NORTH AMERICAN HARPACTICOID COPEPODS

1. Comments on the Known Fresh-Water Species of the Canthocamptidae

Mildred Stratton Wilson

Arctic Health Research Center, U. S. Public Health Service, Anchorage, Alaska

The harpacticoid copepods reported from North American continental waters or inland terrestrial habitats are currently represented by fifty-two species. This count includes euryhaline forms and marine or brackish species that also may be found in inland saline or fresh-water bodies. The greater number of these species belong to the family Canthocamptidae of which thirty-six seemingly valid species referable to seven genera have been recorded in the literature. That this is representative of only a portion of the number that may occur over the entire Continent is indicated by comparison with Gurney's (1932) list of thirty-two canthocamptids from Great Britain alone. In my own collections at present, I already have some twenty additional unreported species, and three additional genera, either new to science or new to North America.

No doubt much of the former difficulty in the taxonomic study or identification of fresh-water harpacticoid copepods has been due to the inadequacy, confusion in, and scattered nature of the literature. Today, much of this basic difficulty has been erased through the summarizing and clarifying works of Chappuis, Lang, Gurney, Borutzky and Coker. It is appropriate to acknowledge here the significance and usefulness of their publications. Taxonomists will probably all agree that one particular paper by Coker (1934) represents the finest single contribution to the field in North America. In this work, the literature and records are summarized and ten species or subspecies are described and most beautifully illustrated. This work of Coker's, the harpacticoid volume of Gurney's *British Fresh-water Copepoda* (1932), and Lang's *Monographie der Harpacticiden* (1948) have been constantly useful references during my own "learning" period. The thorough, detailed descriptions and illustrations of Coker and Gurney, and the summaries of Lang, contribute to accurate, confident identification, as well as to the comparison and evaluation necessary for sound taxonomic interpretation. They further provide essential, informative examples for the novice.

Most of the taxonomic information on North American canthocamptid harpacticoids has been published by two American workers, Willey and Coker, and by two European specialists, Chappuis and Kiefer. Lang has included in his monograph all American records through 1938. The paucity of research in this field in North America is well-indicated by the fact that since that date, only two taxonomic papers have appeared (Coker and Morgan, 1940; Carter, 1944). An incomplete key is given in Pennak (1953).

Coker's 1934 paper was published in December, and the date of preparation did not permit inclusion of species and records from two papers published in the same year by Kiefer, and by Willey. Willey's paper appeared at a slightly earlier date (September, 1934). In this

latter publication, Willey gave more complete descriptions of species he had formerly proposed briefly in the text of a short, non-taxonomic paper published (1925) in Nature, and of which Coker evidently was not aware. The matter of publication date is important because it involves the identity or priority of species. Lang recognizes 1925 as the publication date of the species involved (*Attheyella obatogamensis*, *Bryocamptus douwei*, *B. hiatus*).

The generic categories outlined by Lang (1948) for the Canthocamptidae will be largely followed in this series of papers, though this does not necessarily indicate complete agreement with the system, or acceptance of the narrowly-defined generic limits, which Lang slightly revised from Chappuis (1929). At present, because it has become established in the literature, it appears best to work within the rigid framework of this delimited classification, even though it is believed that it was prematurely formalized on inadequate knowledge and does not always represent a natural system. What may be contributed to the systematics of the Canthocamptidae by increased knowledge of our little known North American groups remains to be seen. From cursory observations made to date, it appears to me that some species groups represented in Eurasia by one or a few long established species have had a much greater surge of speciation on this Continent, and in their present day distribution may be much more abundantly represented both in numbers of species, and in populations. It is also apparent, contrary to the view of early workers, that there are many species of circumarctic distribution or are of common occurrence in the two continental masses, as well as some groups that may prove to be peculiarly American.

Since much of the early part of this series of papers will deal with the fresh-water Canthocamptidae, it is considered advisable to give at the beginning, a check list of the known species. In addition, some comments are needed for clarification of some of the literature in this family, as based either upon study of literature or specimens. These concern in part a few errors in Lang's monograph which appear to have resulted from miscopying or misinterpretation, and are particularly in need of correction because of the reference nature of his work. Unless otherwise stated, all references in the text to Lang, Gurney and Coker refer respectively to their cited works of 1948, 1932 and 1934. References to original descriptions of the species listed for each genus are not included in the bibliography since they may be found in the works of Lang and Coker.

Included in the following lists are records of occurrence of some little-known or questioned species. In addition, there are records of six species not previously reported, two of which belong to a genus not before known from the Continent.

CANTHOCAMPTUS

C. staphylinoides Pearse 1905 (including *minutus* var. *occidentalis* Herrick 1879? and *minutus* Herrick 1883, 1884, 1895?)
C. assimilis Kiefer 1931
C. sinuus Coker 1934
C. vagus Coker and Morgan 1940

As will be discussed further in this series, *assimilis* is a valid species, distinct from *staphylinoides* to which it has been referred by Coker and Lang. Examination of type and other specimens described as *staphy-*

linoides vagus shows that it is allied to *assimilis*, but is specifically distinct. Whether *sinuus* is one of the many variants of *staphylinoides* or a valid species depends upon further study of the forms occurring over the whole of North America.

Specimens with appendages which agree exactly or closely with the details shown in Pearse's illustrations of *staphylinoides* from Nebraska, have been identified in my collections as the type (or typical) form. All these have two setae on the distal portion of the endopod of the second leg in both sexes. All have spinules on the inner margin of the caudal ramus, but the ramus varies in length from two and a half to nearly four times its width. The outer caudal seta is jointed near its base, is slender and setiform, and about one-fourth of the length of the stouter, unjointed middle seta. The number of spines on the anal operculum ranges from five to eight. The fifth leg of the female is very characteristic—that portion of the basal segment bearing the middle setae is conspicuously produced and there is a gap between setae 3 and 4, exactly as figured by Pearse. This differs from the fifth leg of *assimilis* in which there is no prominent irregular production of the basal segment. In these specimens of *staphylinoides*, the endopods of legs 3 and 4 of the male are developed exactly as shown by Pearse—particularly to be noted is the strong development of the setae and the outer apical process of the second segment of the fourth endopod.

Specimens of *staphylinoides* that depart from those considered typical, have been found throughout the same geographical areas in which the type form has been collected. Some of those occurring in Alaska are of interest because of the complete absence of spines on the anal operculum, a character which may be variable in a single sample, or may characterize all of the specimens of a sample or collections from an area. The absence of opercular spines is a character of the little-known arctic species, *glacialis*, which in most respects appears to be allied to North American species. None of these Alaskan specimens are referable to *glacialis* on the basis of the fifth legs shown for this species in the literature. Unfortunately, the absence of opercular spines has been constantly used in the literature as a key character for *glacialis*. Considering these northern variants of *staphylinoides*, this use may be very misleading.

