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COPEPODS FROM LAKE ERH HAI, CHINA

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During the years 1943–45 a limnological survey was made of the fresh-water lake Erh Hai (the Tali Lake) in Yunnan, southwest China. An examination of the copepods from the plankton hauls showed a number of new species of Eucopepoda and a large number of individuals of one species of Branchiura. It is the purpose of this paper to record these forms. The limnological data that accompanied the specimens have been reported elsewhere (Hsiao, 1946 and 1949).

Grateful acknowledgment is made to Prof. G. E. Hutchinson for putting at our disposal specimens collected during the Yale North India Expedition and for his kind advice and encouragement. The present work was done during the tenure of a Seessel Memorial Fellowship in the Osborn Zoological Laboratory of Yale University; the use of the facilities of that laboratory are also gratefully acknowledged.

Order EUCOPEPODA

Suborder Calanoida

Family DIAPTOMIDAE G. O. Sars

Subfamily Diaptominae Kiefer

Genus TROPODIAPTOMUS Kiefer

TROPODIAPTOMUS HEBEREROIDES, new species

Figure 20

Diagnosis.—Very close to *Tropodiaptomus heberer*i from Sumatra and Java but differing from it as follows: Female with a simple anal segment shorter than the furcal rami; endopodite of fifth pair of rudimentary legs in both sexes with a distinct seta on distal end of mesial side in addition to a few hairs on terminal end; no rounded hyaline protuberance on basipodite of the rudimentary leg of female; only one large, elongated hyaline process on right basipodite of male; and spine on segment 15 of right first antenna of male smaller than all the other three spines.

Description.—FEMALE: Anterior body region ellipsoidal except at posterior end, where the hind edge of the fused fourth-fifth thoracic segments expands into a winglike process with a sensory hair on the tubercle of the distal end. Posterior aspect of thorax asymmetrical to subsymmetrical (fig. 20, *a*), generally with left side larger and less sinuous than the right. First thoracic segment slightly larger than second; third equals second; fourth fused with fifth, at the place of union a hyaline hemispherical prominence arising and extending to the posterior border above the anterior end of the genital segment. Length, exclusive of terminal setae on furcal rami, 1.5 mm. The posterior body region, or abdomen (fig. 20, *a*, *b*), consists of two segments: an anterior genital segment and a posterior anal segment. Genital segment nearly twice as long as the total length of the anal segment and furcal rami together, asymmetrical, right side longer by virtue of its caudad outgrowth or extension on this side over the next segment, anterior half slightly greater in diameter than posterior, carrying one minute sensory hair on each side of the expanded portion. Some specimens collected in November carry a single ovisac attached on the ventral side of the posterior portion of the genital segment (fig. 20, *h*) containing eight eggs (sometimes six), spermatophores in the form of two sausages attached near the genital opening above the ovisac. Anal segment shorter than furcal rami, consisting of one single segment only, lateral margins uninterrupted and without indication of being developed by fusion of two segments (thus differing from *T. hebereri* Kiefer, 1929, 1934); supraanal plate visible from lateral side. Furcal rami equal, each three-fifths as broad as long, carrying one outer seta (near distal end), four terminal plumose setae of nearly equal size, 2½ times the length of furcal rami, and one inner or dorsal seta, more slender and noded.

First pair of antennae symmetrical, long, reaching the end of furcal rami, and consisting of 25 joints; ultimate joint with six setae. Endopodite of maxilliped with five joints. First swimming leg with 2-segmented base, 2-segmented endopodite, and 3-segmented expodite; one seta on distal end of mesial aspect of first basal segment, none on second; one on distal end of inner aspect of first endopodite segment; two along mesial aspect, one on lateral side and three on terminal end of second endopodite segment; first exopodite segment with short spine on outer distal corner, one seta on mesial side; second exopodite segment with one long seta on inner surface; third exopodite segment provided with one short spine on outer distal corner, two setae on mesial and three on terminal aspect; outer surface of second and third exopodite segments also provided with short hairs along the whole length (fig. 20, *c*). The next three pairs of legs similar, having two basal segments, three endopodite segments, and three exopodite segments, and similar number of setae on homologous joints (fig. 20, *d-f*) ; first basal segment with one seta on distal inner corner, longer than the length of basal segment 2, which is unarmed; first, second, and third endopodite segments with one, two, and three setae, respectively, on inner aspect, while the last has in addition one seta on outer and three setae on terminal surface, making a total of seven; each exopodite segment with one short spine on outer distal corner, first and second exopodite segment each with one seta on distal inner corner, third joint with three setae on each of mesial and terminal surfaces; terminal setae plumose and nearly as long as the whole leg. "Schmeil's appendage" present on second endopodite segment of second leg (fig. 20, *d*, *l*).

Fifth pair of rudimentary legs (fig. 20, *g*) symmetrical; first basal segment with a strong hyaline spine on distal outer angle, second with a sensory hair on outer surface, but no rounded hyaline protuberance on inner surface (a feature that also helps to distinguish this species from *T. hebereri*). Endopodite consisting of one single piece, equaling two-thirds the length and one-third the diameter of the first exopodite segment; distal end of endopodite provided with two strong spines (one may be twice as long as the other, or they may be subequal in length) and a few small bristles; on the distal end of mesial aspect a small but distinct spinule distinguishes this species from *T. hebereri*. Exopodite consisting of two obvious sections, but the presence of a rudimentary third joint is indicated by a small depression on the outer aspect of the distal end of the second joint, where a stout but short spine arises in addition to a long filamentous seta, which is about as long as the big claw that forms the distal continuation of the second exopodite segment; both filamentous seta and claw provided with a fine hairs along their lengths.

Male: Anterior body region more ellipsoidal than in female, for there is less outflaring of the posterior end of last thoracic segment (fig 20, *i*) ; fourth and fifth segments not fused together, and without a dorsal protuberance (fig. 20, *j*) as in female; posterior outer angle ends in a sharp spine on each side, though much expanded; abdomen in five segments, asymmetrical, the right side being better developed than the left, particularly the fourth segment; furcal rami and their setae similar to those of female. Length, exclusive of caudal setae, 1.4–1.45 mm.

Right first antenna modified into grasping organ, with 22 joints; first six joints symmetrical on both sides and similar to those in female; starting from the seventh to the twelfth the distal end of each joint elongated distally in the form of a triangle. Number and distribution of setae on first 12 joints same as for the female except that joints 10 and 11 each have a spine in addition to setae (fig. 20, *n*); one spine on each of joints 13 and 15; spine on joint 13 very strong, almost twice as long as the segment itself; spine on joint 15 least, only one-half the size of spine on joint 10, which is shorter than that on joint 11. Middle section (joints 13–18) increasing in thickness until the fifteenth, which is greatest in diameter. Antepenultimate joint (fig. 20, *k*) provided with a nearly straight process on distal end, with its tip bent and a thin hyaline lamella on the outer edge of the process; last two joints not armed with appendages except for those found on the left, or on the female, antenna. Maxilliped and first four pairs of legs similar to those of female (e. g., fig. 20, *l*).

Fifth pair of rudimentary legs asymmetrical, greatly modified. On right side first basal segment smaller than second, with a stout spine on outer distal end pointing caudally; second basal segment cylindrical, with hyaline spine on proximal end of mesial surface and only one rounded, though much larger, hyaline protuberance instead of two such structures, shorter in length, found in *T. hebereri;* sensory hair present on distal end of outer surface. Endopodite simple, nearly as long as first exopodite segment, possessing one distinct, though short, spine on distal end of mesial surface and a number of small hairs on terminal end. This spine has not been described for *T. hebereri* at this position. First exopodite segment rather small, with two large hyaline spines on distal end, one mesial, one lateral; second exopodite segment with a long curved outer or posterior border, with a stout claw, equaling the whole second exopodite segment in length and dentate along its concave surface; arising slightly above the middle point of this border, on the middle of the lower half, between the two claws, a rounded hyaline protuberance occurs, and above it a strong but short spine arises. Terminal claw long, sickle-shaped, dentate on concave side, sometimes as long as the whole leg. Left leg small each joint being correspondingly smaller than right; first basal segment also smaller than second, carrying on outer caudal surface a spine as big as that on the right leg; second basal segment cylindrical, nearly twice as long as broad, with a sensory hair on outer distal corner. Endopodite simple, unjointed, with a number of short bristles on distal end. Exopodite modified into a structure comparable to that described by Kiefer for *T. hebereri* (fig. 20, *m*, and cf. Kiefer, 1934).

A large number of males and females were collected from Lake Erh Hai in Yunnan at different times of the year. In November they represent the most abundant copepod among the plankton.

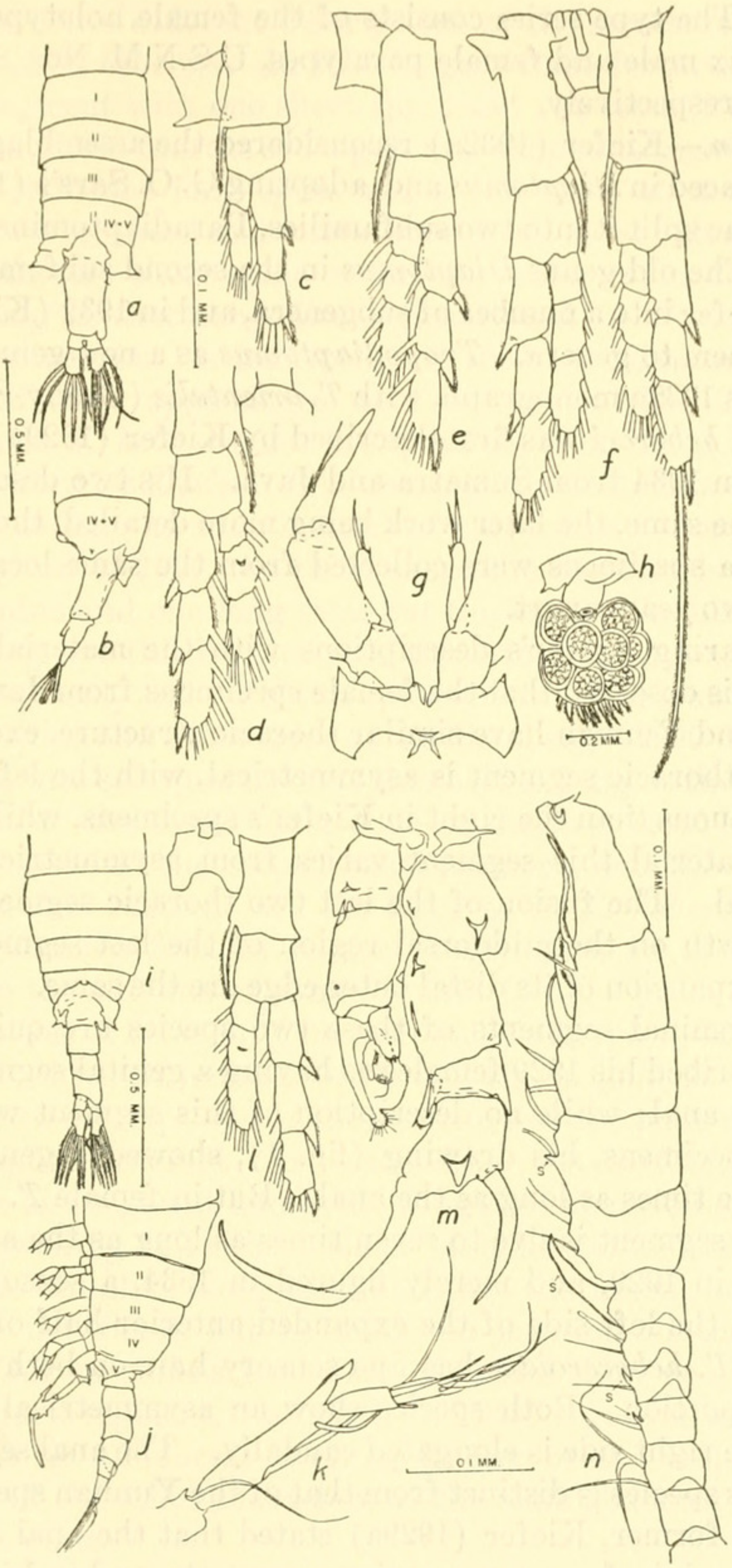

FIGURE 20.—*Tropodiaptomus hebereroides*, new species: *a*, Dorsal view of posterior portion of female; *b*, Lateral view of last two thoracic segments and abdomen of female; *c*, first swimming leg of female; *d*, second swimming leg of female; *e*, third swimming leg of female; *f*, fourth swimming leg of female; *g*, fifth rudimentary leg of female; *h*, ovisac and abdomen of female, ventral view; *i*, dorsal view of posterior portion of male; *j*, lateral view of same; *k*, last three joints of male first (clasping) antenna; *l*, second swimming leg of male; *m*, fifth pair of rudimentary legs; *n*, joints 8–18 of first antenna of male (s=spine).

Types.—The type series consists of the female holotype, male allotype, and six male and female paratypes, U.S.N.M. Nos. 84546, 84545, and 84547, respectively.

Discussion.—Kiefer (1932a) reconsidered the assemblage of species formerly placed in *Diaptomus* and, adopting G. O. Sars's (1903) family Diaptomidae split it into two subfamilies, Paradiaptominae and Diaptominae. The old genus *Diaptomus* in the second subfamily was first split by Kiefer into a number of subgenera, and in 1932 (Kiefer, 1932b) he raised them to genera. *Tropodiaptomus* as a new genus was established in his 1932a monograph, with *T. orientalis* (Brady-Sars) as type species. *T. hebereri* was first described by Kiefer (1929a) from Java and again in 1934 from Sumatra and Java. His two descriptions are not quite the same, the later work being more detailed, though the two lots of Java specimens were collected from the same locality (Dieng Plateau) two years apart.

