

Goidelia japonica—a New Entozoic Copepod from Japan, associated with an Infusorian (*Trichodina*). By ALICE L. EMBLETON, B.Sc. (Communicated by Prof. G. B. HOWES, Sec. Linn. Soc.)

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(PLATES 21 & 22.)

WHILE working last spring in one of the Laboratories of the Royal College of Science, London, on the structure of *Echiurus uncinatus* *, an almost unknown Japanese Gephyrean obtained for me by Professor G. B. Howes, my attention was arrested by the constant occurrence of a parasitic Copepod in the rectum: it was always present in great numbers, along with an Entozoic Protozoan which, so far as I can determine from preserved material, is a new species of *Trichodina* (Pl. 22. fig. 20, i., ii., iii. —see note *infra*, pp. 227–8). Though this soft-bodied unicellular creature was not sufficiently well preserved to give satisfactory results as to its detailed structure, the Copepod was in good condition. In my work upon this parasite I have been greatly assisted by Mr. M. F. Woodward, whose suggestions and advice have been most valuable. The microscopic size and extreme brittleness of the animal rendered dissection difficult, and necessitated the use of many different stains and reagents. I am especially indebted to Mr. Woodward for his experienced aid in the micro-chemical part of the manipulation.

On opening the rectum of the host, large numbers of the parasite are seen free in the contained fluid; many of them, however, are invariably attached to the epithelial lining of the rectum. On trying to remove these it is found that they are adhering very firmly, the anterior end being more or less embedded in the host's tissue; and after they have been detached (with a moderately stiff camel's-hair brush) little crypts, or scars, remain showing the places where the parasites had been situated.

The length of the body—without the caudal setæ—is about .5 mm. to .7 mm. Pl. 21. fig. 1 is a scale-drawing of an adult female (A), an adult male (B), and an immature female (C); it is a *camera-lucida* drawing, in which the specimens were magnified

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to the same extent as the millimetre-scale, where the ultimate divisions are tenths. In this way I have been able to get accurate measurements of the various parts of the body, from which some interesting comparative results were obtained.

Further investigation showed this Copepod to be an entirely new form; and this opinion was confirmed by Dr. Brady, to whom some specimens were submitted. I propose to name it *Goidelia japonica*.

After carefully examining many individuals, and comparing them with descriptions of parasitic and semi-parasitic Copepods, I find they most resemble the *Hersiliidæ*, as described by Claus *, Canu †, and Kossmann ‡. The affinities of this family are still uncertain, and, though *Goidelia japonica* is apparently related to this group, yet it is more truly endo-parasitic than either of the three known genera which have so far made up the family. But apart from the difficulty arising out of the unsettled condition of the affinities of this family, I find that its name, *Hersiliidæ*, is already occupied by a well-known family of Spiders, possessing also the genus *Hersilia*; there is, moreover, a genus *Hersilia* in the Coleoptera and also in the Diptera. On looking up the literature on these four different groups, it is clear the name belongs—by right of priority—to the Arachnida: as the spider *Hersilia* (Audouin) appears in 1825–27 in Savigny's 'Description de l'Égypte.' § The next to receive the name was the beetle of the family *Chrysomelinæ*, which was christened in 1834 by Dejean ||. It was not until November 2nd, 1839, that Dr. A. Philippi ¶ found the Crustacean, which he called *Hersilia apodiformis*, describing it as "Ein neues Genus der Entomostraceen." Some years later, that, in 1863, Robineau-Desvoidy again used

* "Neue Beiträge zur Kenntniss parasitischer Copepoden, nebst Bemerkungen über das System derselben." Zeitschr. f. wiss. Zool. xxv., 1875.

† "Les Copépodes Marins du Boulonnais": iii. "Les *Hersiliidæ*, famille nouvelle de Copépodes commensaux." Bull. Sci. Nord France et Belg. tom. 19, 1888.

‡ "Ueber *Clausidium testudo*, einen neuen Copepoden, nebst Bemerkungen über das System der halb-parasitischer Copepoden." Verhandl. phys.-med. Gesell. in Würzburg, vii., Neue Folge, 1874.

§ "*Hersilia* (Audouin)" in Savigny, Descrip. Égypte (2nd ed.), xxii. 1825–27, p. 317. E. Simon, Hist. Nat. Araignées (2nd ed.), vol. i. p. 446.

|| "*Hersilia* (Dejean)," Catal. Coleop. (2nd ed.), 1834: *Chrysomelinæ*.