Lang's table of setation for legs 1–4 of *Canthocamptus* erroneously shows it to be identical for all species of the genus. The table and discussion fail to include an important difference of the endopod of leg 2 found in *assimilis*, in which only one seta, occurs on the distal inner margin, instead of two. *C. vagus* and an undescribed species in my collection likewise lack the second seta.

The European species, *C. staphylinus*, has been reported from a few localities in North America, but the records are questionable. Lang lists *minutus* var. *occidentalis* Herrick as a doubtful record of *staphylinus*. It seems just as likely from Herrick's figures, however, that his specimens were *staphylinoides* or one of its variants. The typical form of *staphylinoides* does occur in Minnesota as reported by Dineen (1953). Herrick's use of the name *minutus* was due to confusion in European literature at the time he wrote. Unfortunately, this has not been recognized adequately, and his misapplication of the name has been considered sometimes to represent an actual record of the occurrence of *Bryocamptus minutus*.

ATTHEYELLA

A. obatogamensis (Willey) 1925
A. idahoensis (Marsh) 1903
A. dentata (Poggenpol) 1874
A. dentata americana (Herrick) 1884 (=*northumbricoides* Willey 1925; *willeyi* Kiefer 1929)
A. carolinensis Chappuis 1932
A. pilosa Chappuis 1929
A. illinoisensis (Forbes) 1876
A. nordenskioldii (Lilljeborg) 1902 (=*hyperboreus* Willey 1925; *illinoisensis* forma *antiqua* Kiefer 1934?)

Lang has pointed out that specimens described as *wierzejskii* (Mrázek) by Coker (1934) are referable to *obatogamensis* (more fully described by Willey, 1934). The two species are very close but according to Lang are separable by the number of setae on the endopods of leg 2 in both sexes (2 inner marginal setae in *obatogamensis;* 1 in *wierzejskii*). Coker records variation in the number of outer spines (3 or 2) on exopod 3 of the second leg.

American records of *dentata* (= *northumbricus*) have been referred by Lang to the subspecies *americana*. The typical form of *dentata* does occur on the Continent, however; I have collections of it from Alaska and western Canada; Moore (1952) reported it from Saskatchewan. This group will be dealt with in detail in this series. For the present, it is mentioned only that the related Asian species *dogieli* (Rylov) is common in Yukon Territory and Alaska, and has also been found in a collection from the state of Washington (pond near Kent, King County, Feb. 1, 1954, J. E. Lynch).

Apparently the forms which Lang has referred to the single species, *illinoisensis*, are widely spread and common over much of the Continent. By far the most common form recorded in literature, also most commonly present in my own northern collections, is the one in which the caudal rami and setae are modified in both sexes, accompanied in the male by modification of the spines of the third exopod segment of the fourth leg. Specimens with these characters are referable to *nordenskioldii*, orginally described from Siberia. On the basis of present knowledge, it appears that the two should be considered as distinct species. There is no evidence in the literature or in my own collections to indicate that intermediate forms occur over the Continent, though there is some evidence of variation within each. American literature has been much confused in the matter of identity of these two species. Coker (1934) has redescribed *illinoisensis* from type material, and his description should be considered as defining that species. It is evident from study of literature and specimens that much of the confusion has resulted because Herrick's (1884, 1895) and Pearse's (1905) descriptions of Minnesota and Nebraska specimens of *nordenskioldii*, which were wrongly ascribed to *illinoisensis*, have been frequently used as a basis for identification. In addition, too much attention has been given to the relatively insignificant and probably anomalous occurrence of incomplete segmentation in the endopods of some of the legs.

C. B. Wilson's *Attheyella bicolor* is correctly placed in *Cletocamptus* by Lang, following former references of Kiefer and Chappuis.

ELAPHOIDELLA

E. Elaphoidella subgracilis (Willey) 1934
E. bidens coronata (Sars) 1904 (=*caroliniana* Coker 1926)

Both Gurney and Coker have included *Elaphoidella* in *Attheyella*, but Lang follows Chappuis in separating them. It appears to me that there is justification in part for Gurney's and Coker's viewpoint. Some of the species assignations made by Lang and Chappuis seem arbitrary. Aside from the lack of setae on the basal segment of the male fifth leg, which may be reduced, it is difficult to find any striking difference between some species assigned to *Elaphoidella* and *Attheyella*, particularly in the subgenus *Chappuisiella*. Lang's division of *Elaphoidella* into species groups, however, rather than into named subgenera, gives a working flexibility not provided for in the other canthocamptid groups in which formal subgeneric names have been prematurely proposed.

Anyone who identifies American specimens of *bidens* should consider the literature thoroughly. Even with the several excellent descriptions that are available, including those of North Carolina specimens by Coker (1926, 1934), it is apparent that there is much yet to be learned or recorded about the taxonomy and biology of this reportedly parthenogenetic species. Gurney (1932) considered it closely related to *Attheyella crassa* (Sars) and Coker also placed it in *Attheyella*. Lowndes (1950) reported specimens identical to the British females described by Gurney. These were stated as being found *in coition* with males that he has described as the hitherto unknown males of *bidens*. In ascribing these males to *bidens*, Lowndes considered that they demonstrated the close relationship of the European form to *A. crassa*, and the remoteness of its relationship to *Elaphoidella* (*coronata* and other tropical forms). The matter, however, does not seem to be quite so conclusive to me. The males described by Lowndes are puzzling because the setal formula of the third exopod segment of legs 2–4 does not agree with that given for *bidens* females, but does agree with that of *crassa*, which occurred in the same collection. To my knowledge, this is not a sexually dimorphic character in the Canthocamptidae, though it may be noted that Coker recorded variation in *A. obatogamensis*. In view of the association of the two species in Lowndes's collection, the possibility of attempted cross-fertilization, or even of the simpler possibility that *crassa* males might temporarily attach to the caudal rami or setae of *bidens* females and thus be collected *in tandem* without being actually *in coition*, must be considered.

Lang includes *tenuicaudis* Herrick 1884 as a *species incertae* under *Elaphoidella*. The type locality is Decatur, Alabama.