In comparing Kiefer's descriptions with the material from Lake Erh Hai it is observed that the female specimens from Java, Java and Sumatra, and Yunnan have similar thoracic structure, except that the end of the thoracic segment is asymmetrical, with the left side larger and less sinuous than the right in Kiefer's specimens, while among the Yunnan material this segment varies from asymmetrical to nearly symmetrical. The fusion of the last two thoracic segments, the chitinous growth on the middorsal region of the last segment, and the winglike expansion of its distal outer edge are the same.

The abdominal segments of these two species are quite different. Kiefer described his 1929 females as having a genital segment twice as long as the anal; while no description of this segment was given for his 1934 specimens, his drawing (fig. 1), showed a genital segment two to three times as long as the anal. But in female *T. hebereroides* the genital segment is five to seven times as long as the anal. Kiefer mentioned in 1929, and merely figured in 1934, a sensory hair perceivable on the left side of the expanded anterior half of the genital segment. *T. hebereroides* has fine sensory hair on both sides of the expanded portion. Both species show an asymmetrical genital segment whose right side is elongated caudally. The anal segment of the East Indies species is distinct from that of the Yunnan species. In the case of the former, Kiefer (1929a) stated that the anal segment still showed its origin from two previous segments, and in his later paper (1934, fig. 1) he delineated an anal segment slightly longer than the furcal rami and possessing distinct signs of two previous anal segments. In *T. hebereroides* from Lake Erh Hai the anal segment is shorter than the furcal rami and consists of a single piece only, without any sign of its being derived from two earlier segments.

Kiefer gave two different descriptions of the structure of the fifth pair of legs in *T. hebereri*. In 1929 he gave these features: (1) Third exopodite segment with one short spine and one seta, (2) endopodite unsegmented, three-fourths as long as first exopodite segment, and (3) endopodite wtih one long spine and a few setae at the distal end. In 1934, however, these characters were given as (1) third exopodite segment with very short spine or unobservable, (2) endopodite two-thirds as long as first exopodite segment, and (3) endopodite with two strong spines; but his descriptions of the first and second exopodite segment and their appendages were the same. The fifth pair of legs in female *T. hebereroides* are quite different from those of the species described by Kiefer. The rectangular first exopodite segment is 2.5 times as long as wide instead of only twice as long. Like his first description of 1929, the third exopodite segment is armed with one short spine and one long seta, but the end is like his description of 1934, being two-thirds instead of three-fourths as long as the first exopodite segment, and with two spines as in his second description, but not one spine and a few setae at the distal end—1929 description—with these spines subequal or one spine half as long as the other. The strong spine on the distal outer edge of the first basal segment, the fine sensory hair on the second basal segment, and the claw on the second exopodite segment are the same as in *T. hebereri*. For his Java and Sumatra females Kiefer (1934) gave an account of one seta each on the antenna of joints 11 and 13–19. In *T. hebereroides* the distribution of setae is: One each on joints 1, 3–8, 10–21; two on joints 22–23; three on joints 2, 9, 24; and six on joint 25.

Kiefer's two descriptions of the structure of the male thoracic segments are quite different from each other. According to his first account, the last segment had great winglike expansion and the same middorsal swelling as in the female. But he pointed out later that there was no winglike elongation and that the fourth and fifth segments were not fused, but he made no mention of the middorsal swelling. Our specimens from Lake Erh Hai show no elongation of the last thoracic segment, the fourth and fifth segments are not fused, and there is no middorsal swelling in any of the males. Kiefer's description of the other characters of the male abdomen agrees completely with ours.

Of the male fifth pair of legs no description was given by Kiefer in 1929, only figures, but in 1934 they were described in detail. Compared with the later account, *T. hebereroides* shows the following points of difference: (1) Right first basal segment not so long as the second; (2) second basal segment with only one hyaline, mesially placed, protuberance, not two; (3) anterior surface of basal segment with strong spine; (4) endopodite about as long as first exopodite segment, a number of hairs on distal end and a distinct, though short, spine present on mesial surface; (5) terminal end of endopodite armed with some minute setae. But the other characters of the male fifth pair of legs agree with those given by Kiefer.

From this comparison it will be seen that the specimens from Erh Hai have many points in the structure of the abdomen and fifth pair of rudimentary legs to justify putting them in a separate species, though their general form shows close affinity to *T. hebereri;* hence the name *hebereroides.*

Genus ARCTODIAPTOMUS Kiefer

PARARCTODIAPTOMUS, new subgenus

ARCTODIAPTOMUS (PARARCTODIAPTOMUS) HSICHOWENSIS, new species

FIGURE 21

The second new form of diaptomid was collected in the same plankton hauls as the foregoing species. It is nearly as abundant in the lake as *Tropodiaptomus hebereroides.* Its smaller size, both male and female, helps to distinguish it from the other species of diaptomid in the same plankton sample.

Diagnosis.—The subgenus *Pararctodiaptomus* belongs to *Arctodiaptomus* but is distinguishable as a separate group by the smallness of the pincerlike structure on the distal end of the left exopodite of the fifth rudimentary leg of the male. It is separable from *Arctodiaptomus* s. str. by the absence of spine from the fourteenth joint of the right first antenna (grasping antenna) of the male. In contrast to *Rhabdodiaptomus*, the fourth and fifth thoracic segments are not fused, and the antepenultimate joint of the grasping antenna has no spine. The presence of spines on the thirteenth and fifteenth joints of the same antenna, that on the thirteenth being very large, differentiates this subgenus from *Haplodiaptomus.* Unlike *Stenodiaptomus* the distal half of second joint of fifth male right exopodite is not reduced in diameter.

Type species: *Arctodiaptomus* (*Pararctodiaptomus*) *hsichowensis.*

Description.—FEMALE: Anterior body region calanoid; first thoracic segment broadest, carapace only slightly shorter than thoracic segments (actual ratio of their lengths, 11:13), both length and width of thoracic segments decreasing posteriorly from first to fifth, fifth segment not fused with fourth, with posterolaterally extended wings, tip of wing armed with sharp hyaline spine, posterior aspect of fifth segment with hyaline spine near spine on tip of wing, two sides subsymmetrical. Abdomen (or posterior body region) consisting of three segments: genital segment larger, longer than total lengths of rest of the abdomen and furcal rami together, slightly asymmetrical, anterior half of genital segment thicker than the rest, lateral side of swollen portion armed with a hyaline spine, second or preanal segment very short, articulation between this and anal segment distinct; anal segment approximately as long as furcal rami, posterior end slightly wider than anterior, anal sinus shallow; furcal ramus nearly twice as long as wide, left ramus apparently a little longer than right, outer border of both hairless, inner border covered with hair for a greater part of posterior section; caudal setae plumose, well developed, of about equal length, each about half as long as the abdomen. Length of animal from head to end of furcal rami, exclusive of caudal setae, 1.04 mm. (fig. 21, *a*, *i*).

First antenna with 25 joints, very long, with last joint reaching end of caudal setae when antenna is folded backward along side of body, last joint with four setae, second with three, ninth, eighteenth, and twenty-second to twenty-fourth with two each, the rest with only one each, aesthetasc on joints 8 and 12, no claw or teeth on terminal joint.

First pair of swimming legs with one long seta on each basal joint (coxa) of protopodite, arising from a globular, hair-covered protuberance on the mesial side of distal end; outer surface of both joints of protopodite armed with thick hair, the most distal one of the second joint (basipodite) being thickest; endopodite consisting of two segments only, proximal joint with one seta, distal joint with two mesial, one lateral, and three terminal setae; exopodite consisting of three joints, with two spines on the outer edge, one on proximal and the other on distal joint, proximal and middle joint with one seta on mesial surface, distal joint with three mesial and three terminal setae. The three following legs similar and typical of the subfamily Diaptominae; Schmeil's appendage present on second joint of the endopodite of second pair of legs.

Fifth pair of legs symmetrical, first joint of protopodite larger than second, carrying a stout hyaline spine on outer caudal aspect (fig. 21, *b*, *f*) and a hyaline tubercle on medial portion; second joint of protopodite much smaller, carrying a long sensory hair on its outer surface; endopodite cylindrical, without joint, slightly more than half as long as first joint of exopodite, with distal end gently acuminate, carrying on its distal fifth a number of fine hairs; proximal joint of exopodite as long as the whole protopodite, cylindrical, stout, second joint passing distally into a strong curve claw, with dentation on concave surface, claw almost as long as proximal joint, third joint rudimentary, marked by a depression and two short spines, the outer one much smaller, a long seta extending mesial to the longer spine.

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MALE: Anterior body region smaller and slimmer than female, carapace and length of thorax equal; fourth and fifth segments distinct, winglike expansion on fifth segment similar in shape and armor to that of the female; abdomen long and slender, with five segments very slightly asymmetrical, the right side being a little longer than the left; genital segment (first one) thicker than the others, carrying a spine on right side and an irregular indentation on the caudal end of the left (21, *g*); second to fourth segments similar, decreasing in size caudally from second to fourth, caudal segment smallest; furcal ramus more than twice as long as wide, i. e., relatively narrower than in the female, mesial side provided with fine hairs, furcal setae plumose, not quite so long as abdomen. Total length, exclusive of caudal setae, 0.9 to 1 mm.

Right first antenna with spines on joints 10, 11, 13, and 15; fourteenth joint without spine, spine on thirteenth joint large, longer than thirteenth and fourteenth joints together, with its tip dilated and notched, spine on fifteenth joint least, antepenultimate joint without hook or claw, only a thin hyaline membrane on the outer surface of distal section, last joint at distal end unmodified.

Fifth leg asymmetrical, proximal joint of left protopodite larger than distal one, armed with a stout hyaline spine on outer caudal surface (fig. 21, *h*) and a small hyaline process on mesial part; distal joint of protopodite provided with the usual sensory hair on outer surface; endopodite consisting of a single joint, cylindrical, with a slight indentation of its mesial side, without spine, but covered distally with hairs; exopodite apparently in two joints, proximal joint cylindrical with a slight elevation facing the endopodite on the inner side covered with hairs; distal joint conical, half as long as proximal, mesial corner of proximal portion covered with hairs, which become more abundant toward the distal end, apex of cone drawn out into two processes that form at the end a minute pincer covered with hairs. Right leg much larger, basal joint of protopodite larger than the next one, carrying a stout spine larger than the corresponding spine on the left leg, second joint of protopodite thicker than that on the left side, provided with one sensory hair; endopodite a single piece, acuminate, with a slight indentation, about as long as basal joint of exopodite, tip covered with hairs; exopodite with two joints, basal one half as long as distal, with a large hyaline process on inner surface facing endopodite, process rectangular in shape, occupying more than half the length of the basal joint; distal joint large, curved, with concave surface facing the median line, lateral spine arising from near the middle of the convex surface, one-third as long as terminal claw, which is articulated with the distal end of the second joint, claw large, sickle-shaped; second joint without any other process or appendage besides these two; total

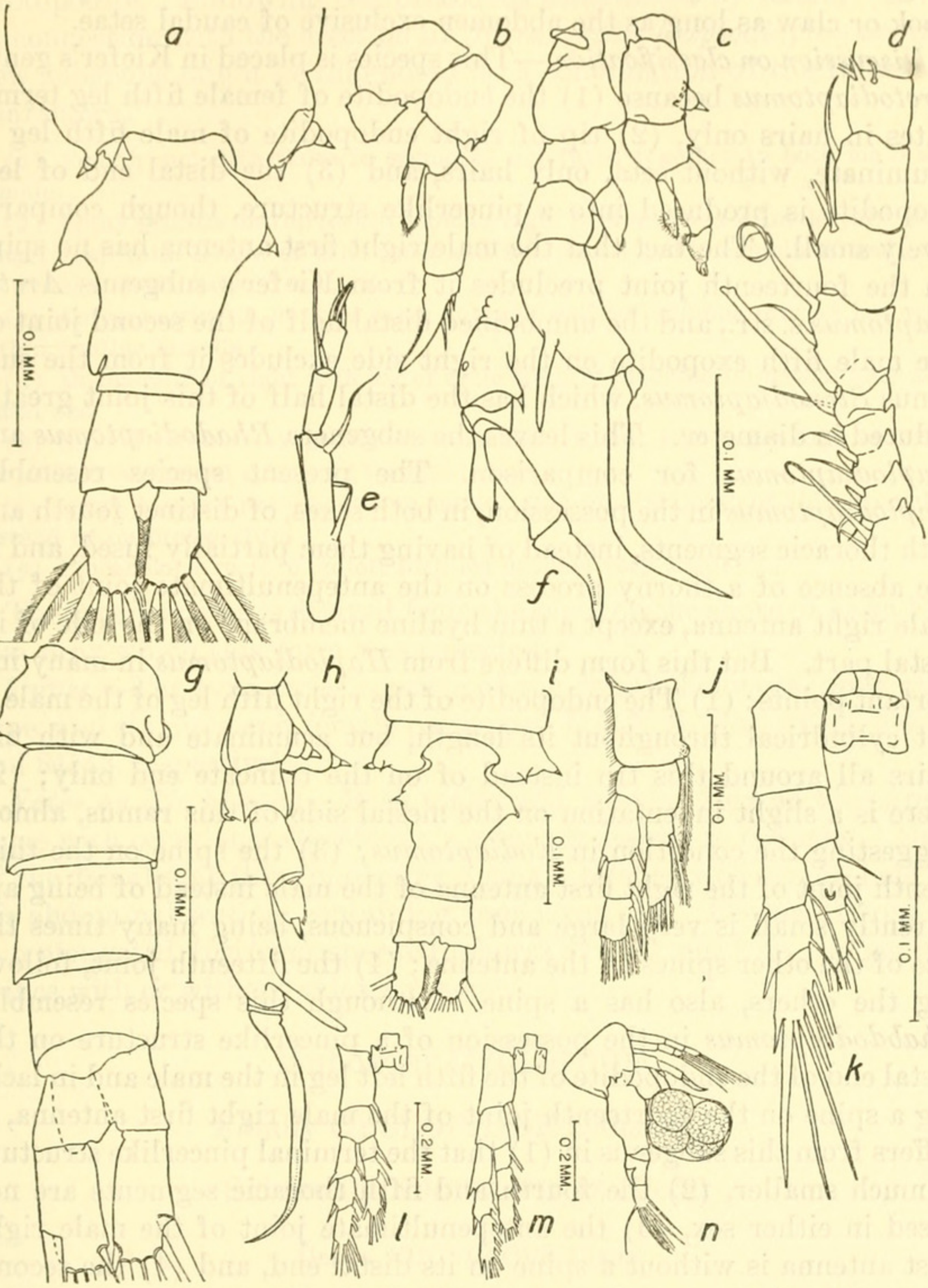

FIGURE 21.—*Arctodiaptomus* (*Pararctodiaptomus*) *hsichowensis*, new species: *a*, Dorsal view of abdomen of female, which has been slightly pressed to one side during mounting on slide (cf. *i* for more common appearance); *b*, fifth rudimentary leg of female; *c*, fifth rudimentary leg of male; *d*, joints 10–17 of first right antenna of male; *e*, last three joints of same; *f*, lateral view of fifth rudimentary legs of female; *g*, ventral view of abdomen of male; *h*, lateral view of fifth pair of rudimentary legs of male; *i*, dorsal view of last thoracic segment and abdomen of female, a commoner form than that shown in *a*; *j*, first swimming leg of female; *k–m*, second to fourth swimming legs of male; *n*, lateral view of posterior end of female showing ovisac with four eggs.

length of right leg from the point of origin to the distal tip of the hook or claw as long as the abdomen exclusive of caudal setae.