¶ "Einige zoologische Notizen." Archiv für Naturgeschichte (Wiegmann), Band v. 1, 1839.

the name for a new genus of *Muscidae*, in the group of Diptera*. Then, in 1874, Dr. R. Kossmann published his account of the Copepod *Hersilia* under the name of *Clausidium testudo*. In 1886 Professor Heller met with it in the branchial cavity of *Callianassa*. Since then several other authors have investigated the parasite under the name *Hersilia*, with the result that the family name, in 1888, became *Hersiliidae*. The consequence is that there exist four genera with the same name, two of which give the name to the family *Hersiliidae*. Such an occurrence is always the source of much confusion; but in this case the possibility of error is increased by the fact that they are all Arthropoda. To avoid any further misunderstanding, I have been advised by Dr. D. Sharp and Mr. C. Warburton, of Cambridge, to entirely remove the names "*Hersiliidae*" and "*Hersilia*" from the order Copepoda. I propose, therefore, to substitute for *Hersiliidae* the family name *Clausidiidae*, and for *Hersilia* the generic name *Clausidium* as proposed and used by Kossmann in 1874. It seems best to thus adopt the name used by Kossmann, instead of introducing a new one, as I had at first intended to do. I shall use these names throughout the paper, except of course where I quote other writers, in which case I shall give those used by them.

In spite of the fact that several authors have paid special attention to it, the genus "*Hersilia*" is still looked upon as aberrant, and the opinions as to its affinities differ widely. Kossmann, as we see, calls it *Clausidium*, and claims for it relationship with the Siphonostomes—*Artotrogus* and *Asterocheres*. Others ally it to the *Peltidiidae*. Claus and Heller claim (and, so far as I can judge, are justified in so doing) that the "*Hersiliidae*" are a family of Copepods, distinct alike from the *Siphonostomidae* and from the *Peltidiidae*; while Milne-Edwards† admits the difficulty in classifying them. He says they seem to have some analogy with the *Sapphirinidae* and *Peltidiidae*, but that they also approach the *Argulidae* in the general form of the body; our knowledge of them being so incomplete, he is unable to determine with certainty their place in the natural system of classification.

* "*Hersilia* (Robineau-Desvoidy)," Hist. Nat. Diptères Env. Paris, i. p. 499, 1863: *Muscidae*.

† Hist. Nat. Crust. iii., 1840.

For purposes of comparison, bearing on the systematic position of *Goidelia japonica*, it may be as well to give the features characteristic of the whole family, as stated by Canu:—

“Body completely segmented; first thoracic segment joined to the cephalic ring; first antenna composed of seven segments, being the same in both sexes; second antenna simple, with four joints; mandibles devoid of a palp, and without masticatory teeth, but provided distally with accessory mobile parts in the shape of a solid bent claw, or rather of flat blades with regular denticles and serrations, or of hooks finely fringed; maxillary rudimentary, showing, however, traces of a division into a masticatory lobe (internal) and a palp (external); maxillipedes well-developed, the first furnish important sexual distinctions; thoracic feet biramous, and the rami of three joints in the four anterior pairs, simple and flat in the fifth pair.”

The family is, according to Canu, made up of the three genera *Hersilia*, *Hersiliodes*, and *Giardella*; of these, he says, *Hersilia* is commensal more intimately—*i. e.* more nearly approaches an entozoic condition—than the other two genera. The classification is based on the differences in the mouth-parts, special significance being attached to the accessory parts at the distal end of the mandibles, as is seen by the following table given by Canu:—

“Table of Genera.—Mandibles bearing at their distal extremity besides the recurved claw common to all the family:—

i. *Two accessory pieces.*

1. The anterior is a flat serrated blade, and the posterior is a small bearded hook. In the male, the 1st maxillipede is formed of two joints, the end being chelate, reduced and toothed.

Genus *Hersilia* (Philippi).

2. Almost the same, with flat, toothed, triangular blades laterally. In the male, the 1st maxillipede has two basal joints, and a well-developed prehensile end in the form of a long recurved claw.

Genus *Giardella* (Canu).

ii. *Three accessory pieces.*

3. The anterior is a subtriangular, toothed blade, and the others are two long bearded flexible hooks. Genus *Hersiliodes* (Canu).”