BRYOCAMPTUS

B. minutus (Claus) 1863 (including *minnesotensis* Herrick 1884?)
B. hutchinsoni Kiefer 1929 (=*minutus* forma *simplicidentata* Willey 1934, new synonym)
B. vejdovskyi (Mrázek) 1893 including *vejdovskyi* forma *minutiformis* Kiefer 1934
B. minusculus (Willey) 1925
B. newyorkensis (Chappuis) 1927
B. hiatus (Willey) 1925 (=*australis* Coker 1934?)
B. morrisoni (Chappuis) 1929
B. morrisoni elegans (Chappuis) 1929
B. hiemalis (Pearse) 1905
B. douwei (Willey) 1925 (=*douweanus* Willey 1934)
B. nivalis (Willey) 1925 (=*hiemalis brevifurca* Coker 1934)

B. zschokkei (Schmeil) 1893 (including *frigidus* Willey 1925; *zschokkei alleganiensis* Coker 1934)
B. pygmaeus (Sars) 1862
B. subarcticus (Willey) 1925
B. cuspidatus (Schmeil) 1893

The *minutus* group is represented in North American literature by the first six species of the list. As already shown, Herrick's *minutus* and *minutus occidentalis* are referable to *Canthocamptus*. Probably the specimens used for illustration of *minutus* by Weckel (1914) are also a species of *Canthocamptus*, as indicated by the extremely long endopod of the first leg: Lang has listed this under *minutus minnesotensis*. Weckel, following Pearse (1905), included *minnesotensis* as a synonym of *minutus*, not as a subspecies as stated by Lang. There is no evidence for the recognition of *minnesotensis* as a subspecies of *minutus*. Considering Herrick's incomplete description and the geographic distance involved, Chappuis's (1927) assignment of specimens from New York state to *minutus* subspecies *minnesotensis* is entirely arbitary, and establishes neither the identity nor the status of Herrick's specimens from Minnesota. At present, the actual identity of *minnesotensis* can be considered questionable and capable of validation only from topotype specimens closely agreeing with such characters as were presented in Herrick's description.

As Chappuis (1927) has pointed out, specimens having bifid opercular spines have been indiscriminately identified as *minutus*. In North America, this character is not uniquely diagnostic for *minutus*, and should never be used as the single character upon which identification is based. There occur in North America, forms of two other species of the group that have bifid opercular spines. One of these forms has been named *vejdovskyi* forma *minutiformis* by Kiefer (1934); the other is an undescribed form in my collections referable in present knowledge to *hutchinsoni*. Since few records of *minutus* in American literature are accompanied by description, and none are completely illustrated, it is hardly possible to judge whether the species is widely distributed and of common occurrence in North America as has been claimed (Marsh, 1918). In addition, the few descriptions given do not, in my opinion, satisfactorily confirm the actual occurrence of the typical European form in North America. It is, for instance, clear from Willey's description and figure of the caudal ramus of Québec specimens (which he called *minutus* forma *simplicidentata*) that he had typical *hutchinsoni*. This latter species differs from *minutus* in having a longer caudal ramus with the outer distal edge produced into a spinous point as in *vejdovskyi*, and with prominent spinules on the inner margin; in addition the caudal setae are terminal in position, with the outer seta completely underlying the larger middle seta; the opercular spines are not bifid in the typical form, as noted by Willey for his specimens. It is quite possible that some other references to *minutus* in the literature are actually one or another of the variants of *hutchinsoni*. From the literature it is already evident that this species is variable, perhaps geographically so; and there is further evidence of this variability from specimens in my collections. Carter (1944) described from Virginia, specimens of *hutchinsoni* having atypical caudal setae. Some of my specimens from widely separated areas of western North America, have typical (unmodified) setae, but as noted above, have bifid opercular spines as in *minutus*. Whether this form is the one that commonly

has been identified as *minutus* or *minnesotensis* is not known, but it is certainly possible that this is so. On the basis of literature and specimens that I have seen, it now appears that the *minutus-hutchinsoni-vejdovskyi* group may represent a highly evolved and widely distributed complex of species or subspecies in North America.

The species *newyorkensis* has not been recorded since its original description, so that it is of interest to report its occurrence in a Louisiana collection (pond, Chicot State Park, Evangeline Parish, Dec. 27, 1951, W. G. Moore).

B. hiatus and *australis* appear to be very similar and may be synonymous, in which case the name *hiatus* has priority. Lang has copied incorrectly the setal formula for leg 4 in *hiatus*; the number is identical in the two species. The figure given by Willey (1925) for the fifth leg of the female is very similar to that of Coker for *australis;* the variation figured in Willey's 1934 paper is less similar. Both authors found considerable variation in their specimens. At present, the two species would appear to be separable only by the number of setae on the distal segment of the male fifth leg (6 in *hiatus;* 5 in *australis*). Willey (1934) considered *hiatus* as the type of a new subgenus *Pentacamptus*, which Lang did not recognize. Borutzky (1948) has reintroduced this subgenus and named three new species (*tuberculatus*, *chappuisi*, *cokeri*) from Lake Baikal. I cannot comment on this because I have not yet seen the paper.

The status of *B. morrisoni elegans* is uncertain since it was established on a single female specimen. Lang has given incorrectly the setal formula of the second endopod segment of leg 3, which differs from that of *morrisoni* in having a total of 3 instead of 4 setae.

From present knowledge, Lang's interpretation of the three closely related species, *hiemalis*, *nivalis* and *douwei*, as summarized in the list above, appears to be valid. It should be kept in mind, however, that they may represent variants of a single, widely distributed species to which the name *hiemalis* is applicable. Coker used the term "provisional" in naming *hiemalis brevifurca*, recognizing that it might be the same as Willey's *nivalis*. Specimens in my Alaskan collections, not yet extensively studied for possible variation, appear to agree very well with Coker's description and with such characters as given by Willey for *nivalis*. Willey (1934) proposed the new name *douweanus* for *douwei* but as Lang has pointed out, this was unnecessary. The characters separating these species are shown in the following key form:

(1) Leg 2 female, apical endopod segment with 5 setae; leg 4 female, endopod segment 1 without inner seta and middle apical seta of segment 2 longer than outer spine..... *B. hiemalis*

Leg 2 female, apical endopod segment with 4 setae; leg 4 female, endopod segment 1 with inner seta and middle apical seta of segment 2 shorter than outer spine..... 2

(2) Leg 1 female and male, endopod reaching beyond exopod by about length of third segment; antennule female 8-segmented; caudal ramus female and male about as long as broad, distal outer seta placed at end of ramus..... *B. nivalis*

Leg 1 female and male, endopod hardly reaching beyond exopod; antennule female 7-segmented; caudal ramus female and male a little longer than broad, distal outer seta not apical in position..... *B. douwei*

B. zschokkei is a highly variable, widely distributed species for which a large number of varietal names have been proposed. As Lang points

out, these numerous forms are not zoogeographically or ecologically restricted. It should be noted, however, that American forms may differ from those described from Eurasia. All of the Alaskan specimens that I have examined have the long terminal seta of the endopod of the male third leg modified as described by Coker for *alleganiensis*. It is not always easy to mount the appendage in the proper position to view this modified seta accurately, and it may be that Willey overlooked it in his specimens of *frigidus*. This modification has not been shown for European or other specimens of *zschokkei*, but is similar to that illustrated for the closely allied species, *pyrenaicus* Chappuis. This character should be carefully confirmed in examination of all American specimens, as should the additional possible difference in the prominent spinules on the inner margin of the caudal rami of the American forms.