Discussion on classification.—This species is placed in Kiefer's genus *Arctodiaptomus* because (1) the endopodite of female fifth leg terminates in hairs only, (2) tip of right endopodite of male fifth leg is acuminate, without seta, only hairs, and (3) the distal end of left exopodite is produced into a pincerlike structure, though comparatively small. The fact that the male right first antenna has no spine on the fourteenth joint precludes it from Kiefer's subgenus *Arctodiaptomus* s. str., and the unmodified distal half of the second joint of the male fifth exopodite on the right side excludes it from the subgenus *Stenodiaptomus*, which has the distal half of this joint greatly reduced in diameter. This leaves the subgenera *Rhadodiaptomus* and *Haplodiaptomus* for comparison. The present species resembles *Haplodiaptomus* in the possession, in both sexes, of distinct fourth and fifth thoracic segments, instead of having them partially fused, and in the absence of a thorny process on the antepenultimate joint of the male right antenna, except a thin hyaline membrane on the side of its distal part. But this form differs from *Haplodiaptomus* in many important points: (1) The endopodite of the right fifth leg of the male is not cylindrical throughout its length, but acuminate and with fine hairs all around this tip instead of on the truncate end only; (2) there is a slight indentation on the mesial side of this ramus, almost suggesting the condition in *Eodiaptomus;* (3) the spine on the thirteenth joint of the right first antenna of the male instead of being apparently small is very large and conspicuous, being many times the size of the other spines on the antenna; (4) the fifteenth joint, following the others, also has a spine. Although this species resembles *Rhabdodiaptomus* in the possession of a pincerlike structure on the distal end of the endopodite of the fifth left leg in the male and in lacking a spine on the fourteenth joint of the male right first antenna, it differs from this subgenus in (1) that the terminal pincerlike structure is much smaller, (2) the fourth and fifth thoracic segments are not fused in either sex, (3) the antepenultimate joint of the male right first antenna is without a spine on its distal end, and (4) the second joint of the right exopodite of the fifth leg in the male has no hyaline appendage.

From both of these two subgenera erected by Kiefer the *Arctodiaptomus* from Erh Hai can be distinguished by the excessive length of the spine on the thirteenth joint of the male right first antenna, the absence of any spiny or other form of process on the second exopodite of the male fifth right leg besides the lateral spine and the terminal claw, and the presence of a hyaline elevation on the mesial aspect of the proximal exopodite of the same ramus instead of one on the second protopodite. Following the precedent established by Kiefer (1939) in connection with the erection of the subgenus *Haplodiaptomus*, this new subgenus might be diagnosed by a combination of the following characters:

(*a*) Fourth and fifth thoracic segments not fused together in both male and female.

(*a*) Spiny process on thirteenth joint of right first antenna of male very long, longer than total length of thirteenth and fourteenth joints combined, and with its distal end dilated and notched.

(*c*) Antepenultimate joint of same antenna without spinous process but with a thin hyaline lamella.

(*d*) Endopodite of right fifth leg of male slightly indented on mesial side near distal end.

(*e*) Second joint of exopodite of same leg without any appendage or process aside from lateral spine and terminal claw.

(*f*) Large hyaline prominence on mesial side of first joint of this exopodite instead of on protopodite.

(*g*) Pincerlike structure on left fifth leg of male very small.

The specific name is derived from the place on the shore of Lake Erh Hai near which this form was collected.

Types.—The type series consists of the female holotype, male allotype, and six male and female paratypes, U.S.N.M. Nos. 84544, 84542, and 84543, respectively.

Notes on life history.—Both males and females feed on blue-green algae with occasional *Cyclotella*, a common diatom in the lake. Most of the females at this time carry a single bilobed egg sac, as long as the abdominal section, containing four large ova. Frequently one or two elongated fusiform spermatophores are attached on the genital orifice with or without ovisacs present.

Suborder CYCLOPOIDA

Family CYCLOPIDAE Dana-Sars

Subfamily EUCYCLOPINAE Kiefer

Genus EUCYCLOPS Claus

EUCYCLOPS SERRULATUS EXTENSUS, new subspecies

FIGURE 22

This cyclopid, which occurs in Lake Erh Hai every month throughout the year, was collected with a half-meter plankton net hauled from east to west across the lake in 1945. It is very similar to G. O. Sars's (1918) *Leptocyclops agilis* (Koch), to Gurney's (1933) *Cyclops agilis* Koch, Sars, and to Kiefer's (1929) *Eucyclops serrulatus* (Fischer) but shows certain minor differences from the descriptions given by these authors. Kiefer included the first two names as synonyms of *E. serrulatus* (Fischer) in his discussion on *Cyclops* (1939). Since "the correct name for this species cannot now be determined, and it is simply a matter of opinion" (Gurney, 1933, p. 99), and since Kiefer's description of material from North India and Tibet at the other end of the Tibetan Plateau has been used for comparison with this material, it is more convenient to adopt his nomenclature. The specimens from Yunnan, China, have been designated as a new subspecies for the following reasons:

(1) The ovisac in the female is smaller than in *E. s. serrulatus*, its posterior edge reaching the middle of the anal segment instead of the end of the furcal rami (cf. fig. 22, *g*, *l*).

(2) The individual segments of the abdomen are longer than those of the Tibetan species.

(3) The anal segment is longer, in both male and female, than the preanal segment, instead of shorter or equal to it. It is true that in fixed material the degree of telescoping of the segments varies, depending upon the degree of contraction of the abdominal muscles at the moment of killing and fixing, but by examining the length of the chitinous shell in transparent or semitransparent specimens this difficulty can be overcome. In comparing the measurements so obtained, the anal segment of the Yunnan material was found to be longer than the preanal segment.

(4) The second (or postgenital) segment in the male is longer than the innermost spine of the sixth (or clasping) foot (see fig. 22, *j*, *k*).

(5) In the third and fourth pairs of swimming legs the skeletal plate that joins the right leg with the left is armed with long hairs on the ventral surface of the right and left sides and extending to well beyond the caudal margin, but in the North Indian and Tibetan specimens of *E. s. serrulatus* the free edge of this plate has very short and evenly spaced hairs (cf. fig. 22, *i*, *n*, *o*, and Kiefer, 1939, p. 137, fig. 14*f*.).

Adult female: Total length 1.05–1.23 mm., length of cephalothorax, abdomen, and furca 116 : 80 : 21; maximum width at about the middle of cephalothorax 0.306 that of total length. Genital segment as long as the total lengths of the next two segments, anterior end of genital segment expanded to about the same width as the last thoracic segment, posterior portion greatly reduced; anal segment slightly longer than preanal (9: 7–8), anal plate semilunar in outline with smooth border, anal slit bordered with spiniform teeth increasing in length posteriorly; posterior border with 10 to 12 strong spinelike indentations on its dorsal and ventral sides. Outline of furcal rami slightly curved on both lateral and medial sides, furcal length 5.5 to 5.7 times its width; medial edge smooth, outer edge armed with sawlike teeth throughout its length from the proximal end caudally to the origin of the lateral seta, those near caudal end slightly larger, and those near the base of the ramus smaller and more ventrally placed, generally 30–35 spiniform teeth on each side (fig. 22, *a*).

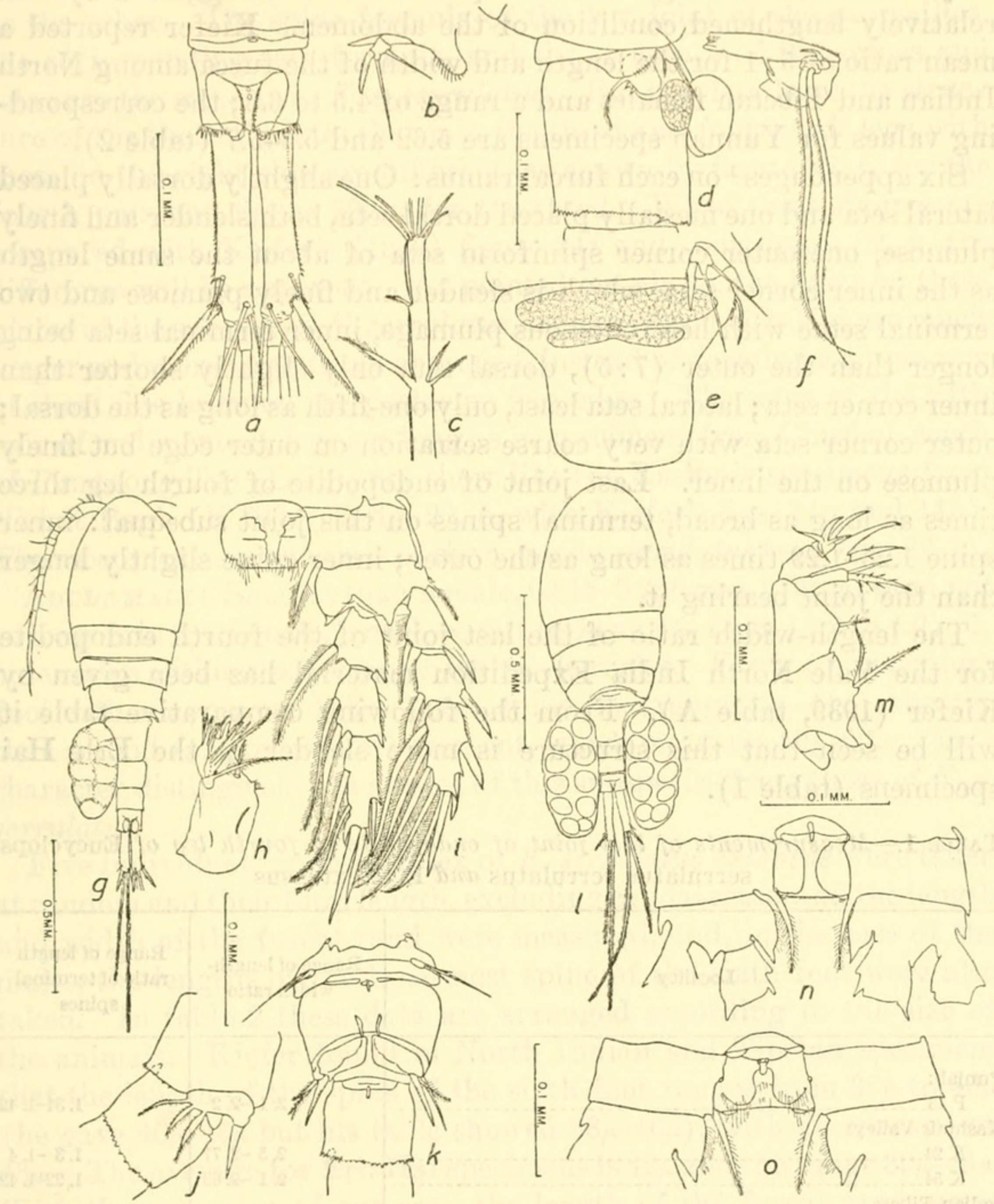

FIGURE 22.—*Eucylcops serrulatus extensus*, new subspecies: *a*, Furcal rami and last abdominal (anal) segment of female, dorsal view; *b*, fifth leg of female; *c*, last joint of first antenna of female; *d*, genital segment of female, lateral view showing spermatophores and fifth and sixth legs; *e*, ventral view of genital segment of female showing receptaculum seminis; *f*, mandible of female showing elongated setae; *g*, dorsal view of female with one ovisac and one antenna removed; *h*, maxilla of female; *i*, fourth leg of female; *j*, genital segment of male showing sixth leg, lateral view; *k*, same, ventral view; *l*, dorsal view of *E. s. serrulatus* from Leh, Ladak (L 13); *m*, anterior maxilliped of female; *n*, base of fourth pair of legs of *E. s. serrulatus* (Fischer) from Kashmir, Yale North India Expedition, station K 35; *o*, same of *E. s. extensus* from Lake Erh Hai.