The distinguishing features of the three genera, as given by Canu, are as follows:—

“Genus *Hersilia* (Philippi).—Body flattened, composed of very distinct segments, male with ten, female with nine (not counting the furcæ); first antenna seven-jointed; second antenna simple, four-jointed; cutting-mandible relatively small, bearing at its distal end three accessory pieces

in the form of a claw, a toothed plate, and a hook; maxillæ rudimentary and of the form common to all three genera; first maxillipede same in female and male, and made up of (i.) in female three parts (and not as Claus says four), all bearing long hooks, often bearded; (ii.) in male, two parts, basal well-developed, and a terminal joint reduced to a short prehensile spine; first pair of thoracic feet very different from the three following which are alike, and transformed into organs of adhesion; second, third, and fourth thoracic somites formed of three basal parts, and of two rami each with three joints; fifth pair simple, two-jointed, and flat."

"Genus *Giardella* (Canu).—Body flattened, 'cyclopoid,' and of distinct segments, male and female with ten; first antenna seven-jointed; second antenna four-jointed; mandibles large, bearing at their distal ends as accessory pieces a claw and two large bearded hooks; first maxillipede different in the two sexes and made up (1) in female of three parts carrying bearded hooks; (2) in male, a basal joint carrying two bearded hooks, a median long and enlarged joint, toothed on its inner edge, and armed with two hooks on its interior surface; finally a terminal joint in the form of a spine, recurved at its tip, and almost as long as the rest of the appendage. Thoracic feet of four first pairs of normal form, biramous with three joints; fifth simple, two-jointed and flat."

"Genus *Hersiliodes* (Canu).—Body slightly flattened, rather elongated, and composed of distinct segments; first antenna seven-jointed; second antenna four-jointed; mandibles rather large, with four accessory pieces (a claw, a toothed blade, two long flexible bearded setæ); thoracic feet of fifth pair simple, two-jointed and flat."

On comparing *Goidelia japonica* with these descriptions, it is at once evident that the agreement is not sufficient to justify me in placing it in either of these genera, differing as it does from all three in many fundamental points. This may be due largely to its very different mode of life, for these three known genera are ecto-parasites, or merely commensals, whereas this creature is truly entozoic. It may be that its host, *Echiurus unicinctus*, has anal respiration*, in which case there would be a current of water flowing continuously in and out of the rectum, rendering the life of the parasite there far less accurately endo-parasitic than would be the case in the more anterior tracts of the alimentary canal. However, it is not at all certain that such a process of anal respiration takes place; so the life of the Copepod may be looked upon as typically entozoic.

According to Kossmann, Philippi, Claus, and Canu, the female and male of *Clausidium* not only differ in size, but the male is

* See paper in the Trans. Linn. Soc. already referred to.

attached to the abdomen of the female. Kossmann says the female is 1.7 mm. and the male 0.6 mm. in length. Claus repeats Philippi's measurements of $\frac{2}{3}$ line for the female, the male being but half as long. In this new Japanese form, however, the sexes show little (if any) difference in size, and I have found no single instance of the male being attached to the female. Sexual dimorphism between the female and male is not very apparent, only being manifest on a closer examination of the more minute parts; none of the adult females have egg-sacs, as these would doubtless only be present for a very short period, which may explain their absence from my specimens if they were collected at a time of year when the sacs are not developed. Thus, a general description of the animal applies equally to the two sexes.

The body is flattened dorso-ventrally, the carapace being, however, slightly arched above. Dorsally, the outlines of the segments are quite clear, there being four well-marked thoracic segments behind the head; following on this is the small tapering abdomen made up of 6 segments, the last two of which are divided and constitute the furcæ, each limb carrying an inner long and an outer short seta (Pl. 21. figs. 1, 2, 3, 4). In the adult female the first three abdominal segments are fused, and in this fused region the paired genital pores open ventrally (Pl. 21. fig. 2, *g.*).

There are no eyes, which may be an adaptation to its habitat. Canu figures *Hersiliodes* as being destitute of eyes, though the other two genera possess them paired and well-developed.

Anteriorly the carapace curves down, as is seen on looking at the creature from below (Pl. 21. figs. 2, 3). Notches in this in-turned edge occur to allow for the free movement of the first antennæ, between the bases of which the carapace bears at its edge two short spines (not, however, in the adult male, though present in its earlier stages).

In order to investigate the appendages, it was necessary to get separate dissections of each. The animal being so small and its chitinous parts being so brittle, I experienced considerable difficulty in obtaining satisfactory preparations. The best results were secured when I boiled the material in strong potash for some minutes, washing it thoroughly in water before staining with safranin. Specimens treated in this way showed most of the hard parts with great clearness, though the safranin being an aniline dye, fades in glycerine, with the result that the mountings

are not permanent. To obviate this difficulty borax-carminé, or Ehrlich's hæmatoxylin, can be utilized instead.