Willey (1925) mentioned an undescribed form of *cuspidatus*; in his 1934 paper he apparently described these specimens and referred them to the European species. It is not possible to judge exactly whether he had the typical European form of *cuspidatus*. However that may be, a closely related species to be described in an early number of this series of papers, is also present in North America. This paper also includes Alaskan records of the related species, *B. arcticus* (Lilljeborg), not otherwise reported in the literature from North America.

Moraria

M. cristata Chappuis 1929
M. laurentica Willey 1927
M. laurentica americana Chappuis 1927
M. affinis Chappuis 1927
M. virginiana Carter 1944

Carter (1944) has given a good key and summary of the species known for North America. To her records, the following may be added:

M. affinis is known only from the original occurrence in New York. Specimens agreeing with Chappuis's description have been found near Anchorage, Alaska—in moss on a roadside cliff over which a melt water stream from the Chugach Mountains was flowing.

M. duthiei (T. & A. Scott) 1896 has been reported already from Greenland, so it is not suprising to find it in collections from Yukon Territory and Alaska, where it is one of the most commonly found harpacticoids. Occurring with it in some Alaskan collections is *M. mrazeki* (T. Scott) 1895.

Epactophanes

Lang recognizes only one cosmopolitan species in this genus—*E. richardi* Mrázek, as based upon his studies in variation and breeding (Lang, 1934). The species was reported by Willey (1927) from Québec as a "juvenile" of *Moraria laurentica*, and from New York by Chappuis (1927). It occurs also in my Alaskan collections.

Maraenobiotus

There are no published records of this genus from the North American continent, although it is known to occur in Greenland. Specimens agreeing very closely with the typical form of *M. insignipes* (Lilljeborg)

have been identified in my collections from Yukon Territory and Alaska; and others agreeing with *M. brucei* (Richard) have been found in Alaska. These will be fully described in a paper of this series dealing with these and other American forms of the genus.

Mesochra

Species of this genus have been recorded in North America only from brackish waters. In Alaska, the euryhaline species, *M. rapiens* (Schmeil) 1894, has been found in both brackish and fresh-water bodies of the Bering Sea coast. It has been reported from the Continent only from a British Columbia brackish lagoon by Carl (1940).

2. CANTHOCAMPTUS OREGONENSIS N. SP. FROM OREGON AND CALIFORNIA

A new species of the fresh-water genus *Canthocamptus* was present in a collection recently made in western Oregon. I am indebted to Mr. A. R. Roth, Entomology Research Branch, U. S. Department of Agriculture, Corvallis, Oregon, for assistance in making this collection. While the manuscript was in preparation, a California collection containing specimens of this new species was referred to me for identification by Mr. Donald R. Zuckswert, Entomologist, San Joaquin County Agricultural Department, Stockton, California. This collection is of value because it contains not only the new species, but numerous specimens of both sexes of *C. assimilis* Kiefer (1931a), to be fully described later in this series of papers.

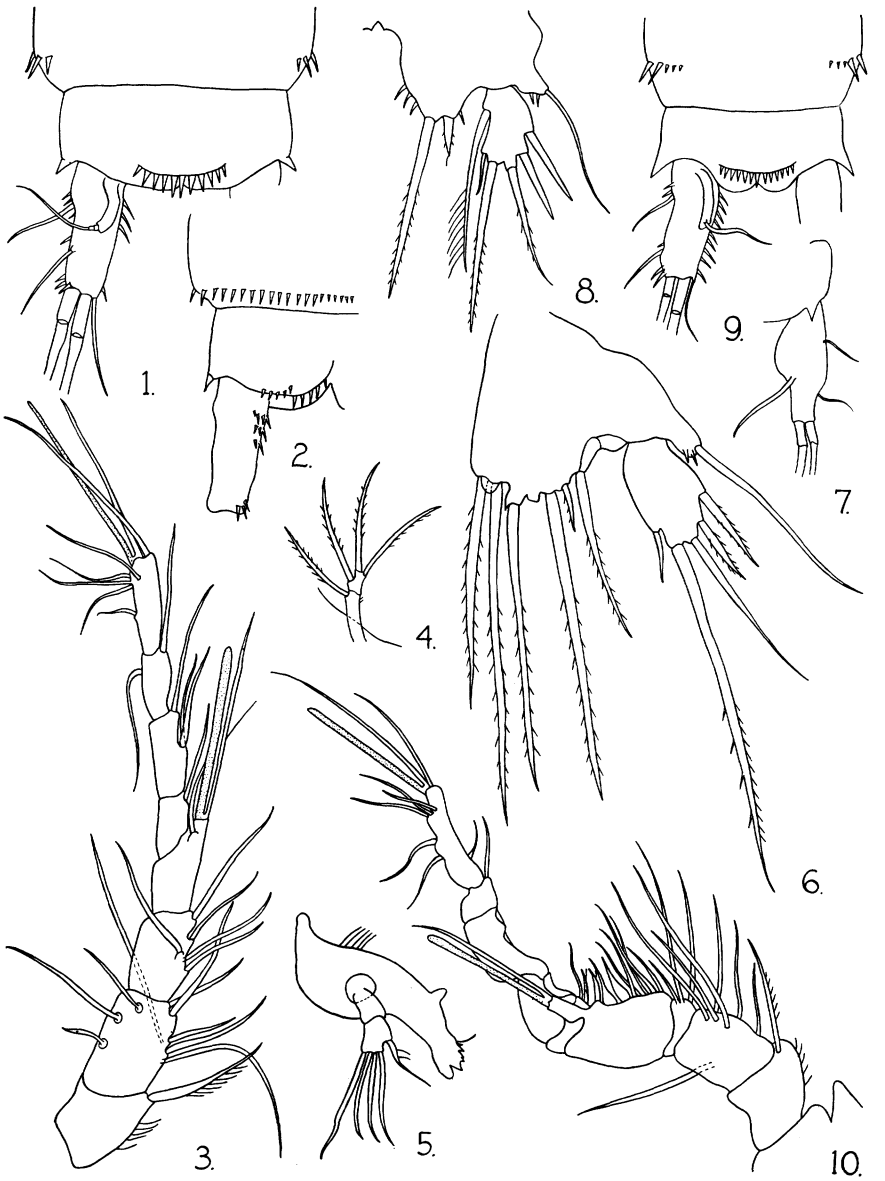
Canthocamptus oregonensis, n. sp. (Figs. 1–20)

Specimens examined.—Type lot: 6 females, 3 males. From among weeds of seasonal roadside ditch pond about 3 miles south of Corvallis, Benton County, Oregon; March 8, 1954; M. S. Wilson and A. R. Roth. Occurring with *Canthocamptus staphylinoides* Pearse var., *Attheyella nordenskioldii* (Lilljeborg), and *Diaptomus caducus* Light. Holotype female, U. S. National Museum no. 97437; allotype male, no. 97438.

