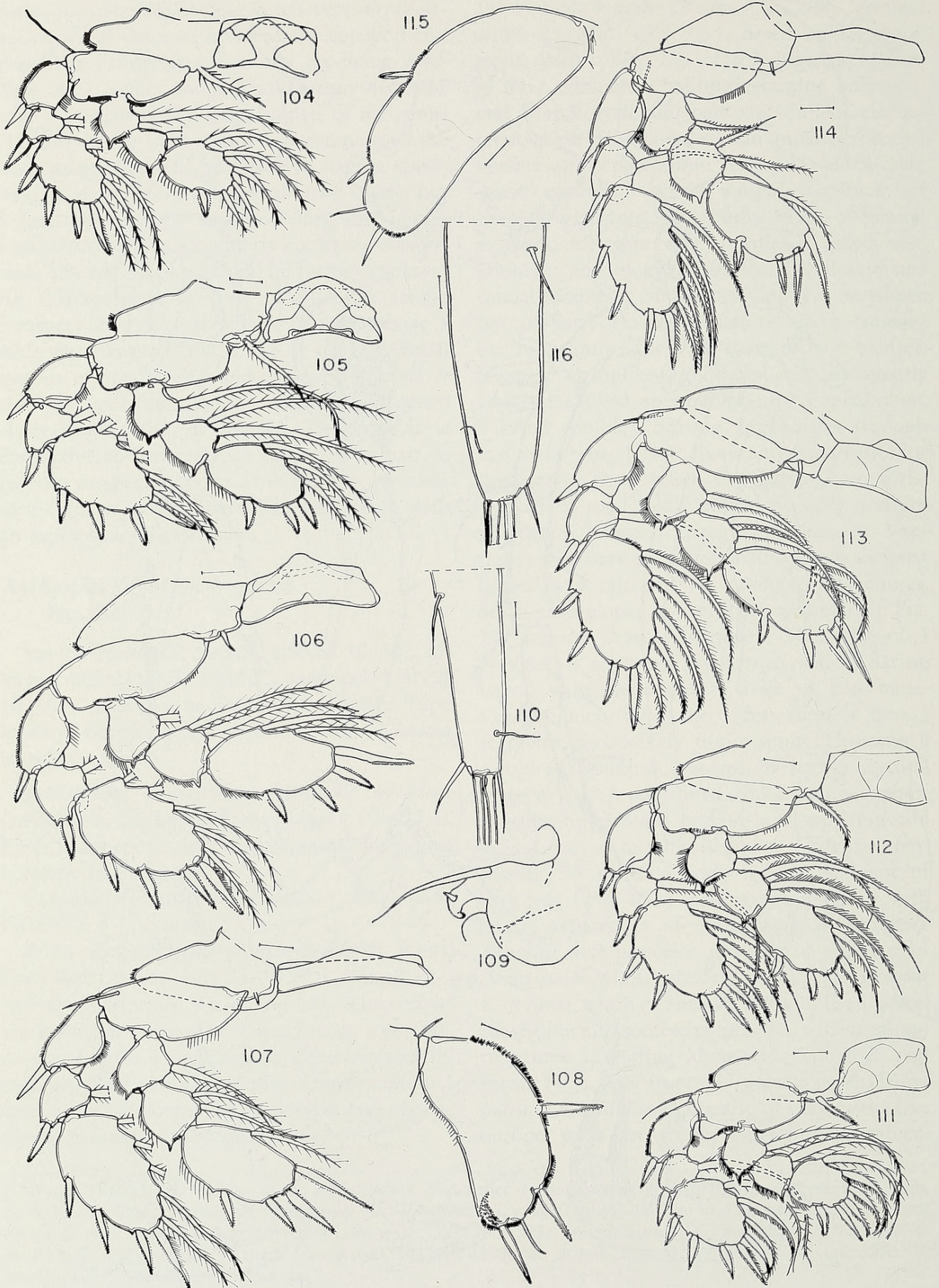
From *Zirfaea pilsbryi* Lowe: Fossil Point, Coos Bay, Oregon, July 23, 1959, 1 ♀.

The description below and the illustrations are based on a number of specimens, some unmounted, some whole mounts, some temporarily mounted dissections, some permanently mounted dissections. Holotype and allotype are permanently mounted dissections.