Gurney (1933) reported the cephalothoracic, abdominal, and furcal length as 90:40:20; the corresponding ratio for the specimens from Erh Hai is 116:60:21. In other words, the cephalothorax in *E. s. serrulatus* is 2.25 as long as the abdomen, while in *E. s. extensus* it is only 1.93 times as long. The subspecific name is suggested by this relatively lengthened condition of the abdomen. Kiefer reported a mean ratio of 5:1 for the length and width of the furca among North Indian and Tibetan females and a range of 4.5 to 6.3; the corresponding values for Yunnan specimens are 5.62 and 5.5–5.7 (table 2).

Six appendages [1] on each furcal ramus: One slightly dorsally placed lateral seta and one mesially placed dorsal seta, both slender and finely plumose, one outer corner spiniform seta of about the same length as the inner corner seta, which is slender and finely plumose and two terminal setae with heteronomous plumage, inner terminal seta being longer than the outer (7:5), dorsal seta only slightly shorter than inner corner seta; lateral seta least, only one-fifth as long as the dorsal; outer corner seta with very coarse serration on outer edge but finely plumose on the inner. Last joint of endopodite of fourth leg three times as long as broad, terminal spines on this joint subequal: inner spine 1.23–1.29 times as long as the outer; inner spine slightly longer than the joint bearing it.

The length-width ratio of the last joint of the fourth endopodite for the Yale North India Expedition material has been given by Kiefer (1939, table A). From the following comparative table it will be seen that this structure is more slender in the Erh Hai specimens (table 1).

TABLE 1.—*Measurements of last joint of endopodite of fourth leg of* Eucyclops serrulatus serrulatus *and* E. s. extensus

Locality	Range of length-width ratio	Range of length ratio of terminal spines
Punjab:		
P 13	2.1 -2.2	1.31-1.42
Kashmir Valley:		
K 24	2.5 -2.77	1.3 -1.4
K 54	2.1 -2.63	1.22-1.42
Indian Tibet:		
L 13	2.4 -2.5	1.48-1.54
L 16	2.44	1.42-1.54
L 71a	2.54-2.56	1.45
L 72	2.42-2.5	1.62
L 72a	2.5 -2.63	1.57-1.63
Erh Hai	3.0 -3.17	1.24-1.29

[1] In this paper the names for the caudal seta used by Harding (1942) have been adopted, because they are more specific. The correspondence between his names and those of the continental workers follows: Outer corner seta=seta of the outer edge; inner corner seta=innermost apical seta; inner and outer terminal setae=two middle setae.

It will also be seen from table 1 that with the exception of one case (K 54) the difference between the lengths of the two terminal spines is greater among North Indian and Tibetan specimens. The specimens from Erh Hai show a ratio of 1.24–1.29 only; among Kiefer's material one spine may be one-third or one-half again as long as the other. The spine formula of the last joint of the exopodites, the corresponding seta formula, and the structure of the spines and setae are the same as in *E. s. serrulatus.* But the details of the structure of the skeletal plates that join the third and fourth left legs with those on the right side are different, as shown by figure 22, *i*, for the fourth pair and figure 22, *o*, for the third. When these figures are compared with Kiefer's (1939) figure 14*f* and our figure 22, *n*, the difference will be apparent. As pointed out above, the hairs on these plates of the subspecies *E. serrulatus extensus* from Erh Hai are much longer and more irregularly arranged, instead of forming a single row of short fine hairs on the posterior free edge. The setae of the fifth pair of rudimentary legs are long as in specimens from Chushol, south of Panggong Tso (L 72), not short like the Kashmir specimens from Nishat Bagh (K 24) (cf. fig. 22, *b*, with Kiefer's figs. 14*g* and 14*h*). The receptaculum seminis is of the common *serrulatus* type (fig. 22, *e*).

Adult male: Smaller than female, 0.815–0.900 mm.; furcal rami not so long as in the female, length-width ratio varies from (4.2 to 4.9) : 1, outer edge without serration or lateral denticles. Sixth (or clasping) foot with one spine and three setae, spine 42μ (range 39μ–44μ), shorter than second (or postgenital) segment, which measures 59μ–60μ. This character distinguishes the males of this subspecies from those of *E. s. serrulatus.*

Five individuals from each sex of *E. serrulatus extensus* were taken at random and their total length, excluding caudal setae, and the length and width of the furcal rami were measured, and, in the case of the males, the lengths of the innermost spine of the sixth foot were also taken. In table 2 these data are arranged according to the size of the animals. Kiefer found in North Indian and Tibetan specimens that the length of the spine of the sixth foot ranges from 38μ to 46μ (he gave 40μ–46μ but his table showed 38μ–46μ), with an average of 43μ. The average for Erh Hai specimens is 42μ and the range 39μ–44μ. With the exception of one case, the length of the furcal rami seems to increase with the increase in total length of the whole animal.

Although the structure of the mandible of cyclopoids is used in the classification of the group into families, no drawing of this organ in the *serrulatus* group of species is included in the literature. In figure 22, *f*, it is shown for the first time for *E. serrulatus.* The reduced mandibular palp carries three appendages, one very short and two very long setae. The free ends of the long setae nearly reach the base of the first swimming leg.

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TABLE 2.—*Measurements of five males and five females of* Eucyclops serrulatus extensus

MALES

Length	Furcal rami			Sixth leg	Second abdominal segment
	Length	Width	L-W ratio		
900μ	90.6μ	18.5μ	4.9:1	44μ	59μ
865μ	73.5μ	18.5μ	4.2:1	43μ	59μ
847μ	85μ	18.5μ	4.6:1	44μ	60μ
840μ	85μ	18.5μ	4.6:1	41μ	60μ
815μ	78μ	18.5μ	4.2:1	39μ	59μ
Average			4.5:1	42μ	

FEMALES

Length	Furcal rami length	Width	L-W ratio	Sixth leg	Second abdominal segment
1,232μ	138	24	5.7:1		
1,155μ	138	24	5.7:1		
1,140μ	137	24.1	5.7:1		
1,078μ	133	24	5.5:1		
1,067μ	133	24	5.5:1		
Average			5.62:1		

Specimens collected from Erh Hai in March are sexually mature; the females carry either a pair of ovoidal spermatophores, which are quite small, one-fifth the size of seminal receptacles, on the ventral side against the opening of the receptaculum seminis (fig. 22, *d*), or a pair of ovisacs on the dorsal side lateral to the abdomen, or both. Very often females carrying empty shells of the ovisacs with their contents discharged are observed among these eucyclopids, indicating that spawning has just taken place. Specimens collected by the Yale North India Expedition at Kashmir in April contain a number of immature *E. serrulatus* and some nauplii, while the mature females have shed or are shedding the contents of their ovisacs. This may indicate that this species breeds at nearly the same time in these two places.

Types.—The type series consists of the female holotype, male allotype, and male and female paratypes, U.S.N.M. Nos. 84541, 84539, and 84540, respectively.

Genus TROPOCYCLOPS Kiefer

TROPOCYCLOPS BREVIRAMUS, new species

FIGURE 23

This species is the smallest cyclopoid found in the lake. It is similar to *Tropocyclops prasinus* (S. Fischer) but is differentiated from it as follows: (1) The furcal rami are only twice as long as wide; (2) the terminal setae of the last joint of the endopodite of the fourth leg are not elongated; the inner longer seta is only 1.36 times as long as the joint itself, which is 3.7 times as long as broad, while Kiefer (1931, p. 507) gives 2.3–2.6, average 2.4–2.5 : 1 for this ratio; and (3) the seminal receptacle has a different structure from Kiefer's figure (1929b, p. 40, fig. 13).

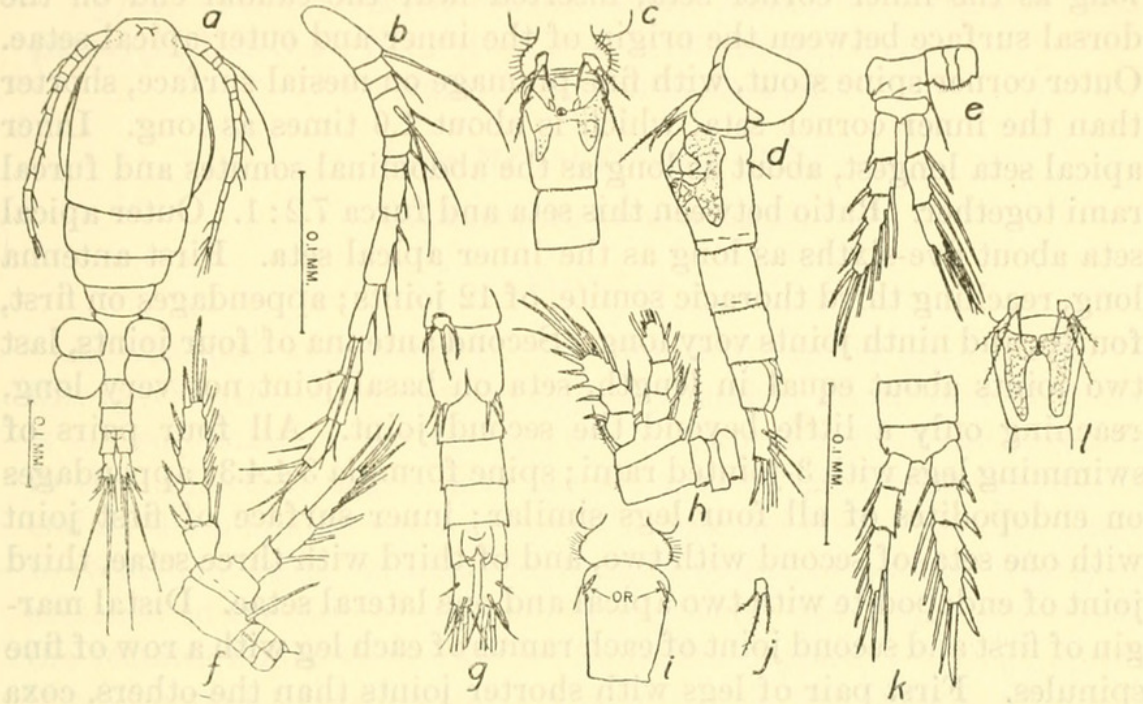

FIGURE 23.—*Tropocyclops breviramus*, new species: *a*, Female, dorsal view; *b*, first antenna of female; *c*, genital segment of female, ventral view; *d*, same, lateral view; *e*, fourth leg of female; *f*, third leg of female; *g*, abdomen of male, dorsal view; *h*, first leg of female; *i*, genital segment of female, dorsal view; *j*, fifth rudimentary leg of female; *k*, second leg of female; *l*, genital segment of female, ventral view.

Description.—FEMALE: General body appearance similar to *Eucyclops serrulatus extensus* described above, but only one-half its size; total length, executive of caudal setae, 573μ. Body flattened; anterior end of cephalothorax slightly truncate, fifth thoracic somite very small, as wide as the anterior portion of the genital segment, with rounded lateral edge armed with evenly spaced row of long stiff hairs (fig. 23, *a*, *c*). Abdomen consisting of four somites. Genital somite longer than broad, as long as the next two somites together, anterior portion slightly broader than the posterior; two ovisacs, each with two large ova, attached on the dorsal side through an elongated oval-shaped orifice near the anterior end of the somite (OR in fig. 23, *i*). Seminal receptacle in two lobes as shown in figure 23, *c*, *d*. Figure 23, *l*, shows the seminal receptacle of another individual. In both cases the organ is apparently unlike Kiefer's description, which gives a larger anterior portion snakelike in form and a smaller posterior portion, which is curved dorsally on the sides. Here the division into two lateral lobes is very obvious. Second to last abdominal segments equal in size, posterior margin of each with a row of fine teeth. Furcal rami 2.25 times as long as wide, both lateral and mesial margin hairless, no oblique row of spinules from the base of the lateral seta running mesially on the dorsal surface. Lateral seta large, about half the length of the outer corner spine, inserted at about the middle of the ramus on the dorsal surface. Dorsal seta long and slender, about as long as the inner corner seta, inserted near the caudal end on the dorsal surface between the origin of the inner and outer apical setae. Outer corner spine stout, with fine plumage on mesial surface, shorter than the inner corner seta, which is about 1.6 times as long. Inner apical seta longest, about as long as the abdominal somites and furcal rami together. Ratio between this seta and furca 7.2:1. Outer apical seta about five-sixths as long as the inner apical seta. First antenna long, reaching third thoracic somite, of 12 joints; appendages on first, fourth, and ninth joints very long. Second antenna of four joints, last two joints about equal in length, seta on basal joint not very long, reaching only a little beyond the second joint. All four pairs of swimming legs with 3-jointed rami; spine formula 3.4.4.3; appendages on endopodites of all four legs similar; inner surface of first joint with one seta, of second with two, and of third with three setae, third joint of endopodite with two apical and one lateral setae. Distal margin of first and second joint of each ramus of each leg with a row of fine spinules. First pair of legs with shorter joints than the others, coxa and basis (first and second protopodite) with long stout setae, outer fringe of coxa with three or four stiff hairs, setae on all joints of about the same length; first and second joints of exopodite with one mesial seta and one lateral spine each; third joint with three lateral spines and five setae; uniting lamella between coxa with concave, smooth margin on the middle third of its posterior border. Leg 2 longer than leg 1; outer edge of second joint of endopodite bordered with fine hairs (fig. 23, *k*); third joint of exopodite with four spines and five setae; Leg 3 with similar number of spines and setae as leg 2; uniting lamella with a row of spinules across the middle of its ventral surface, leaving its posterior border smooth (fig. 23, *f*). Third joint of endopodite of leg 4 more than three times (3.7) as long as wide, two terminal setae unequal, inner one twice as long as the outer, slightly curved, uniting lamella with convex posterior border covered with a row of spinules. Fifth rudimentary leg with one single plate carrying three appendages: median one thickest, more like a spine than a bristle, lateral seta shortest, seta between these two longest; fine hairs present on all three appendages (fig. 23, *j*).