Ten females, 5 males. Pond off Tioga Road, Yosemite National Park, California; July 4, 1954; D. R. Zuckswert. Occurring with *Canthocamptus assimilis* Kiefer, *Cyclops vernalis* Fischer, and *Diaptomus hirsutus* M. S. Wilson.

Diagnosis.—Last body segment of both sexes produced distally on each side into stout spine-like process. On dorsal surface of caudal ramus of both sexes, a prominent lobelike swelling, more or less defined by a thickening of the cuticle. Outer and middle caudal setae of both sexes jointed near base, outer, about one-third length of middle. Leg 2 of both sexes with two inner setae on distal segment or portion of endopod. Leg 4 of female with middle apical seta of endopod longer than outer spine. Leg 3 of male with two well-developed setae on apex of endopod, outer about twice length of endopod. Leg 5 of male with six setae on segment 2; inner spine of basal segment much longer than outer spine (4–5 times) and subequal to longest (fourth) seta of segment 2.

Description.—Length (dorsal midline), female, 0.87–0.88 mm., male, 0.82 mm.



Canthocamptus oregonensis, new species

FIGS. 1–7, female: 1. Distal portion of urosome and caudal ramus, dorsal. 2. Same, ventral. 3. Antennule. 4. Antenna, exopod. 5. Mandible. 6. Leg 5. 7. Caudal ramus, dorso-lateral view.

FIGS. 8–10, male: 8. Leg 5. 9. Distal portion of urosome and caudal ramus, dorsal. 10. Antennule.

Female

Distal membrane of segments not serrate. Dorsal surface of metasome and both surfaces of urosome with numerous broken, crosswise rows of minute scale-like spines. Metasome without other dorsal ornamentation.

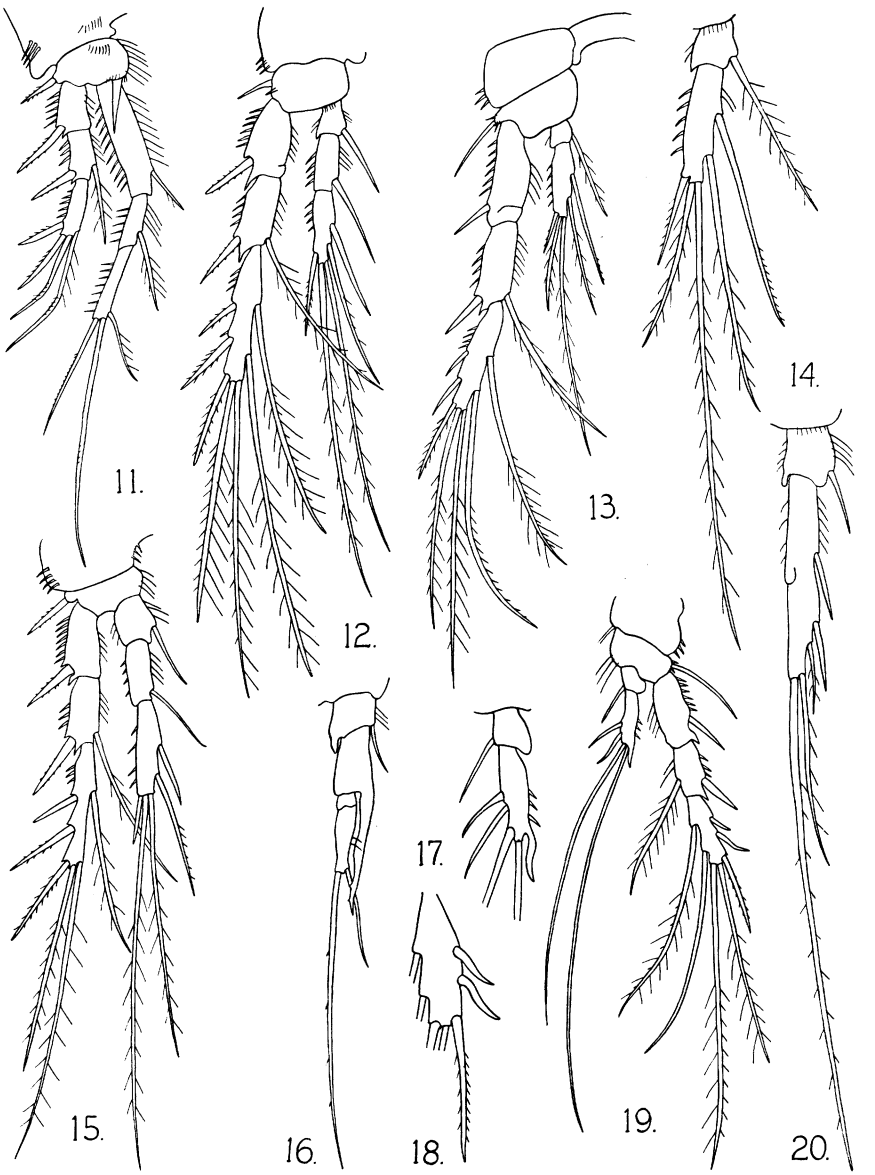
Urosome with large spines at posterior margins of segments, as follows. Dorsal: Genital segment (urosome segments 1 and 2) with distally placed row broken by small center gap; segment 3 with 10–11 lateral spines on each side and large center gap; segment 4 with 2 or 3 lateral spines; segment 5 lacking spines. Ventral: Genital segment with distal row broken by center gap; segments 3 and 4 each with complete row, center spinules smaller than outer; segment 5 (Fig. 2) with two groups of center spinules, unequal in size, the smaller placed outwardly and partially overlying inner base of caudal ramus, the larger placed along margin of medial incision.

Urosome segment 5 (last body segment) somewhat constricted and shortened in comparison to preceding segment which is about 2.3 times longer than outer margin of segment 5. Distal corner drawn out into sharply pointed process on each side; process more or less demarcated from segment, its length about one-fifth of margin of segment. Anal operculum armed with 11 moderately stout spines.

Caudal ramus a little less than 3 times longer than broad (23: 8) (width measured at midpoint between outer lateral setae), and slightly more than 2 times longer than outer margin of segment 5 (23: 10). Outer margin with the usual two slender setae, with spinules at their bases; neither seta as long as ramus. Dorsal inner surface of area above middle of ramus swollen into dorsally protuberant lobe more or less defined by cuticular thickening or sclerotization at apex of which the dorsal seta arises. In dorsal view, outlines of lobe appear somewhat like ridges (Fig. 1); its real nature as tumid surface protuberance with thickened cuticle more evident in dorso-lateral view (Fig. 7). Minute cuticular lappet on midventral surface near base of proximal lateral seta. Inner margin of ramus with group of spinules above middle, arranged in about three rows on ventral surface (Fig. 2), the larger inner edge spinules appearing marginally in dorsal view. (The California specimens varied from this arrangement, having spinules ranged along entire inner margin.) Distally, on both inner and outer margins, two or three spinules above bases of caudal setae. Both outer and middle caudal setae stout, distinctly jointed near bases; spinulose on margins and tapering to hair-like tips; middle seta about 3 times longer than outer; inner seta very slender, almost hair-like.