DESCRIPTION: Female (Figs. 92–102, 104–110): Body length 5.8 mm. (5.6–6.1), greatest width 2.1 mm. (2.0–2.3), based on 10 specimens. Body (Fig. 92) of this gigantic species of most distinctive habitus, retaining only general overall cyclopid contours. Salient characteristics of habitus consist in much expanded outline of cephalosome, elongate antennules, much expanded lateral winglike epimera of thoracic segments, lateral expansions of genital segment, elongate and distally widened anal segment, and elongate, flattened and widened caudal rami. Not continuously present on adults, but of such distinctive nature as to contribute to definite aspect of characteristic habitus, elongate stringlike egg sacks and persistently attached stalked spermatophores. Cephalosome a fused complex bearing appendages through first swimming legs without any demarcation of segment of these latter. Cephalosome comprising .25 of total body length. Apically a slight protrusion between bases of antennules. Ventrally, area between antennular bases somewhat bulged and outlined by cuticular thickenings, but not developed as a proper rostrum (see Fig. 117 for this feature in male). Metasome of 3 pedigerous segments, each with widely flaring lateral winglike epimera, those of first metasomal segment much the widest, those of next 2 segments successively diminishing. Urosome a complex including segment of legs 5, genital segment and 3 additional abdominal segments, considering element bearing anal opening and caudal rami as terminal segment. Urosome comprising .55 of total body length. Segment of fifth legs (Fig. 102) lacking epimera, but with lateral expansions of entire mass of segment. Anterior and posterior margins of segment of about same width, greatest lateral extent about 2.33 times width of anterior margin. Each lateral protrusion also somewhat inflated, with resultant structures extending almost to center of segment. Fifth legs inserted apically on each expansion. Genital segment also of very distinctive outline, with two widely extending lateral ex-

FIGS. 92–103: *Anthessius fitchi*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 92, habit, dorsal; 93, antennule; 94, antenna; 95, oral area; 96, labrum and supporting structure of oral area with appendages removed; 97, mandible; 98, maxillule; 99, maxilla; 100, maxilliped; 101, apex of maxilliped; 102, segment of fifth legs, dorsal. Male: 103, habit, dorsal. Legend: L, labrum; M, mandible; P, maxilliped; U, maxillule; X, maxilla.





pansions. Anterior and posterior margins of segment about equal width, greatest lateral extent over 3 times width of anterior margin. Median mass of segment not notably intruded on by reproductive structures, these occupying most of each strong lateral protrusion. Dorsally on each lateral process 1 or 2 spermatophores usually seen in persistent attachment. Each spermatophore elongate, ovoid, length about 3 times greatest width, with gradual taper to apical filiform attachment stalk, about .3 times as long as spermatophore proper.

Elongate egg sacks, about .75 as long as the body and with width only .05 length, hence of pronounced filiform aspect, attaching near posterior margin of each process of genital segment.

In remainder of urosome anterior 2 of 3 abdominal segments subequal, much smaller than anal segment. Latter almost 2 times as long as next anterior and with distinctive flaring outline, greatest width, just subterminal, 1.5 times width of anterior margin of segment.

Antennule (Fig. 93) long, somewhat flattened, 7-segmented, fifth segment with notable expansion of outline. Approximate proportional lengths of segments, basal to distal: Segment I, 2.5; II, 4; III, 1; IV, 3.3; V, 2.7; VI, 1.7; VII, 1.4. Setae varying in length. Count of setae, per segment: Segment I, 4 setae; II, 7 setae near base of segment, 8 around distal end; III, 5 setae; IV, 3 setae; V, 4 setae, 1 aesthete; VI, 2 setae, 1 aesthete; VII, 6 setae, 3 on basal prominence of segment, 3 setae and 1 aesthete apical.

Antenna (Fig. 94) with segmental composition much obscured by flexures, involving integumental folds, and torsions of regions of appendage, probably essentially 3 segments. Basal segment not clearly defined, apical articulation incomplete, 1 short external seta apically. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; 1 short seta on external margin. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated claw-

like elements and 2 setae. Another seta near distal margin. A subapical group of 4 setae of diverse lengths. Total elements: 4 claws, 7 setae.