Male: Slightly smaller than female. First antenna modified, short, and stout. Leg 5 as in female but with broader basal plate. Abdomen with five somites. Sixth leg on posterior margin of genital somite instead of being on the anterior half of this somite as in female (fig. 23, *g*).

This species is fairly abundant. Specimens collected in December are all mature; the females are either carrying ovisacs or just through with spawning, as evidenced by the remains of the outer shell of the ovisacs.

Types.—The type series consists of the female holotype and female paratype, U.S.N.M. Nos. 84537 and 84538, respectively.

Subfamily CYCLOPINAE Kiefer

Genus MEGACYCLOPS Kiefer

MEGACYCLOPS VIRIDIS (Jurine)

FIGURE 24

All the specimens found in Erh Hai in November are females. As this species, the commonest cyclopoid found in all manner of waters, is not euplanktonic but belongs to the littoral region, the specimens in this collection might have been caught at the beginning and the end as the plankton net was towed across the lake. All the females were without eggs, but many had empty ovisac, or part of ovisac, still attached to the side of the genital segment. There is a chance that the females might have wandered offshore to spawn, or after spawning they went to open water. The males, on the other hand, stayed among weeds near the margin of the lake and were not caught.

Compared with specimens collected by Hutchinson in Kashmir and Tibet (K 35 and L 16), the furcal rami seem to be longer in absolute length, but their relative length in terms of total body length is not significantly different. This is shown in columns 1 to 3 in table 3, where the measurements from five individuals taken at random are compared with the measurements made on five females by Kiefer (1939). The wide range of variation of this percentage value—92 to 106 for Yunnan material, 97 to 118.5 for Kashmir, and 78.5 to 104 for Ladak—is, as pointed out by previous workers, due to the difference in contraction of the preserved specimens. But this does not apply to the measurement of the length and width of the furca which is a single segment enclosed in a chitinous shell. In column 4 the ratio between length and width is compared with Kiefer's observation on Indian and Tibetan specimens. The Yunnan material seems to be more like Tibetan (Ladak) than Indian. *M. viridis* from Erh Hai has longer inner and outer corner setae on the posterior end of the furca. From columns 5 and 6 it will be seen that Kiefer's material has inner corner seta 58 percent and outer corner seta 57–60 percent as long as our specimens. But in both groups of animals the inner corner seta is a little over twice as long as the outer. The Kashmir material seems to have longer and thinner furca than Ladak and Yunnan specimens, while the last endopodite segment of the fourth leg of the latter is slenderer than in Kashmir animals. These are suggested by columns 4 and 8, respectively.

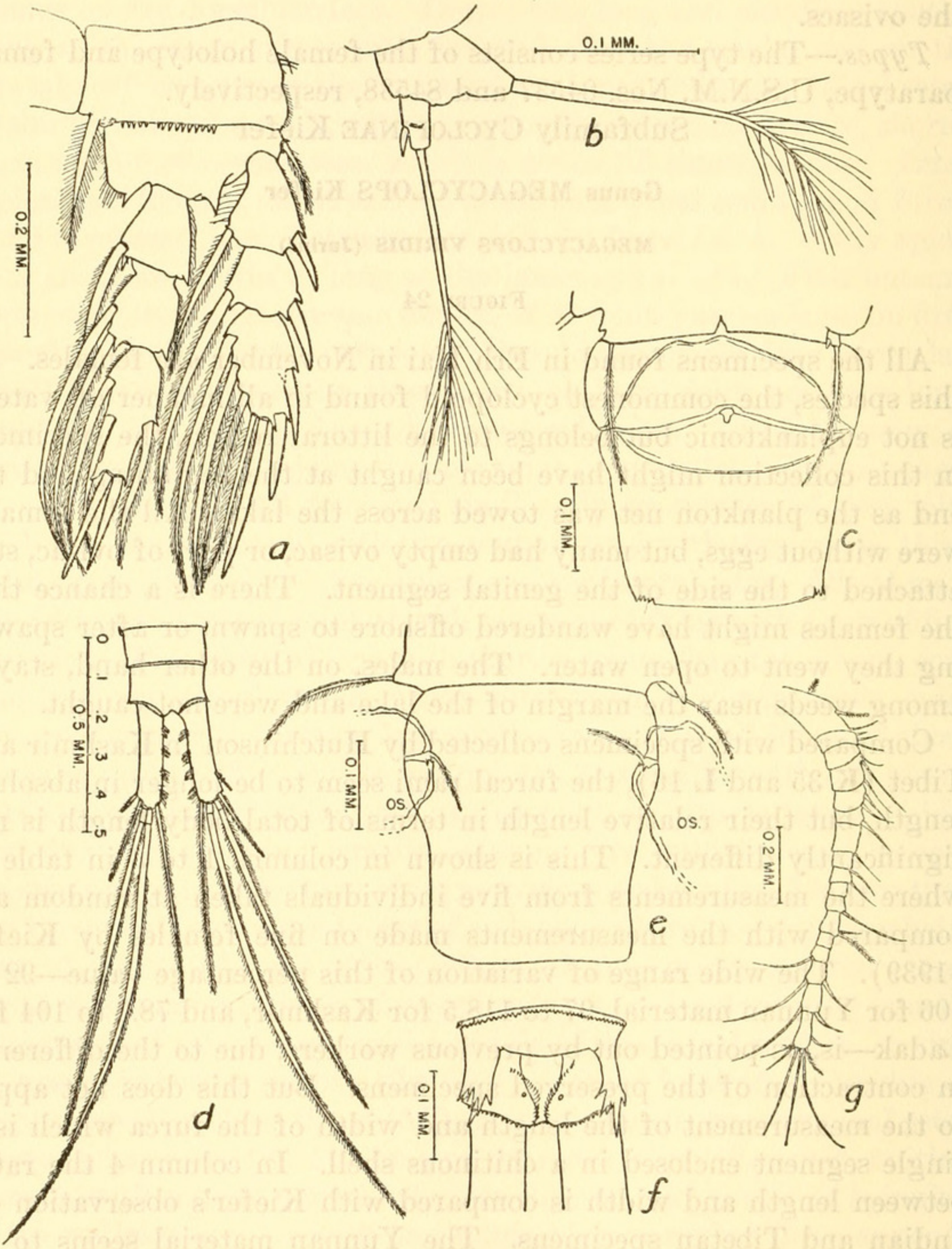

FIGURE 24.—*Megacyclops viridis* (Jurine), female: *a*, Fourth swimming leg; *b*, fifth rudimentary leg; *c*, genital segment, ventral view; *d*, last two segments and furcal rami with caudal setae, ventral view; *e*, genital segment, dorsal view showing part of empty shell of ovisacs (OS); *f*, anal segment, dorsal view; *g*, first antenna.

The subspecies *M. viridis acutulus* was named by Kiefer (1930) for the Sunda Expedition material from Java because the hairs on the inner border of the furcal rami are not evenly distributed but in groups as in *Cyclops venustus*—according to Klie (1928) they are in three groups in *C. venustus*—and the structure of the spine on the distal joint of the fifth rudimentary leg is large, smooth or with fine spinules, and like that in *Cyclops strenuus*. Later Kiefer (1934) added some measurements made on two females and stated that the spine on the mesial surface of the distal joint of the fifth leg was very conspicuous, separated from the joint by a suture and armed with featherlike spinules. The specimens from Erh Hai are like this subspecies in that the hairs on the inner surface of the furcal rami are not evenly distributed but in groups of four (fig. 24, *d*), not three. However, the spine of the fifth leg is not separated by a suture from the distal joint which carries it and has no hair or spiny armor. From the measurements Kiefer gave, which are appended at the end of table 3, it will be noted that the length of the inner and outer corner setae on the caudal ends of the furcal rami are similar to the Erh Hai specimens and, like them, are much longer than in the Indian or Tibetan material. But on the whole this *Megacyclops* is not identical with Kiefer's subspecies *M. viridis acutulus* from Java. As it is also different in many quantitative aspects of its characters, a summary of the measurements which are often used for taxonomic purposes are presented in table 4 so that material from China and other parts of the Orient may be compared with this form in the future.

TABLE 3.—*Measurements of* Megacyclops viridis *and* M. viridis acutulus

	Body length	Furcal ramus			Caudal setae			Third endopodite of fourth leg
		Length	Percent of body length	Length / Width	Inner corner	Outer corner	Inner / Outer	Length/ Width
	Mm.							
Erh Hai, Yunnan	2.55	260μ	102	4.13	506μ	237μ	2.14	2.60
	2.26	240μ	106	3.67	520μ	240μ	2.16	2.61
	2.48	229μ	92	3.81	520μ	240μ	2.16	2.84
	2.60	247μ	95	3.67	520μ	240μ	2.16	2.73
	2.48	240μ	96	4.00	480μ	240μ	2.00	2.53
Ladak, Kashmir	1.9	210μ	110	4.66	278μ	131μ	2.12	2.43
	2.0	237μ	118.5	4.74	304μ	136μ	2.23	2.50
	2.2	213μ	97	4.44	300μ	140μ	2.14	2.31
	1.86	193μ	104	3.71	320μ	157μ	2.04	2.61
	2.0	157μ	78.5	3.74	268μ	131μ	2.05	------------
Java	2.3	225μ	98	3.88	500μ	220μ	2.27	2.25
	------	226μ	------------	3.58	------------	------------	------------	------------

TABLE 4.—*Measurements of* Megacyclops viridis (*Jurine*) *from Erh Hai*

Measurement	Mean, with standard error [1]	Range
Total length, exclusive of caudal setae	2.48±0.071 mm	2.26–2.64 mm.
Furcal rami, length	243±4.556μ	229–260μ.
Furca, percent of total length	9.8±1.13 percent	92–106 percent.
Furca, Length: Width	3.86±0.081	3.67–4.13.
Inner corner caudal seta:		
Length	509±6.965μ	480–520μ.
Percent of total length	20.64±2.92 percent	19.4–23.0 percent.
Inner terminal caudal seta:		
Length	1158±18.38μ	1120–1232μ.
Percent of total length	46.78±7.73 percent	44.6–49.1 percent.
Outer terminal caudal seta:		
Length	872±21.61μ	800–940μ.
Percent of total length	35.24±5.73 percent	33.8–36.9 percent.
Outer corner caudal seta:		
Length	239.3±0.39μ	237–240 μ.
Percent of total length	9.7±0.221 percent	9.2–10.6 percent.

[1] Figures after ± indicate standard errors of the means.

Order BRANCHIURA

Family ARGULIDAE O. F. Müller

Genus ARGULUS O. F. Müller

ARGULUS JAPONICUS Thiele

FIGURES 25–30

Among the plankton collected in one of the hauls made across Lake Erh Hai, Yunnan, China, on November 28, 1945, was a large number of argulids. In the course of determining their systematic position it was found that the taxonomy of the species *Argulus japonicus* and *A. trilineatus*, which this plankton material resembles closely, was in a confused condition. In the first place, descriptions of these species by various authors differ widely, and the question of how much should be accepted as variation within a species and whether reclassification should be attempted needs to be worked out. In the second place, the question of synonymy incolving *A. japonicus* and *A. trilineatus*, the chief bone of contention between two American workers, both examining specimens from the same collection at the National Museum in Washington, needs reexamination. It may serve some useful purpose, particularly to students of copepods and fish culture, to summarize in one place the more important points of the confused situation in the literature as a part of this study of argulids from Lake Erh Hai and to note the main characters of the specimens found in this part of the world, so that future workers may use them for comparison.

Argulus japonicus was first described by Thiele (1900) from a single female from Yeddo, Japan. His description consisted of a short note on the outline of the carapace and abdomen and the relative lengths of the legs, but no figure was published. In his monograph on North American argulids, with a bibliography of the group and a systematic review of all the known species, Wilson (1903) translated Thiele's note but added no further information of the species. In 1904 Thiele (1904) published the first detailed description of this species, based on both male and female specimens from goldfish in Yokohama, and supplied five figures of its appendages. This should be the basis of specific determination of *A. japonicus*. In 1913 Nakazawa published a description of this species in Japanese. A long while later, Tokioka (1936a) gave a detailed description with two figures (ventral view of a female and of the three posterior legs of the male) of specimens from Japan where they were "commonest . . . found in any season on goldfish and also on *Cyprinus carpio* (Linné), *Carassius carassius* (Linné), and many other freshwater fishes." His account added the following features: (1) Dorsal ridge branched at the anterior end, (2) coxa of the second leg of male with a spine near the base of anterior margin, (3) center of posterior margin of rounded, scaled, area on maxilla (hind maxilla of Thiele) provided with two setae, which were figured in Thiele's drawing (fig. 95) but not mentioned, (4) flagella on