In addition to the adults of both sexes, I succeeded in detecting earlier stages in which certain of the appendages exhibit striking modifications; other appendages, however, are alike in both sexes and in all stages. Those that are constant are:—

- i., the first antenna;
- ii., the second antenna;
- iii., the mandibles;
- iv., the maxillæ;
- v., vi., vii., viii., the first four thoracic legs—the fifth seems to be much bigger in the adult female than in the adult male, though similar in other respects.

First Antenna.—Alike in all stages and both sexes; it is composed of five segments, bearing numerous setæ; the first is the longest and largest segment, the remaining four gradually diminishing and tapering to the end (Pl. 22. fig. 5).

In all published accounts of the family this appendage is described as having seven segments, in fact Canu gives that as one of the family features; however, he figures the first and second Copepod stages of *Hersiliodes* and *Giardella* as having but five joints.

Second Antenna.—Alike in all stages and both sexes. It consists of four segments, the first being the largest, the other three being bent back on this basal joint, forming a conspicuous and characteristic elbow; this elbow of each antenna approaches the other in the middle line above the upper lip (Pl. 22. figs. 6, 7), and is seen very clearly on the ventral surface; it is characteristic of the three genera described by Canu. On the inner edge of the distal end of the first segment there are two small spines and one long feathered seta (figs. 6, 7); the second joint is small and, so far as I can make out, carries no process at all; the third has on its outer surface two setæ, one being feathered and much longer than the other. All the complex hooking apparatus is confined to the fourth and smallest factor of the appendage. This apparatus is built up of five prehensile claws or processes: the first, and smallest, is a short stout organ with its inner face toothed near the extremity (figs. 6, 7); the next process is similar to this, only slightly longer; the third differs only in the fact that it is more slender; the fourth has a long, slightly curved, smooth portion which abruptly passes over into a

smaller part ending in three teeth on its inner surface; the fifth is the same, being however longer and stouter (Pl. 22. figs. 6, 7).

In none of the descriptions of allied forms can I find an account of such an apparatus as this on the second antenna, though the number of parts going to make up the limb agrees with that in other genera, but this hooking arrangement is peculiar to *Goidelia japonica*. Doubtless these hooks serve to fix the parasite to the walls of the rectum of its host.

Mouth-parts.—These consist of an upper lip, mandibles, and maxillæ, all grouped on a raised dome-shaped area, occupying a relatively small space, owing to the reduction and degeneration of the various parts (Pl. 21. figs. 2, 3, *mx.*).

Upper Lip.—Overhanging the mouth-opening is a flattened lip; its lower edge is not pointed into a "beak" as Kossmann says of *Clausidium*:—"die Oberlippe läuft nach hinten zu in einen spitzen Schnabel aus, und erinnert insofern an die Rüsselbildung der verwandten Copepoden." Claus, however, speaking of the same creature says:—"Der breite Oberlippe bleibt von der zweilappigen mit feinen spitzen überkleideten Unterlippe vollkommen getrennt, kann die letztere aber beim Weibchen bedecken. Eine dem Rüssel von Parasiten vergleichbare Schnabelbildung vernennen wir durchaus." In Claus' fig. 3, the lip appears very similar to that in my specimens. The double-lobed lower lip he mentions is present, fringed with fine setæ. The upper lip forms a sort of flap, alike in female and male, its lower edge being slightly curved (Pl. 22. fig. 10, *l.u.*), with a line of fine setæ just above the free edge. In the male this lip bears stronger and more numerous setæ, being particularly well-developed at the side angles of the lip. Beneath it, and just above the lower lip, is the small, almost circular, mouth-opening. The upper lip almost completely covers the mandibles, which are very small and simple.

Mandibles.—These are a pair of very small chitinous structures of simple organization. Each mandible is a slightly curved claw-like organ, ending in a serrated hook (Pl. 22. figs. 8, 9, 10, *md.*), the lower edge of which is toothed; this claw articulates on to the main stem of the mandible. The mandible of each side approaches the other in the middle line, not sloping to each other in an accurately transverse direction, but both pointing a little posteriorly. There are no "accessory pieces" or palps on this simple organ, though Canu, in all the three known genera,

gives two or three additional plates or processes. The form of the mandible in *Goidelia japonica* is constant for the adult and immature stages of both sexes. Canu also finds that the mouth-parts of the *Clausidiidæ* are not altered by the various moults. Claus, in *Clausidium*, depicts the mandible with this claw-shaped end-piece, but in this case there is, in addition, a fringed process beneath it, entirely absent in *Goidelia japonica*. Therefore, by taking the mouth-parts as the basis for classification, it becomes necessary (on this point alone) to separate this new form from the other three genera, though it is undoubtedly related to the group, in spite of its entozoic mode of life, which has made its structure much more modified than these less parasitic forms. These three known genera, Canu asserts, form, in respect to degrees of parasitism, a series: in such a series *Goidelia japonica* would have to be placed at the one end as being the most parasitic.