Mouthparts compactly and intricately arranged in oral area (Fig. 95). Labrum with 2 lobes, overlying blades of mandibles. Basal structures of labrum complex, associated with other sclerotized pieces located posteriorly, to form an intricate mouth apparatus (Fig. 96).

Mandible (Fig. 97) a flat plate, with very cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Most basal elements of ornamentation flat platelike structures articulating with margin of appendage. Remainder of ornamentation a long graduated row of denticles. On anterior margin of mandible articulated a long lashlike auxiliary seta with conspicuous marginal cuticularization. Basal two-thirds of outer margin bearing graduated row of spinules. Between apical lash and auxiliary seta a flat cuticular piece with indented distal margin, forming an outer lobe with acuminate apex and an inner lobe with rounded terminal outline.

Maxillule (Fig. 98) of characteristic type for genus, an elongate lobe with flaring apex. On apex a more medial spine and very long lateral seta. A medial apical indentation setting off a blunt medial subapical lobe. Margins of appendage much sclerotized, produced into spine-like cuticular processes apically and on medial lobe.

Maxilla (Fig. 99) with very long articulation with body, resulting in characteristic basal segment, on which articulates flattened apical segment, with heavily cuticularized margins. Apex produced in sharp angle anteriorly with toothlike expansions of marginal cuticle forming a medial saw-edge. Five to 7 large teeth formed by flangelike protrusions of cuticle. Apex produced as more elongate spinelike process. Inserted at base of angle of curvature of this segment and lying on surface, a stout, short articulated spine.

FIGS. 104-116: *Anthessius fitchi*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 104, first leg; 105, second leg; 106, third leg; 107, fourth leg; 108, fifth leg; 109, sixth leg; 110, caudal ramus. Male: 111, first leg; 112, second leg; 113, third leg; 114, fourth leg; 115, fifth leg; 116, caudal ramus.

Maxilliped (Fig. 100) fairly long, a prominent mouthpart, as seen in general habitus of mouth area, but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Basal segment fairly well defined, unornamented. Second segment ornamented with 1 marginal setule and an arching row of spinules. Terminal segment with 2 apical setules and an interrupted row of spinules on the surface (Fig. 101). Margin cuticularized and produced into 2 or more spinulelike protrusions.