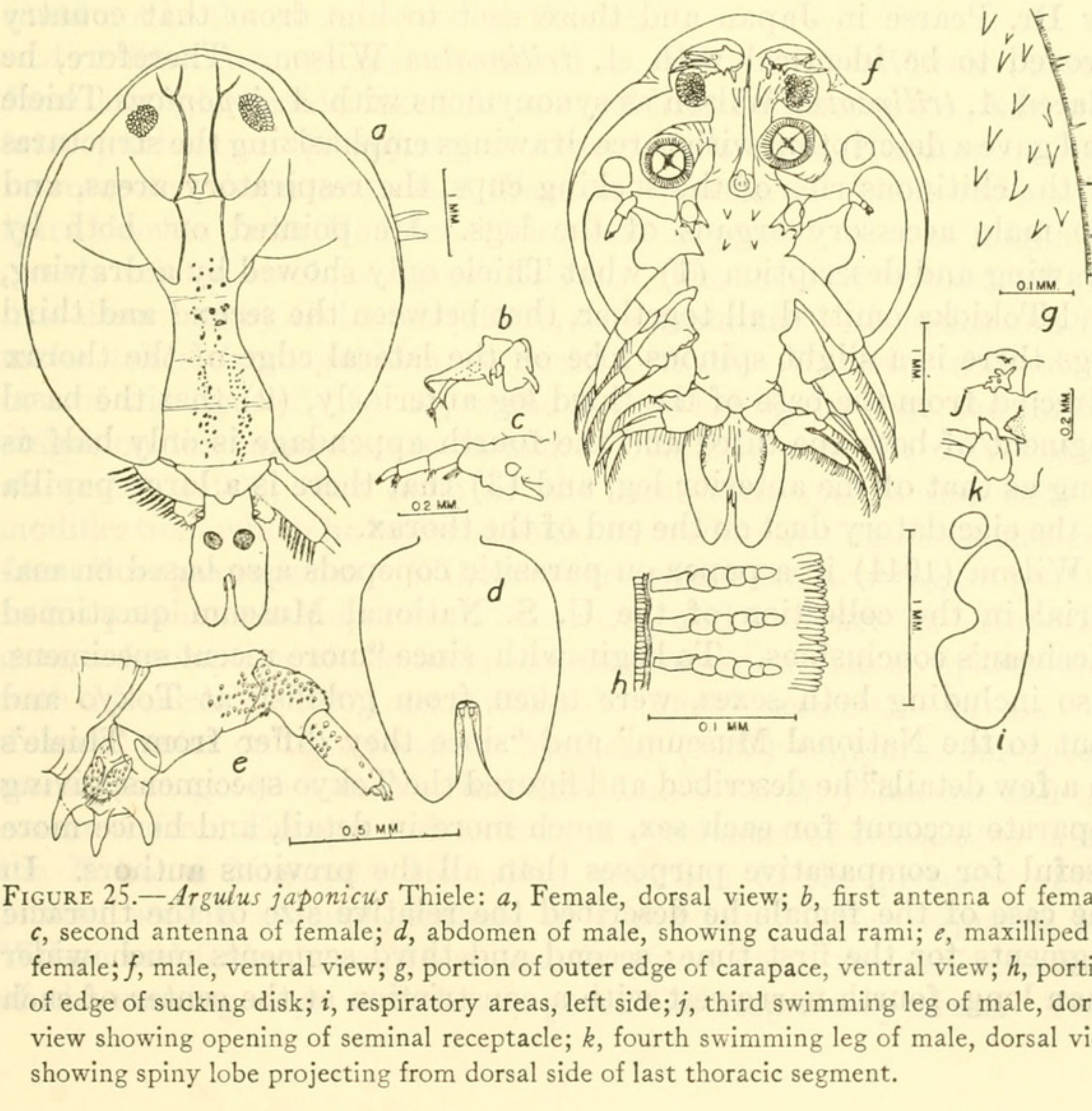

FIGURE 25.—*Argulus japonicus* Thiele: *a*, Female, dorsal view; *b*, first antenna of female; *c*, second antenna of female; *d*, abdomen of male, showing caudal rami; *e*, maxilliped of female; *f*, male, ventral view; *g*, portion of outer edge of carapace, ventral view; *h*, portion of edge of sucking disk; *i*, respiratory areas, left side; *j*, third swimming leg of male, dorsal view showing opening of seminal receptacle; *k*, fourth swimming leg of male, dorsal view showing spiny lobe projecting from dorsal side of last thoracic segment.

first and second swimming legs, reaching the base of their coxa, and (5) "posterior margin distal to the capsule with a few plumose setae." The capsule apparently refers to the semen capsule on the dorsal surface of the third leg in the male, though not shown in his figures.

In a footnote Tokioka mentioned the fact that Dr. Wilson in a personal note to Professor Komai stated that he had examined some specimens of *Argulus* collected from goldfish in Tokyo, which showed difference in several features from Thiele's original description, and expressed in this footnote the opinion that all the differences alleged by Dr. Wilson were "nothing but individual or rather seasonal variations . . . The material of this group in my hand which have been obtained from various seasons and from various localities show a fairly wide range of variation in all respects he mentioned." But unfortunately, though Tokioka had at his disposal large quantities of this species and made (1936b) observations on larval development and metamorphosis, he gave no critical comparison or statistical study of the variations in question. Had this been done, there might be less confusion in the taxonomy of this species.

In his review of the genus *Argulus* in the collection of the U. S. National Museum, Meehean (1940) stated that specimens collected by Dr. Pearse in Japan and those sent to him from that country proved to be identical with *A. trilineatus* Wilson. Therefore, he placed *A. trilineatus* Wilson as synonymous with *A. japonicus* Thiele and gave a description with three drawings emphasizing the structures of the chitinous ribs of the sucking cups, the respiratory areas, and the male accessory organs of the legs. He pointed out both by drawing and description (1) what Thiele only showed by a drawing, and Tokioka omitted all together, that between the second and third legs there is a slight spinous lobe on the lateral edge of the thorax directed from the base of the third leg anteriorly, (2) that the basal segment of both the third and the fourth appendage is only half as long as that of the anterior leg, and (3) that there is a large papilla at the ejaculatory duct on the end of the thorax.

Wilson (1944) in a paper on parasitic copepods also based on material in the collection of the U. S. National Museum questioned Meehean's conclusions. To begin with, since "more recent specimens, also including both sexes, were taken from goldfish at Tokyo and sent to the National Museum" and "since they differ from Thiele's in a few details" he described and figured the Tokyo specimens, giving separate account for each sex, much more in detail, and hence more useful for comparative purposes than all the previous authors. In the case of the female he described the relative size of the thoracic segments for the first time: second and third segments much wider than long, fourth narrowest with a constriction at the center of each lateral margin. The anal sinus was described as narrow and V-shaped, less than one-fourth of the abdomen length, instead of deep (Meehean) or cut almost to the center (Thiele and Tokioka). The second antenna was both figured and described as having six joints, basal one large, terminal five much smaller and subequal, instead of Thiele's 4-jointed antenna with a spine-covered wart on the two proximal joints and with the third comparatively short and fourth long. Both Tokioka and Meehean said nothing about the number of joints though their figures indicated a 4-jointed second antenna. Three long, acuminate posterior spines were described on the raised knob of the basal plate of the maxilliped (Thiele's hind maxilla), while Tokioka said there were two, and Thiele said nothing but indicated two setae on that structure in his figure 95. But the most outstanding feature of difference is perhaps the nine small segments, like a row of beads, described as forming the chitinous rib supporting the margin of the sucking cup (see also his fig. 69), for all the other authors agreed in describing one long basal and five distal (5 to 7, according to Meehean) segments. Wilson's description of the male showed no material difference from the other writers. It will be noticed that in view of these last four points of difference Wilson's *A. japonicus* obviously could not be the same species as Thiele's.

A. trilineatus was first described as *trilineata* by Wilson (1904), from a single female taken from a goldfish in Macon, Ga., but in a later publication (1916) on another female from Henderson, Ky., he corrected the name to *A. trilineatus.* Cockerell (1926) reported a third female from Boulder, Colo., and suggested that it might be closely related to *A. coregoni* Thorell. The male of *trilineatus* was first described by Guberlet (1928), who examined both males and females taken from goldfish at Seattle, Wash. Guberlet showed in one of his figures (fig. 1), without mentioning it, that the dorsal ridges on the carapace are forked. This is in contrast to Wilson's statement (1902) that none of the American species has such a modification, which he believed could be used to distinguish American from European species. Wilson reiterated the character again (1944) in his posthumous paper both in writing and in figure 79. Guberlet gave a description of the male accessory organs which compares well with Meehean's (1937) and Wilson's (1944) accounts. In his additional notes on *A. trilineatus* Meehean (1937) compared his specimens from goldfish at Natchitoches, La., with *A. foliaceus* and *A. coregoni* from Europe and with type specimens of *trilineatus* from the National Museum. He called attention to the presence of 4-jointed second antenna, instead of the 3-jointed ones reported by Wilson and Guberlet, and clarified the structure of the chitinous ribs of the sucking cups and the shape of the respiratory areas. Two contributions from this paper are noteworthy. He pointed out (1) the branching of the anterior end of the dorsal ridge on the carapace, and how it could be made clear, and (2) the striking similarity between *A. trilineatus* and *A. foliaceus* in all details of characters except the slight difference in the armature of the second leg of the male. He suggested that the American species was derived from European origin. Three years later, Meehean (1940) decided that the specimens from Louisiana as well as those of Guberlet and Wilson were referable to *A. japonicus*. He based this conclusion on a comparative study of specimens of *A. japonicus* that Wilson lent him and examples of the same species from Tokioka and Watanabe in Japan and A. S. Pearse's material. It is apparent that *A. japonicus* from Japan and the United States is a very variable form. The difference between extreme specimens appears greater than that between this species and *A. foliaceus*, a supposed indigenous European form. Wilson (1944) maintained the validity of his species *A. trilineatus* and referred to it more specimens that Meehean described in 1937 and 1940 as *A. japonicus*. He redescribed the male, the allotype of *A. trilineatus*, and emphasized the following features:

(1) Pattern of dorsal ridge (or groove) on the carapace, which is not forked anteriorly.

(2) Length of the posterior lobe of the carapace, which reaches only to the anterior margin of the fourth thoracic segment in the male, but well beyond the base of the abdomen in the female.

(3) Details of the second antenna, which has only one large basal joint and two distal ones instead of being 4-jointed as in Thiele's or 6-jointed as in Wilson's own description of *A. japonicus*.

(4) Supporting ribs of the sucking cups are in four segments.

(5) Male maxilliped (Thiele's hind maxilla) has its distal joint divided longitudinally.

(6) Caudal rami subbasal in the anal sinus, which ends anteriorly in a triangle.

(7) Absence of flagella on the first and second legs, so resembling Wilson's *A. japonicus* but differing from the specimens of Tokioka, Guberlet, and Meehean, who described such flagella.

"The sum total of these differences is more than sufficient to overcome any similarity that may be found in the pattern of the respiratory area" and would preclude this form's being placed under *A. japonicus*.

Through the courtesy of the U. S. National Museum, three females, one male, and one immature specimen of *A. japonicus* have been sent to us for comparison. They are from a lot of 75 argulids and labeled "#69835, skin, goldfish, Tokyo, Japan, June 10, 1929, Taku Komai Coll., Id. C. B. W." These differ from Wilson's own description of this species (1944) in the following characters:

(1) The last (fourth) thoracic segment is without a constriction at the center of each lateral margin.

(2) Anal sinus is not V-shaped but depends upon how the caudal lobes contracted and hardened during fixation, so its form is variable.

(3) Second antenna is only 4-jointed, not 6-jointed, the fourth (distal) joint being the shortest.

(4) First and second swimming legs are with flagella.

(5) Supporting ribs of the sucking cups are not made of nine pieces, like a row of beads, but of six, the basal one longest in the form of a rod, others platelike, diminishing in size distally.

(6) Anal sinus though not half as long as abdomen, but almost one-third rather than one-quarter as lcng.

There were two possible explanations for this discrepancy. Either Wilson made a mistake in his material or there are other specimens in the National Museum collection that answer Wilson's description. As it seems highly desirable to have all the specimens labeled *A. japonicus* in the National Museum reexamined with the objective of either invalidating Wilson's (1944) *A. japonicus* as a species if no specimens agree with his description, or extending the range of variation of this universally occurring argulid, this problem was brought to the notice of Dr. Fenner A. Chace, Jr., in the U. S. National Museum. Dr. Chace, who had Paul L. Illg examine the types of *A. trilineatus* and *A. japonicus*, made the following statement:

The types of *Argulus trilineatus* are in two separate lots of one female each, U. S. N. M. Nos. 32828 and 39551. The former specimen is very flattened and apparently has been dried out at some time. In the present condition the carapace reaches to about the middle of the basal segment of the fourth legs, as seen dorsally; the specimen was too fragile to allow examination for flagella; the anterior dorsal ribs are forked. In a temporary mounting in Euparal, a count of four segments to both second antennae was made under a compound microscope; the caudal rami were not determinable under a compound microscope. A permanent Euparal mount of a fragment of the sucking disk was made and six segments per supporting rib were made out, the innermost being the longest and vaselike or rodlike. This is the Macon, Ga., specimen.

In the other female, No. 39551, from Washington, D. C., the carapace reaches to the fourth legs, which are completely visible in dorsal view; the dorsal anterior ribs are forked; the first and second legs bear flagella. A permanent mount of a portion of the sucking disk shows 6-segmented ribs.

Of the allotype male, No. 78900, from Takoma Park, Md., five specimens remain of the original six. In all, the carapace reaches to the fourth legs which are entirely visible in dorsal view; in all, the anterior dorsal ribs are forked.

Of *Argulus japonicus* Thiele, there are but two lots from Tokio in the U. S. National Museum, Nos. 78894 and 69835. The former contains a male and female collected by A. S. Pearse and identified by Wilson. In both, the entire fourth legs are visible dorsally; the dorsal anterior ribs are forked; the first and second legs bear flagella; the fourth segment is not laterally constricted; the anal sinus is plus or minus one-third the length of the abdomen; the antennules and antennae are missing on one side of the female; those from the other side were prepared as a permanent Euparal mount. A_2 is 4-segmented. A permanent mount of the sucking disk was made, but the state of the specimen renders determination of rib segmentation difficult. Basal segments of the ribs are identical with those in all "*trilineatus*" specimens. In most ribs a count of six segments can be made; there certainly are not nine small, beadlike, uniform segments per rib.