Antennule (Fig. 3) 8-segmented; only seta of segment 1 plumose; aesthete of segment 4 reaching nearly to end of segment 7; apical segment nearly 1.5 times longer than segment 7 (about 11: 8), and about 3.6 times its own width. Exopod of antenna (Fig. 4) 2-segmented, first segment with one plumose seta, apical segment with one lateral and two apical plumose setae. Mandible palp (Fig. 5) 2-segmented, first segment without seta, apical segment with five setae, one placed laterally, the others terminally.

Segmentation of legs 1–4 as usual for *Canthocamptus* s. str., exopods 3-segmented, endopods of first three legs 3-segmented and of fourth leg 2-segmented. All legs with outer seta or spine on basipod 2; only leg 1



Canthocamptus oregonensis, new species

FIGS. 11–15, female: 11. Leg 1. 12. Leg 3. 13. Leg 4. 14. Leg 4, detail of endopod. 15. Leg 2.

FIGS. 16–20, male: 16, Leg 3, endopod. 17. Leg 4, endopod. 18, Leg 4, exopod segment 3, detail of spines. 19. Leg 4. 20. Leg 2, endopod.

with inner basipod spine (Fig. 11). Exopod segment 3 of leg 1 with two outer spines, legs 2–4 with three outer spines. Figures 11 to 15 show comparative size and arrangement of setae and spines. Summary of setation (Sp = spine; s = seta):

	EXOPOD				ENDOPOD			
	1	2	3	Total Seg. 3	1	2	3	Total Apical Seg.
Leg 1	Sp-0	Sp-s	2 Sp-2 s	4	O-s	O-s	Sp-2 s	3
Leg 2	Sp-0	Sp-s	3 Sp-3 s	6	O-s	O-s	Sp-4 s	5
Leg 3	Sp-0	Sp-s	3 Sp-4 s	7	O-s	O-s	Sp-4 s	5
Leg 4	Sp-0	Sp-s	3 Sp-4 s	7	O-s	Sp-4 s		5

Leg 1 (Fig. 11). Endopod segment 1 not reaching to end of exopod; relative length to total exopod, 23: 28, and of endopod segments to one another, 23: 9: 15 (measured along inner margin of segments).

Legs 2 and 3 (Figs. 12, 15). Exopod segment 3 longer than exopod 1. Endopod of leg 2 reaching to about middle of exopod 3; that of leg 3 shorter, reaching to about proximal fourth of exopod 3.

Leg 4 (Fig. 13). Exopod segment 3 about same length as exopod 1. Endopod reaching to near end of exopod 1, actual length slightly less (17.5: 19). Middle apical seta of endopod nearly twice length of outer apical spine, 19: 10. All inner setae including that of segment 1, longer than endopod.

Leg 5 (Fig. 6). Length of distal segment 2 about 1.6 times its width, with five setae. Fourth seta (from outer edge) much longer than others, its length a little more than 4 times that of segment; two outer setae equal; third seta twice their length, nonplumose; apex hair-like; relative length of setae to one another, 7: 7: 14: 33: 5. Basal segment not produced as far as middle of second segment, with six setae of which the second is as usual, extremely reduced. Setae 2–4 borne on slightly produced portion of segment; between setae 3 and 4 a distinct gap in which is a marginal production resembling base of seta; rounded cuticular lappet overlying bases of setae 5 and 6. None of the setae as long as fourth seta of segment 2; setae 3, 4 and 5 reaching to nearly same point; of these, seta 4 shortest, and seta 5 longest; last seta (6) longer than first. Relative length of setae to one another, 15: 4: 26: 23: 27: 21.

Male

Surface of body with crosswise groups of minute scale-like spines as in female. Arrangement of urosome spines similar to that of female; dorsally, segments with center gaps, segment 4 with only 2 or 3 large and a few small lateral spines; ventral rows complete on all segments. Spinous process at distal corner of last segment stouter and longer than that of female, length about one-fourth that of margin of segment.

Caudal ramus as in female except that inner marginal spinules run along entire margin in both lots of specimens (Fig. 9). Caudal setae as in female.

Antennule (Fig. 10) 9-segmented, three segments beyond geniculation,

penultimate segment distinctly set off on outer margin. Apical segment subequal in length to the two preceding segments. Seta of segment 1 plumose as in female; segment 4 with two types of short, modified setae distally, and with aesthete borne on the usual distal process.

Leg 1 and exopods of legs 2–3 as in female; endopods of legs 2–4 modified as usual for *Canthocamptus*.

Leg 2 (Fig. 20). Endopod 2-segmented; reaching to about middle of exopod 3. Basal segment of endopod with inner seta. Distal segment (segments 2 and 3) with outer, partially free, cuticular lappet and inner seta near middle; with two short, inner distal setae and two long, apical setae, of which the outer is much longer than endopod (52: 26), and a little more than twice length of inner seta (52: 23).

Leg 3 (Fig. 16). Endopod reaching to about distal third of exopod segment 2. Basal segment with seta on inner margin and cuticular process on distal outer edge. Segment 2 (to base of apophysis) nearly twice length of segment 1 (7: 4); apophysis comparatively slender throughout; reaching a little beyond apex of endopod, length (measured from its base at distal inner edge of segment) less than that of total endopod (14: 19) and nearly equaling that of segments 2+3 (14: 15). Apical segment reduced in width, but length subequal to that of segment 2 (excluding apophysis); near base, a distinct crosswise line which appears to represent a surface marking rather than a division into another segment. Outer apical seta stout, reaching beyond exopod, its length twice that of endopod, inner seta shorter than endopod.

Leg 4 (Fig. 19). Exopod segment 3 subequal in length to first exopod segment, differing from female in having outer marginal spines somewhat modified (Fig. 18). These spines unarmed, bent near bases and placed submarginally on segment; outer apical spine hardly modified, only slightly bent at base, length greater than that of segment (19: 13). Endopod (measured to base of outer apical process) reaching to about end of exopod 1, actual total length about equal to that of exopod 1. Second segment a little more than twice length of first (9: 4). Outer distal process of segment 2 (Fig. 17) a little enlarged and bent outwards just beyond its base and more or less recurved near tip; length of process (measured from its subterminal base) about two-thirds that of segment (6: 9). Basal segment with inner seta (this seta absent in one dissection). Second segment with two inner setae, both shorter than endopod (8: 13). Apical setae very long, outer reaching to near end of longest seta of exopod; relative length of outer seta, inner seta and endopod, 52: 34: 13.