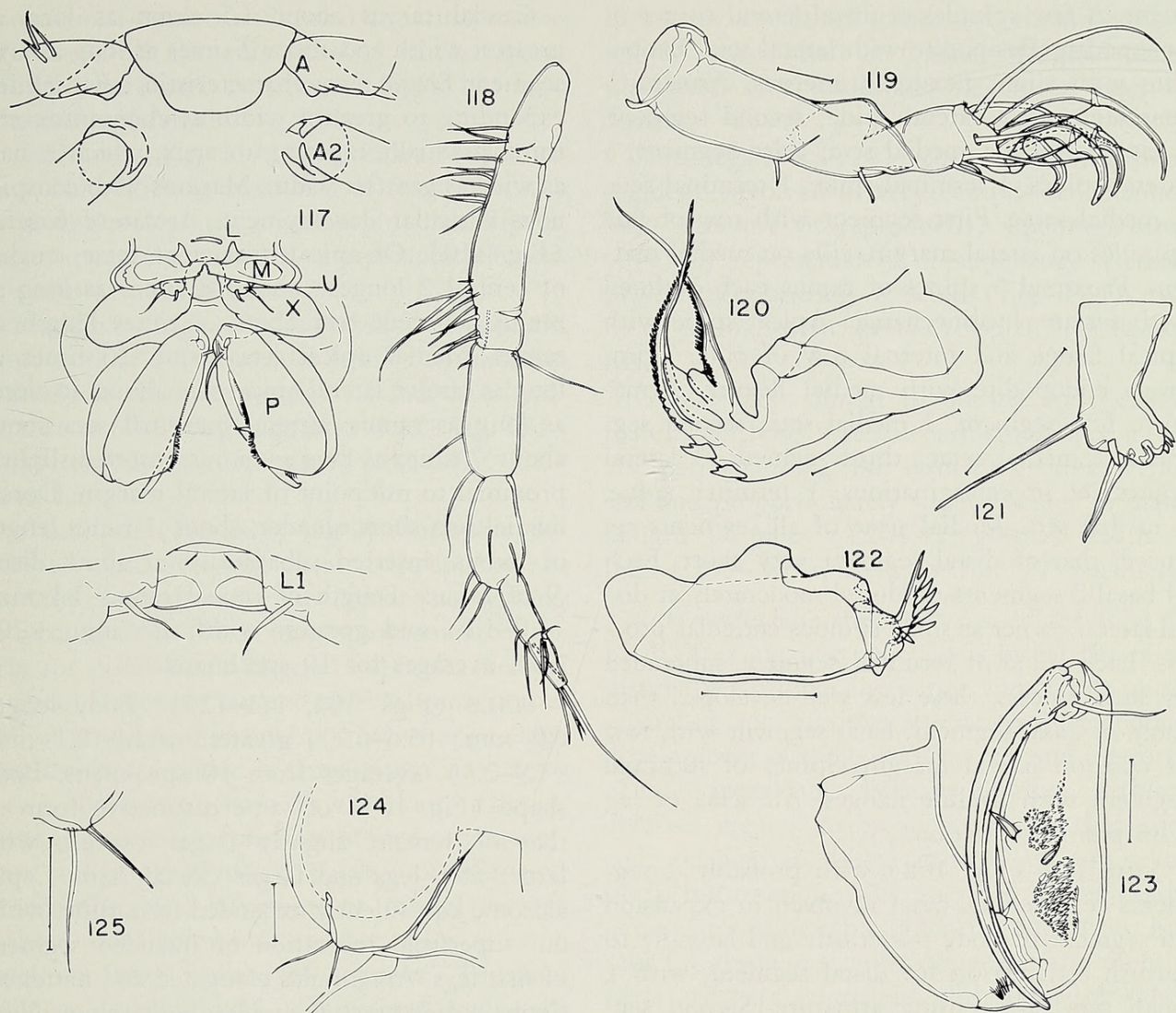
Legs 1 to 4 very characteristic for the species and unlike those of any other form so far described in the genus in marked flattening and exaggerated development of terminal segments of rami as broad laminae. Armature and ornamentation essentially identical with that of other species. A peculiar type of cuticular ornament distributed over various body elements, seemingly highly distinctive for the species. Each element of this ornamentation apparently a small cylinder with flat end, the whole of fairly soft consistency and protruding like a tube from surface of body. A large number of these over ventral surfaces of wide epimeral expansions of cephalosome, a few on each epimeron of metasomal segments, a few on each basipodite, some on terminal segment of each ramus of each leg, some on fifth leg, fairly large numbers forming rows down middle of surface of each caudal ramus.

First legs (Fig. 104) with well-developed bimerous protopodites, yoked by substantial intercoxal plate. Basipodite laterally offset on coxopodite, so medial seta of coxopodite inserted on free portion of terminal margin. Coxopodite seta extending rather more medially than distally, and with its length slightly less than width of intercoxal plate. Distal lateral corner of coxopodite with row of spinules. Basipodite with small lateral seta proximal to insertion of exopodite and with short rows of cilia on distal margin. Exopodite trimerous; armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin and row of cilia on medial margin. Proximal 5 spines of ramus

each outlined with serrate hyaline flange. Apical spine with external entire hyaline flange and internal row of cilia. Endopodite flexed medially and proximally, trimerous. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in slight emargination, 2 apical setae, 3 medial setae. Three most distal setae reduced in length. Each of basal 2 segments of ramus produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by minute spinous process, and with outlining hyaline flange. Each segment with row of cilia on lateral margin. All setae of leg with plumose ciliation.