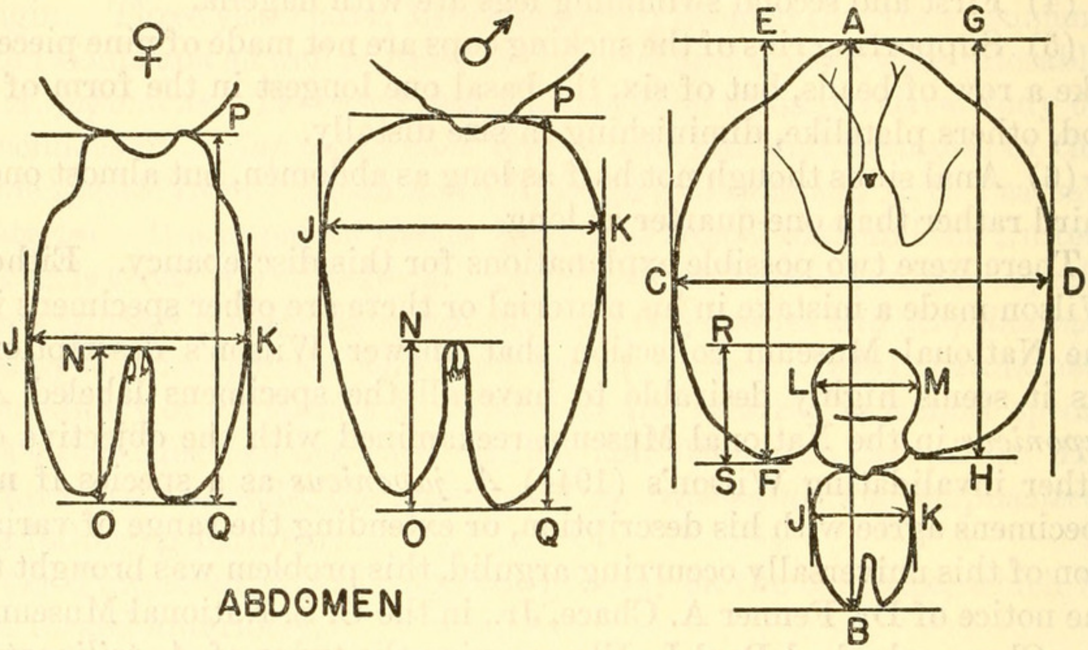

FIGURE 26.—Method used for measuring *Argulus japonicus:* AB, total length; CD, maximum width; EF, length of left carapace; GH, length of right carapace; JK, width of abdomen; LM, maximum width of posterior sinus of carapace; NO, length of anal sinus; PQ, length of abdomen; RS, length of posterior sinus of carapace.

It will be seen that the characters (1), (2), (3), (4), and (7) claimed by Wilson for the type specimen of *A. trilineatus* are all contradicted by this reexamination of the type deposited by Wilson in the National Museum. The discrepancies between Wilson's description of *A. japonicus* and the specimens identified by him as *A. japonicus* described above are confirmed by Dr. Chace and Mr. Illg. It is clear that Wilson, according to the records on the labels of the specimens in the National Museum, did identify specimens as *A. japonicus* that showed characters as first enumerated by Thiele as well as the additional features recorded by Tokioka and Meehean. There is no specimen available that corresponds with either one of the *A. trilineatus* and *A. japonicus* descriptions given by Wilson. Until such specimens can be found, the two descriptions published by Wilson must be considered invalid. It is clear that *A. trilineatus* is synonymous with *A. japonicus* Thiele. What *A. japonicus* Wilson (1944) may be cannot now be settled; it is certainly not *japonicus* Thiele and may be based entirely on errors of observation. Until specimens answering to the description are found no new name is required.

Finally the question of the justification of erecting two species, *A. japonicus* and *A. foliaceus*, should be carefully considered. There is more difference between the two European species, *foliaceus* and *coregoni* (Meehean, 1937), than between the Oriental and American species, *japonicus*, and the European species, *foliaceus*. It might be asked: Is a single difference in male character of two very variable species sufficient to validate both as separate species, which, though apparently separate in geographic distribution, actually might, by artificial agents, be mixed through transportation of the host fish? A world-wide survey may be required to clear this point.

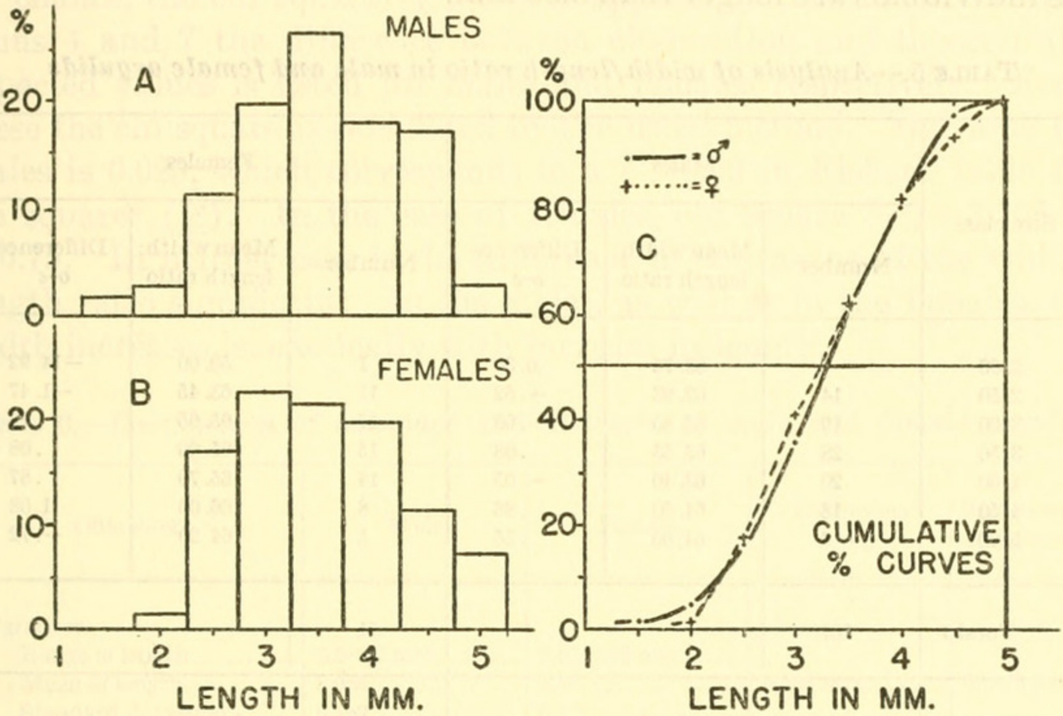

FIGURE 27.—Size distribution of *Argulus japonicus* from Erh Hai.

This series of specimens collected from Erh Hai offers itself as good material for a statistical analysis of the specific characters. Among this population of 210 argulids collected while they were free-swimming, 58.5 percent were males and 41.5 percent females. The animals are measured under a dissecting miscroscope with a calibrated ocular micrometer. The measurements taken are defined in figure 26. The width of the abdomen in the male is its maximum width, which is at the anterior quarter; in the female it is the width across the abdomen immediately anterior to the base of the anal sinus. This difference in measuring abdominal width is necessitated by the fact that the two sides of the female abdomen are parallel at the middle half, but the posterior quarter may be bent laterally beyond the true maximum width during fixation. The maximum width of the posterior sinus of the carapace is the maximum distance between the two concave sides, but in the female, where the two sides are nearly straight and diverge continuously from each other, the middle part of this sinus is measured.

The size of the males ranges from 1.72 to 4.99 mm. and of the females from 2.12 to 5.09 mm. The size distributions of males and females are shown in figure 27, A and B. The cumulative percentage curves of both sexes are shown in figure 27, C. The percentage of individuals of each class, with class interval of 0.5 mm., is plotted against size class in the histograms. The model class among the males as well as the females is 3.5 mm. (3.25–3.75 mm.) in total length. From the cumulative percentage curves it will be seen that half of the individuals are longer than 3.25 mm.

Table 5.—*Analysis of width/length ratio in male and female argulids*

Size class	Males			Females		
	Number	Mean width: length ratio	Difference *o–e*	Number	Mean width: length ratio	Difference *o–e*
2.00	4	63.75	0.30	1	50.00	−14.92
2.50	14	62.93	−.52	11	63.45	−1.47
3.00	19	62.80	−.65	17	65.65	.73
3.50	28	63.53	.08	15	65.00	.08
4.00	20	63.40	−.05	14	65.79	.87
4.50	18	64.30	.86	8	66.00	1.08
5.00	4	64.00	.55	5	64.20	−.72
Total 7	107			71		
o=observation	n=6 (degrees of freedom) Chi square (χ^2)=0.029 (by calculation) P>0.99 (from Fisher's table)			n=6 Chi square (χ^2)=3.508 P=0.75		

The ratio between maximum length and maximum width has been determined for each individual. The mean value of this ratio in the male population is 63.45 percent, in the female population 64.92 percent. As this ratio among males varies from 54.7 to 69.3 percent and among females from 4.66 to 83.8 percent, it would be interesting to find out whether, by making use of the relationship $y=bx^k$, proposed by Huxley, the increase in the width (change of y) with respect to growth in total length (change in x) is heterauxetic or isauxetic. In Figure 28, A, the log. of width is plotted against the log. of total length for all the males and a straight line with a slope=1 is drawn through the points. The points all fall close to this line, suggesting that length and width of *Argulus japonicus* grow at the same rate. In Figure 28, B, the same is done for all the females measured. The line with slope=1 also shows the trend of all the points which, however, show more scattering than in the case of the males. To analyze further, the specimens are arranged in seven classes according to size, with a class interval of 0.5 mm. (table 5).

The mean of the ratios of width to length is calculated for each class and listed in percent in column 3 for males and column 6 for females. The mean value for the male population is 63.45 percent and for the female population 64.92 percent. To test the hypothesis suggested by the above curves in figure 28, namely, that width and length show isauxesis, and hence variations in the mean values of the ratios between width and length in different size classes have occurred by chance, the chi square (χ^2) test is applied to these data. In columns 4 and 7 the difference between observation and theoretically expected values is listed for males and females respectively. From these the chi square is calculated by the usual method. Its value for males is 0.029, which corresponds to a $P>0.99$ in Fisher's table for chi squares (χ^2). In the case of females, chi square (χ^2) $=3.508$, P is 0.75. In neither case is the difference in the means of the width/length ratio significant. In the males, as well as in the females, the width increases isauxetically with increase in length.

TABLE 6.—*Comparison of carapace and abdomen of male and female argulids*

Character	Male	Female	Difference ♀−♂	Stand. error of difference
1. Carapace:				
Range of length	2.8–3.5 mm	2.53–3.62 mm		
Mean of length	3.065	3.14	0.075 mm	0.0075 mm.
Standard deviation	0.198	0.271		
Standard error of mean	0.044	0.06		
Coefficient of variation	6.45 percent	8.62 per cent	2.17 percent	
Range of width/length	88.6–101.1 percent	84.7–102.5 percent		
Mean of width/length	93.02	92.0	−1.02 percent	1.22 percent.
Standard deviation of width/length.	3.230	4.712		
Standard error of mean	0.722	1.054		
Coefficient of variation	3.47 percent	5.12 percent	1.65 percent	
2. Abdomen:				
Range of length	1.03–1.25 mm	0.72–0.995 mm		
Mean of length	1.127	0.966	−0.161 mm	0.0255 mm.
Standard deviation	0.067	0.092		
Standard error of mean	0.015	0.20		
Coefficient of variation	5.98 percent	9.56 percent	3.58 percent	
Range of width/length	63.6–81.1 percent	41.2–68.0 percent		
Mean of width/length	71.13	56.62	−14.51 percent	2.304 percent.
Standard deviation of width/length.	4.698	9.171		
Standard error of mean	1.05	2.05		
Coefficient of variation	6.59	16.2	9.61 percent	

The ratio of width over length, i. e., constant *b*, in the above growth equation, is not the same in the two sexes. From the following list of requisite statistics:

	Male	*Female*
Number of individuals	107	71
Mean width/length ratio	63.45%	64.92%
Standard deviation	0.498	1.979
Standard error of mean	0.048	0.234
Coefficient of variation	0.786	3.03

the difference in the mean values of this ratio between males and females is found to be 1.47 percent and the standard error of this difference 0.24. As the difference is more than six times its standard error, it may be concluded that the females as a whole have broader carapaces than the males, though in neither sex does the ratio between width and length alter appreciably with growth.

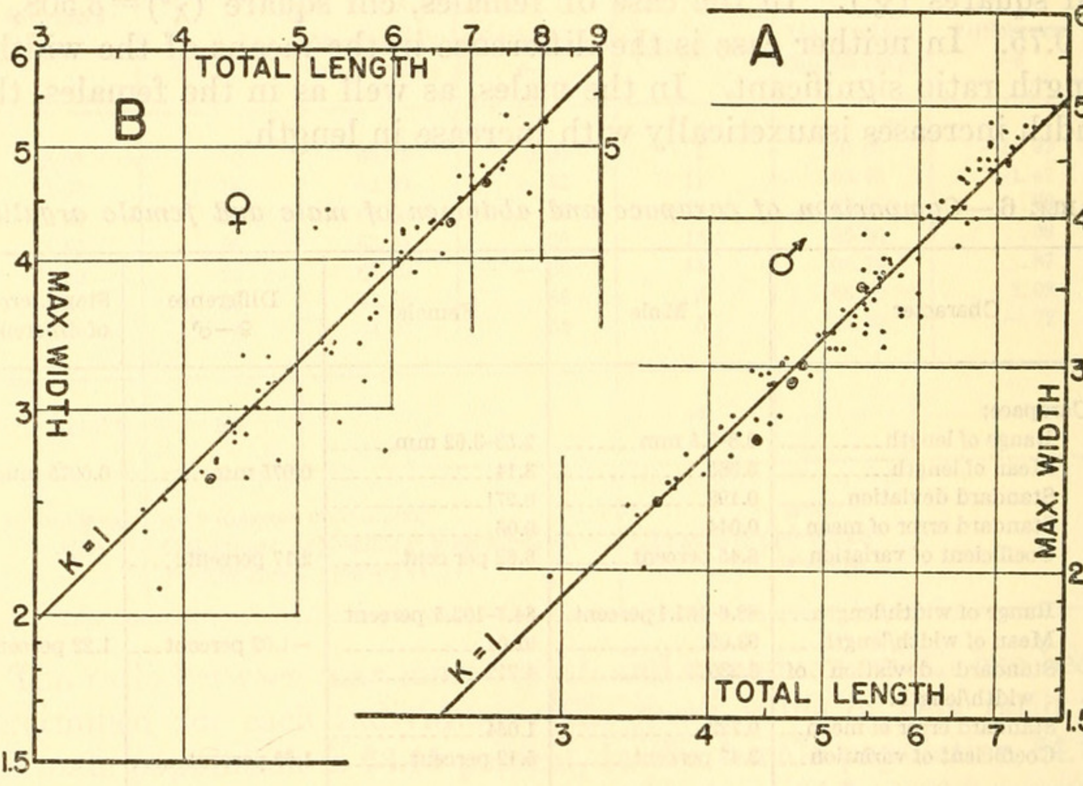

FIGURE 28.—Length-width curves of *Argulus japonicus* from Erh Hai (o = locus for more than one point.