Leg 5 (Fig. 8). Length of segment 2 about 1.5 times its width; with 6 setae, sixth seta placed on inner margin near base of segment. Relative length of setae to one another (from outer to inner), 7: 7: 12: 17: 3: 15. Basal segment produced to near middle of segment 2, with short outer and long inner, spine-like setae; inner nearly 5 times length of outer (19: 4), nearly reaching to end of longest (fourth) seta of second segment, its actual length subequal to that of this seta (19: 17).

Discussion

From all other described American species or forms of the genus, *Canthocamptus oregonensis* is immediately distinguishable in both sexes by the distal spinous processes of the last body segment. This is a prominent character of the Eurasian species *staphylinus* and the European-

North African *microstaphylinus*, from which *oregonensis* differs most conspicuously in having well-developed apical setae on the endopod of the male third leg. The strong development of these setae in the known American representatives of *Canthocamptus* constitutes a noticeable difference from most of the species of the genus. Excepting the male described as that of *C. glacialis* Lilljeborg by Borutzky (1931), all others have extremely reduced setae or none. In North American forms, at least the outer seta is considerably longer than the endopod.

Of the two European species, *oregonensis* is most similar to *microstaphylinus* (as redefined by Gurney, 1932 and Lang, 1948) in such characters as the jointing of the outer and middle caudal setae; the relative length of the outer to the middle caudal seta, and the relative length of the long spines of the basal and second segments of the male fifth leg. It differs from the typical form of *microstaphylinus* in having (1) a larger number of opercular spines, (2) spinules on the inner margin of the caudal ramus, (3) six (instead of five) setae on the distal segment of the male fifth leg. These characters also distinguish *microstaphylinus monardi* described by Roy (1927) from Algeria and redefined by Gurney (1932) from Tunisian specimens.

The females of *oregonensis* are separable from *m. monardi* on the basis of the much greater size of the spines of the last body segment in the African forms. There are also differences in the comparative lengths of the setae of the fifth leg. The figures given by Gurney and Roy show agreement between the British and the African forms in the relative lengths of certain setae which differ from those in *oregonensis*. These are:

Basal segment: The first (outer seta in *microstaphylinus* is longer than the last (seta **6**); in *oregonensis* the last seta is longer than the first. In *microstaphylinus*, the middle setae **3**, **4**, **5** are graduated in both actual length and the point to which they reach, decreasing from the outer to the inner; in *oregonensis*, seta **4** reaches to a point between the other two setae, its actual length being less than that of setae **3** or **5** which are more or less subequal to one another.

Segment 2: The two outer setae are of nearly equal length in all three forms. The third seta in *oregonensis* is twice the length of the outer, but considerably less than twice the length in *microstaphylinus*.

The relative lengths of these setae in *microstaphylinus* and *m. monardi* agree with the usual condition found in *staphylinus*. The pattern of relative lengths of the middle setae (3, 4, 5) of the basal segment is apparently little variable, if at all, in the Eurasian-African forms and is the most significant. The difference of the pattern of these setae in *oregonensis* is of interest because the relative length of its setae agrees with the pattern found in the common American species *staphylinoides* (as illustrated by Pearse, 1905, and invariable in specimens I have examined from several localities). The fifth leg of *oregonensis* is very like that of *staphylinoides* but differs in that the midportion of the basal segment is not so prominently produced. Quite possibly, it may be found with further study, that this pattern of setal length has taxonomic significance as one of the characters relating the Eurasian *staphylinus* group through *oregonensis*, to the American *staphylinoides* group.

The males of *oregonensis* and *m. monardi* presumably differ in the length of the apical endopod setae of the third leg. Neither Roy nor Gurney specifically mentioned or figured this character, and the agreement of *m. monardi* with *microstaphylinus* s. str. must be assumed for

the present. This assumption may be made with some degree of confidence because of the thoroughness of Gurney's work. In comparison with Roy's figure of *monardi*, the basal segment of the male fifth leg in *oregonensis* is conspicuously produced and the inner spine is considerably longer than the outer. In the latter difference, it more closely resembles the British specimens of *microstaphylinus* figured by Gurney.

The lobe-like swelling of the inner proximal part of the dorsal surface of the caudal ramus in *oregonensis* may be a point of difference between it and the European-African forms, but does not distinguish it from all American forms. All of the specimens of *staphylinoides* and *assimilis* that I have seen have such a dorsal swelling, though it is not usually so prominent as that of *oregonensis*. It has not been mentioned in literature, but its presence is suggested in some illustrations.

One of the important differences between *staphylinus* and *microstaphylinus* is the shape of the spermatophore. Unfortunately, no females with attached spermatophores were present in either of the collections of *oregonensis*, nor were any observed in the male. In the California sample, most of the females of *C. assimilis* collected with *oregonensis*, were ovigerous or carried spermatophores, suggesting that these two related, sympatric species have different breeding seasons in the Yosemite Park pond.

The discovery of an American form of *Canthocamptus* with a distinctive character of the Eurasian-African *staphylinus* group (spinous process of last body segment) is of particular interest not only zoogeographically, but because it may serve at least partially, to clarify some North American records. *C. staphylinus* has been reported from scattered localities on the Continent but it is not certain that any of the records are based on accurate identification. If *C. oregonensis* is found to be widely distributed over North America it might be assumed with more or less confidence that some of these records are of this new species rather than one of the European forms. Records based solely upon Marsh's key (1918) may be considered as indefinite. Unfortunately, Marsh ascribed the spinous process not only to *staphylinus* but also to the common American species *staphylinoides*, not distinguishing between the distinct production of the segment in *staphylinus* and the surface spinules grouped at the distal edge in *staphylinoides*. If either of the European forms are present in North America, it is still necessary to establish their occurrence by substantiated records based upon the redefinitions of Gurney and Lang.

In the records of associated species given above for the type lot of *oregonensis*, *C. staphylinoides* is listed as a variety to indicate that the specimens are not of the typical form. It has already been noted above, p. 292 that variants of *C. staphylinoides* occur over the Continent; these will be considered in detail in later papers of this series. The record is included here because of its value in establishing the co-occurrence of two species of *Canthocamptus* s. str., a fact exemplified in both the Oregon and California collections of *oregonensis*. Ward (1940) recognized that two species occurred together in Ohio collections, but identified them as *staphylinoides* and *staphylinus* on the basis of Marsh's (1918) inadequate separation. It is evident that in sorting samples of these small copepods, the possibility that more than one species of this genus might be present, should always be considered.

Literature Cited

Borutzky, E. W. 1931. The fresh-water and brackish-water harpacticoids of the U. S. S. R. In: Keys to determination of fresh-water organisms of the U. S. S. R. A. Fresh-water fauna, Pt. 3. 246 pp. 102 Figs. (In Russian).