Second legs (Fig. 105) with well-developed bimerous protopodites yoked by substantial intercoxal plate. A row of spinules at distal lateral corner of coxopodite. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. Basipodite with long lateral seta; terminal margin with rows of cilia. Exopodite, flexed and at angle to protopodite, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with apical hyaline flange and internal row of cilia. Endopodite flexed medially and proximally, trimerous. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in slight emarginations, 1 terminal spine, 3 medial setae. Setae of terminal segment progressively reduced. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Basal spine of terminal segment subtended by such process, but this much less developed than those of basal segments. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 106) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Small medial seta of coxopodite inserted on medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with lateral seta;



FIGS. 117–125: *Anthessius fitchi*, new species. The scales accompanying certain figures represent 0.1 mm. Male: 117, ventral view of mid-region of cephalosome; 118, antennule; 119, antenna; 120, mandible; 121, maxillule; 122, maxilla; 123, maxilliped; 124, sixth leg and reproductive aperture; 125, setae of sixth leg. Legend: A, antennule; A2, antenna; L, labrum; L1, base of first leg; M, mandible; P, maxilliped; X, maxilla.

terminal and medial margins with rows of cilia. Exopodite, with medially curving flexure, trimorous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with apical hyaline flange and internal row of cilia. Trimerous endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in slight emarginations, 1 terminal spine, 2 me-

dial setae. Setae of terminal segment reduced. Each of 2 basal segments produced at distal lateral corner as moderately small spinous cuticular process. Basal spine of terminal segment subtended by such process, but less developed than those of basal segments. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges, apical spine with flange only on distal lateral margin. All setae of leg with plumose ciliation.

Fourth legs (Fig. 107) with well-developed bimerous protopodites yoked by widely extending, short proximal to distal, intercoxal plate. Medial seta of coxopodite very small, inserted on medial free portion of distal border of seg-

ment. A few spinules at distal lateral corner of coxopodite. Basipodite with lateral seta. Exopodite with slight flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with apical flange and internal row of cilia. Trimerous endopodite with medial flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in emarginations, 1 terminal spine, 1 medial seta. Medial setae of all segments reduced, that of distal segment very short. Each of basal 2 segments produced moderately at distal lateral corner as small spinous cuticular process. Each spine of terminal segment subtended by such process, these less well-developed than those of basal segment. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fifth legs (Fig. 108) with probably 2 segments represented, basal involved in expansion on segment of body posteriorly and laterally to furnish articulation for distal segment, with 1 small seta representing armature. Second segment elongate, very wide, flattened, with cuticularized medial and lateral margins. Length about 2 times greatest width. Armature 3 spines and 1 seta, spines about equally spaced on lateral and terminal margins: 1 lateral spine at about distal half of lateral margin, 1 lateral spine at about distal .9 of margin; apical spine at medial distal corner. Short, slender seta between terminal 2 spines, somewhat closer to apical spine. Spines subtended by small groups of spinules. A row of spinules on proximal third of medial margin and a row on most of lateral margin. Several short rows of spinules forming dense patch at apical medial corner.

Sixth legs probably represented by setiferous curving process (Fig. 109) at aperture of oviduct, located dorsally on lateral expansion of genital segment. Armature 1 relatively well-developed seta and 1 short, tapered, stout spinule.

Caudal ramus about 4.5 times as long as greatest width and about 2 times as long as anal segment. Shape most characteristic, a flat lamina expanding to greatest width at about proximal third, gradually tapering to apex, which is half as wide as greatest width. Margins with conspicuous cuticular development. Armature 6 setae (Fig. 110). Of apical quartet of setae, medial of central 2 longest, about .8 times as long as ramus, adjacent seta about .4 times length of ramus. Medial apical seta about .16 times as long as ramus; lateral apical seta about .16 times as long as ramus. Lateral marginal seta short, about .7 times as long as ramus, inserted slightly proximal to midpoint of lateral margin. Dorsal medial seta short, slender, about .1 times length of ramus, inserted subapically, at about distal .9 of ramus. Length of caudal ramus 1.1 mm. (1.0–1.1) and greatest width .23 mm. (.20–.25), averages for 10 specimens.