In comparing the carapace, abdomen, and anal sinus only individuals larger than 3.5 mm. in length are used so as to exclude the immature forms. In table 6 the carapace and abdomen of the two sexes are compared with reference to absolute length and the ratio of width and length of these organs. As the two sides of the carapace are generally not of the same size in fixed material, by length of carapace is meant the average of the left and right lengths measured.

It will be seen from table 6 that these two structures in the female are slightly more variable than those in the male, as shown by their greater coefficient of variation. The females have longer carapaces than the males—the difference between male and female carapace lengths is 0.075 mm., which is ten times the standard error of the difference of the means. On the other hand, the ratios between the width and length of the carapace in the two sexes are not significantly different. This agrees with the fact noted above that the females have broader carapaces. In other words, the carapace is larger in the female than in the male.

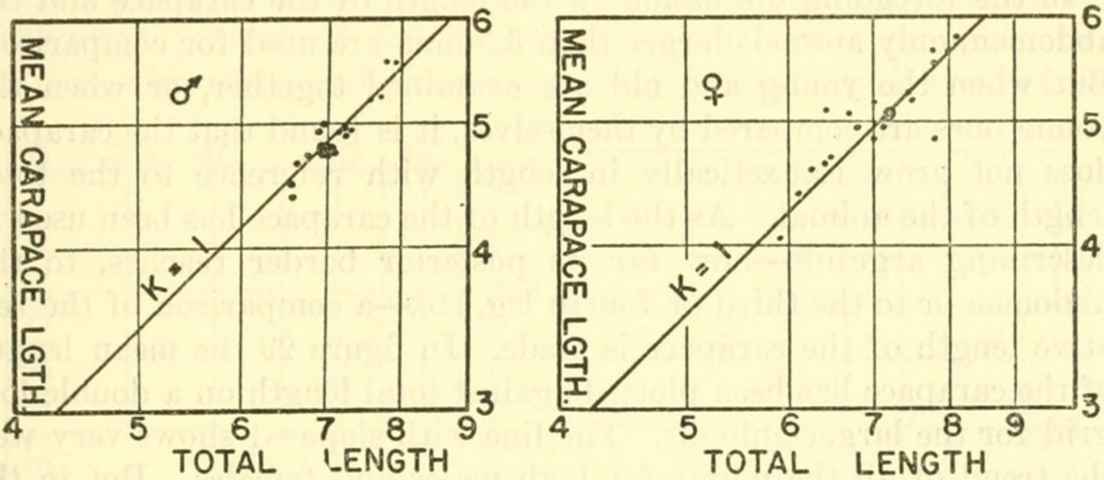

Figure 29.—Carapace length-total length curves of *Argulus japonicus* from Erh Hai.

On the average, the males have longer and wider abdomens than the females—0.16 mm. longer in this population. The width of the abdomen in the male is 71.3 percent of its length, while in the female it is only 56.62 percent. As shown in table 6, the difference in the mean values in both cases is significant. The presence of testes in the abdomen makes that part of the body of the male not only longer and broader but also thicker.

The length of the anal sinus has been given by systematists as from one-quarter to one-third the length of the abdomen. From this series of material it is found that in the male the sinus is 37.755 percent of the abdomen in length and in the female 38.435 percent. The other data on abdominal sinus are listed below.

	Male	*Female*
Anal sinus, length, range	0.37–0.56	0.22–0.45 mm.
length, mean	0.385	0.375
length, standard deviation	0.047	0.053
length, standard error of mean	0.001	0.001
length, coefficient of variation	0.69 percent	0.88 percent
$\frac{\text{Length of anal sinus}}{\text{Length of abdomen}}$	37.755 percent	38.435 percent

Tokioka was the first person to report that in *A. japonicus* Thiele the number of supporting ribs in the sucking disk is about 50. An examination of a random sample of this species from Erh Hai shows that the number of supporting ribs varies from 38 to 50, with 44–45 (44.6) as the mean. It also shows that the two sucking disks of the same animal do not have the same number of ribs. A random counting is shown below:

	Number of supporting ribs in sucking disk											
Right side	43	43	45	46	43	48	45	42	43	39	45	45
Left side	46	45	48	43	45	45	50	44	41	38	47	50

In the foregoing discussion on the length of the carapace and the abdomen, only animals larger than 3.5 mm. are used for comparison. But when the young and old are examined together, or when the young ones are compared by themselves, it is found that the carapace does not grow isauxetically in length with reference to the total length of the animal. As the length of the carapace has been used in describing argulids—how far its posterior border reaches, to the abdomen or to the third or fourth leg, etc.—a comparison of the relative length of the carapace is made. In figure 29 the mean length of the carapace has been plotted against total length on a double log. grid for the larger animals. The line with slope=1 shows very well the trend of all the points for both males and females. But in the case of animals less than 3.5 mm. long, as shown in figure 30, B, the slope of the line of best fit drawn by sight is 0.957. In other words, K is less than 1, which means that the anteroposterior length of the carapace shows brachyauxesis though its width shows isauxesis with reference to total length. In the very young specimens in this collection the posterior border of the carapace reaches only the anterior edge of the second leg, while in larger ones, it reaches the base of the fourth.

In the case of the abdomen, as shown in figure 30, A, the points relating abdomen and total lengths in animals less than 3.5 mm. long seem to fall along a line with $K=1.65$; in larger animals along the line with $K=1$. In this figure the dots represent larger animals, and the crosses, whose trend is indicated by the broken line, are based on animals smaller than 3.5 mm. in total length. This means that during rapid growth the abdomen increases in length tachyauxetically with reference to the rest of the body, but after maturity, or near maturity, it shows isauxesis.

With the above statistical data a slightly different description, more useful for comparative purposes, might be given as follows:

Adult female: Carapace nearly circular, width 92 ± 1.05 percent[2] of carapace length, carapace length 64.92 ± 0.23 percent of total length, nearly reaching anterior margin of fourth swimming leg, parts of

[2] Figure after $\pm$ sign represents standard error of mean. This applies to all the figures used in this description.

rami of first three pairs of legs and all of the fourth visible from the dorsal side. Compound eye of medium size, median eye small, distance from anterior end of median eye to tip of carapace 23.34±0.50 percent of total length of animal. Anterior end of dorsal ridge forked. Abdomen nearly elliptical, with two sides parallel for a greater part of their length, abdomen 56.62±2.05 percent of total length, anterior end contracted into a short neck where it joins the thorax, each side of this necklike portion carrying a triangular process (fig. 25, *a*)—a structure not described by earlier authors. Anal sinus 38.44±0.81 percent of abdomen length, each caudal ramus in two sections, a broader basal portion, arising from the anterior end of the

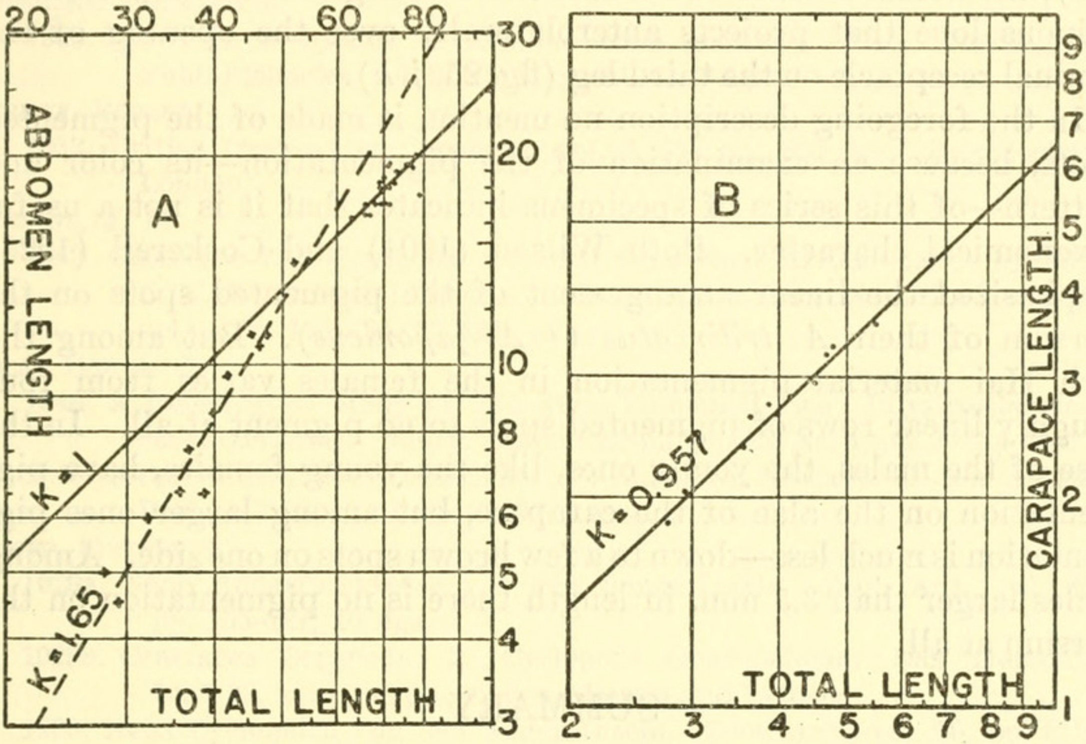

Figure 30.—A, Abdomen length plotted against total length of *Argulus japonicus*, dots based on data from animals larger than 3.5 mm. and crosses based on those of smaller ones; B, carapace length plotted against total length of argulids smaller than 3.5 mm. long, scales in ocular division of microscope.

abdominal sinus, and a slenderer distal portion bearing seta on its caudal end (fig. 25, *d*)—this has not been described thus before. Antenna, maxilliped, and swimming legs as given by Thiele (1904), Tokioka (1936), and Meehean (1940) and as shown in figure 25, *b-e*. Sucking disk with 38–50 supporting ribs, average 44–45, two sucking disks of the same animal with different number of ribs, each rib consisting of one long basal and five short distal segments, decreasing in size distally. Width of animal 64.92±0.234 percent of total length.

Adult male: The males show comparatively less variation than the females in the characters measured. Carapace smaller than in the female, being 63.45±.048 percent of total length; compared with that of the female it is narrower and shorter. Distance from anterior end of median eye to the foremost tip of the carapace 27.085±0.335 percent of total length. Abdomen obovate in outline, anterior end broader, maximum width 71.13±1.05 percent of length of abdomen, being significantly wider than in the female. Anal sinus 37.76±1.15 percent of abdomen. Caudal rami basal (fig. 25, *d*), each in two sections as in the female. Secondary sexual characters on the swimming legs as described by Thiele (1904), Tokioka (1936), and Meehean (1940). But in addition to a slight spinous lobe on the lateral edge of the thorax, between the second and third legs, directed from the base of the third thoracic appendage anteriorly (see Meehean's fig. 32*c*), the dorsal surface of the last thoracic segment has a prominent spinous lobe that projects anterolaterally over the opening of the seminal receptacle on the third leg (fig. 25, *j*, *k*).

In the foregoing description no mention is made of the pigmented spots, because an examination of the pigmentation—its color and pattern—of this series of specimens indicates that it is not a useful taxonomical character. Both Wilson (1904) and Cockerell (1926) emphasized the linear arrangement of the pigmented spots on the dorsum of their *A. trilineatus* (=*A. japonicus*). But among the Erh Hai material pigmentation in the females varies from four roughly linear rows of pigmented spots to no pigment at all. In the case of the males, the young ones, like the young females, have pigmentation on the alae of the carapace, but among larger ones pigmentation is much less—down to a few brown spots on one side. Among males larger than 3.5 mm. in length there is no pigmentation on the dorsum at all.

SUMMARY

Two new diaptomid copepods, *Tropodiaptomus hebereroides* and *Arctodiaptomus* (*Pararctodiaptomus*) *hsichowensis*, found in Lake Erh Hai, China, are described in this paper. Three cyclopoids occur in this lake. *Tropocyclops breviramus* is described as a new species and *Eucyclops serrulatus extensus* as a new subspecies. The universally occurring *Megacyclops viridis* (Jurine) is compared with forms found in North India and Tibet and with *M. viridis acutulus* Kiefer from Java.

A detailed examination of the literature on *Argulus japonicus* and *A. trilineatus* is made. Wilson's *A. trilineatus* cannot be considered valid but is a synonym of *A. japonicus* Thiele as indicated by Meehean. Wilson's *japonicus* (1944), if not based on errors of observation, must refer to a different species, but no specimens in agreement with the description are known. A statistical analysis of *A. japonicus* from Erh Hai is made and, based upon it, a supplementary description of

the material is given for adult males and females. Statistical analysis indicates that during growth the width of the carapace increases isauxetically with the total length, but its length shows brachyauxesis with reference to the whole body. The abdomen of growing young, on the other hand, shows tachyauxesis with respect to the rest of the body.

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