1948. Copepoda Harpacticoida of Lake Baikal of the genus *Bryocamptus* Chappuis. Compt. Rend. Acad. Sci. Moscow, 59(9): 1669–1672. 3 Figs.

Carl, G. Clifford. 1940. Some ecological conditions in a brackish lagoon. Ecol., 21(1): 65–74. 2 Figs.

Carter, Marjorie E. 1944. Harpacticoid copepods of the region of Mountain Lake, Virginia (with description of *Moraria virginiana* n. sp.). Jour. Elisha Mitchell Sci. Soc., 60(2): 158–166. Pls. 65–67.

Chappuis, P. A. 1927. Freilebende Süsswasser-Copepoden aus Nordamerika. 2. Harpacticiden. Zool. Anz., 74: 302–313. 20 Figs.

1929. Die unterfamilie der Canthocamptinae. Arch. Hydrobiol., 20: 471–516.

Coker, Robert E. 1926. Plankton collections in Lake James, North Carolina—copepods and Cladocera. Jour. Elisha Mitchell Sci. Soc., 41: 228–258. 11 Pls.

1934. Contribution to knowledge of North American freshwater harpacticoid copepod Crustacea. Ibid., 50: 75–141. Pls. 1–15.

Coker, Robert E., and Morgan, Juanita. 1940. A new harpacticoid copepod from North Carolina. Jour. Wash. Acad. Sci., 30: 395–398. 1 Fig.

Dineen, Clarence F. 1953. An ecological study of a Minnesota pond. Amer. Mid. Nat., 50(2): 349–376. 6 Figs.

Gurney, Robert. 1932. The British fresh-water Copepoda. Vol. 2. 336 pp. 1195 Figs. Ray Society, London.

Herrick, C. L. 1884. A final report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda. 12th Ann. Rep. Geol. & Nat. Hist. Surv. Minnesota for 1883: 3–191. Pls. A-V.

1895. Copepoda of Minnesota. In: Herrick, C. L., and Turner, C. H. Synopsis of Entomostraca of Minnesota. 2nd Rep. State Zoologist, Geol. & Nat. Hist. Surv. Minnesota, Zool. Ser. 2. 525 pp. 81 pls.

Kiefer, F. 1931. Kurze diagnosen neuer Süsswasser-Copepoden. Zool. Anz., 94: 219–224. 10 Figs.

1931. Zur Kenntnis der freilebenden Süsswassercopepoden, insbesondere der Cyclopiden Nordamerikas. Zool. Jahr. Abt. Syst. Oko. Geog., 61: 579–620. 55 Figs.

1934. Neue Ruderfusskrebse aus Nordamerika. Zool. Anz., 108: 206–297. 2 Figs.

Lang, Karl. 1934. Studien in der Gattung *Epactophanes* (Copepoda Harpacticoida). Ark. Zool., 28A(11): 1–27. 47 Figs.

1948. Monographie der Harpacticiden. Vols. 1, 2. 1683 pp. 610 Figs. Stockholm.

Lowndes, A. G. 1950. The males of *Canthocamptus bidens* Schmeil. Proc. Zool. Soc. London, 120: 395–403. 18 Figs.

Marsh, C. Dwight. 1918. Copepoda. In: Ward, H. B., and Whipple, G. C. Fresh-Water Biology. pp. 741–789. Figs. 1171–1243.

Moore, J. E. 1952. The entomostraca of southern Saskatchewan. Canad. Jour. Zool., 30(6): 410–449. 1 Fig.

Pearse, A. S. 1905. Contributions to the copepod fauna of Nebraska and other states. Trans. Amer. Micr. Soc., 26: 145–160. Pls. 13–17. Reprinted in: Stud. Zool. Lab. Univ. Nebraska, No. 65.

Pennak, Robert W. 1953. Fresh-water invertebrates of the United States. 769 pp. Ronald press, New York.

ROY, JEAN. 1927. Sur deux varietes nouvelles de *Canthocamptus microstaphylinus* Wolf recueillies en Afrique du Nord. Bull. Soc. Zool. France, 52: 166–172. 7 Figs.

WARD, ELIZABETH B. 1940. A seasonal population study of pond Entomostraca in the Cincinnati region. Amer. Mid. Nat., 23: 635–691. 11 Figs.

WECKEL, ADA L. 1914. Free-swimming fresh-water Entomostraca of North America. Trans. Amer. Micr. Soc., 33: 165–203. 14 Figs.

WILLEY, ARTHUR. 1925. Copepods in the northern hemisphere. Nature, 116: 206. 1 Fig.

1927. Description of a new species of fresh-water copepod of the genus *Moraria* from Canada. Proc. U. S. Nat. Mus., 71(1): 1–12. 30 Figs.

1934. Some Laurentian copepods and their variations. Trans. Roy. Canad. Inst., 20(1): 77–98. Pls. 13–15.

THE CHEMICAL NATURE OF THE CYST MEMBRANE OF *PELOMYXA ILLINOISENSIS*

IRVING B. SACHS

Department of Biology, Wisconsin State College, Stevens Point, Wis.

A. G. Richards (1951) comments briefly on chitin in various groups of animals and refers to the lack of verification of chitin among Protozoa. Thus more data are needed on its occurrence and distribution among unicellular animals.

Stein (1954) appears to be the first to have studied the chemical nature of protozoan cysts. He obtained a positive reaction (wine-red color) when cysts of *Vorticella microstoma* Ehr. were treated with iodine and sulfuric acid, and believed that the cyst membranes were composed of a substance that was combined with cellulose and which could be dissolved in potassium hydroxide. Fabré-Domergue (1885) found that in concentrated sulfuric acid or potassium hydroxide the cyst membrane of *Vorticella nebuilfera* Ehr. did not dissolve. Nor did the membrane show a cellulose reaction with iodine and sulfuric acid. Goodey (1913) reported that the cyst membranes of *Colpoda cucullus* Müll. are insoluble in strong acid, alcohol and ether, give no reaction with iodine and strong sulfuric acid, and are dissolved only in low concentrations of caustic soda. Judging from enzyme actions, Goodey believes that the endocyst membrane of *Colpoda*, and other Ciliata which form double-walled cysts, is composed of a carbohydrate which he names "Cystose". This substance is allied to glycogen, paraglycogen and paramylum.

Sebestyén (1935) found the cyst membranes of *Diplosalis acuta* (Apstein) Entz resisted concentrated acids (sulfuric, hydrochloric) and were not affected by potassium hydroxide. Using polarized light she was able to conclude that cyst membranes are composed of a substance closely allied to cellulose.

---

[1]This paper is a portion of a dissertation submitted in partial fulfillment of the requirements for the degree Doctor of Philosophy, University of Illinois, 1954. The author wishes to thank Professor C. C. Clark for his helpful advice and guidance during the course of this study.