MALE (Figs. 103, 111–125): Body length 6.0 mm. (5.6–6.2), greatest width 2.1 mm. (1.9–2.3), averages from 10 specimens. Body shape (Fig. 103) of same distinctive form as that of female, slightly larger overall, with larger fifth legs and larger caudal rami. Cephalosome equivalently expanded in outline, without superficial indication of included segment of first legs. Antennules elongated and flattened. Cephalosome much the widest body region. Ventrally at apex a bulgelike protrusion (Fig. 117), not an actual rostrum. Three segments of metasome each with distinctive expanded lateral epimera, as in female. Urosome 6-segmented, very characteristic in structure, by enormous size of fifth legs, uniquely developed anal segment and caudal rami. Segments of legs 5 and 6 much coalesced in a genital complex containing elongate paired spermatophores. Segment of leg 5 widest segment of urosome, fifth legs borne far laterally and each lying along and parallel with margin of next posterior segments. Fifth leg reaching to middle of third urosomal segment. Segment of leg 6 longest segment of urosome, with some lateral expansion, this involving only very gradual taper from anterior margin of segment. Anal segment, as in female, with flaring outline, and supporting enormous, elongate, flattened caudal rami.

Antennule (Fig. 118) markedly similar in

proportions, segmentation and armature to that of female, all elements seeming to correspond in the two sexes. Antennae (Fig. 119) also like those of female.

Oral area (Fig. 117) with characteristic aspect, only differing from that of female because of great development of dimorphic maxillipeds, these appearing as most conspicuous element in complex of mouthparts.

Mandible (Fig. 120) essentially as in female, some minute differences in details of ornament, possibly as much expression of individual difference as of dimorphism. Maxillule (Fig. 121) almost exactly as in female. Maxilla (Fig. 122) as in female.

Maxilliped (Fig. 123) highly dimorphic, developed as massive, complicated appendage, apparently 3-segmented. First segment not as long as second, about .75 as long, unornamented, except for distal lateral clump of spinules. Second segment somewhat tapered apically, margin medial in position in normal posture of appendage bearing characteristic ornamentation serving to act in conjunction with clawlike terminal segment in prehensile function. Medial ornamentation consisting of dense patches of denticles. In addition, near midpoint of medial margin a short, stout spine and another spine at same level on inner surface of segment. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, slightly longer than second segment. One long seta, accompanied by 1 setule, inserted on expanded region of articulation with segment 2.

Dimorphism expressed also in first legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs (Fig. 111) essentially as in female. Basal segments of endopodites as in female, terminal segment of each with lateral spine, 1 apical spine, 1 apical seta, 3 medial setae, the apical spine representing a seta of female appendage. Leg 2 (Fig. 112), leg 3 (Fig. 113), leg 4 (Fig. 114) in general aspect and ornamentation essentially similar to those of female.

Fifth legs (Fig. 115) only resembling those of female in general structure and ornamentation, but of different outline and proportionately much longer. Length equaling about 3 times

greatest width. Distal spines and seta much more widely spaced than in female. Marginal ornamentation of spinules less developed than in female.

Sixth legs (Fig. 124) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 setae (Fig. 125), the more medial with well-developed articulating base.

Caudal rami similar in outline and general features to those of female, armature (Fig. 116) also corresponding, but rami of greater overall size and proportionately slightly wider in male. Length 1.3 mm. (1.2–1.4), greatest width .3 mm. (.295–.305), averages from 10 specimens.

REMARKS: The species is named for John E. Fitch. This gigantic copepod is by far the most distinctive form in the genus and stands much separated from all other species by the elaborate development of the body processes and the form of most appendages. Perhaps its unique habitus deserves greater taxonomic emphasis than specific designation, but I cannot see any additional information to be provided by the designation of a monotypic taxon for this form. Except for absolute size, the antennae and mouthparts are very consistent with those of other species. In the other appendages the numerical complement of segments and elements of armature are entirely the same as for other species, but in outlines and dimensions the structure remains unique. The typical host is a giant piddock, boring burrows in substantial rock. The copepods occur over the general body surface of the host and in its burrows, according to the collector. The distribution of this host is apparently a limited one. An indication of broader distribution of the copepod exists in the single specimen, collected in Oregon, 1959, from *Zirfaea*, a large boring mollusk, closely related to *Chaceia*.

SUMMARY: Five species of *Anthessius* are described in detail, two of these, *A. hawaiiensis* (Wilson) and *A. navanacis* (Wilson), being redescribed from type material. These occur in Hawaii and Southern California, respectively. New species described are *A. lighti* and *A. fitchi*



Illg, Paul L. 1960. "Marine Copepods of the Genus *Anthessius* from the Northeastern Pacific Ocean." *Pacific science* 14(4), 337–372.

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