Maxillæ.—Alike in all stages and both sexes. They are greatly reduced, being merely small oval organs (fig. 10, *mx.*), unsegmented, and perfectly simple except for the fact that they possess three feathered setæ. They are situated behind the mandibles, but are not covered by the lips; their insertion is on a level with the base of the mandibles, and, so far as it is possible to judge from preserved specimens, they seem incapable of movement as a whole, though doubtless the setose processes function instead. The maxillæ here agree very closely with the descriptions given by Canu in *Hersiliodes* and *Giardella*, though they are smaller and more simple in *Goidelia* and have fewer processes. Canu says that in the above two genera traces can be seen of a division into a masticatory internal lobe, and a palp-like external lobe—quite absent in my specimens, however. Kossmann describes the maxilla of his *Clausidium* as “eine fast rehgeweihformige Maxille,” and from his fig. 6 the organ has indeed almost the appearance of a stag’s horns; he figures only three setæ, as also does Claus for the maxilla of the same form: these two figures agree in all other respects with mine.

First Maxillipede ♀.—This appendage differs strikingly in the various stages of development; I have been able to distinguish four very sharply defined stages in the female:—

A.—The youngest and least differentiated condition, in which the appendage is scarcely more than a flattened disc or plate, bearing a fringe of short setæ. A rudimentary palp can just be

discerned (Pl. 22. fig. 11, *p*), though in this stage it has not yet developed its two setæ.

B.—The organ at this stage is larger and more modified, it ends in a strong recurved hook (figs. 12, 13); its lower edge is fringed with setæ, and about a third of the way along this border is another spine, almost as strong as the terminal one. Laterally, on the inner surface, there is a palp (figs. 12, 13, *p*), the rudiment of which was seen in stage A, but now it bears two long terminal setæ; this palp is apparently a moveable organ and serves as a brush.

C.—This is a very interesting stage, for one can make out *within* the chitin of the maxillipede two folded hooks; the terminal spine and setæ of stage B remain, but the palp is not always present at this stage. It is obvious that the two immature enclosed hooks belong to the new appendage, and that they will unfold at the next moult when the old chitinous coat is shed (fig. 14).

D.—This is the largest and final stage in the development of this appendage. All sign of setose fringing is gone along with the palp (fig. 15). It is now a clearly-outlined claw-like organ, ending in a powerful recurved tip, directed backwards; along the posterior surface is a second, stout, hooked process. It is probable that this organ is prehensile, and helps to fix the parasite securely to its host.

First Maxillipede ♂.—I find this limb is unaltered in all the stages in the male, except that in its very early stages it has setæ on its surface as well as on its edge. It is a flattened petaloid plate of chitin, having its free border fringed with fine setæ (Pl. 22. fig. 16); and is evidently greatly reduced, for it resembles the first and very undifferentiated form which this appendage has in the stage A of the female. The first is applied closely to the highly-specialized second maxillipede, from which, however, it can be detached by careful dissection of a specimen boiled in potash. Judging from the three known genera, I had expected to find this appendage highly developed in the male, as it is in all the three allied forms, where, however, it is alike in the two sexes, being a short solid organ with two joints and armed with hooks and setæ. That it should be so degenerate in *Goidelia* in the male is a very remarkable fact, and serves to distinguish this from any other form.

Second Maxillipede ♀.—This is very feebly developed in all

the stages, being merely a papilla with but slight elevation above the surface. Relatively to the mouth-parts it is situated somewhat postero-laterally (Pl. 21. fig. 2, *mp.*²), and is less conspicuous in specimens boiled in potash than in those which have been treated with borax-carmines (or alum-carmines), and cleared in oil of cloves.

According to other authors, the second maxillipede is a very important appendage in *Clausidium*, *Hersiliodes*, and *Giardella*, and, unlike the first maxillipede, it differs in these genera in the female and male. In *Clausidium* female, Canu says it has three parts (Claus describes four), bearing setæ; in the male it has two well-marked basal joints and a terminal factor in the form of a short prehensile hook. In the female of *Giardella* it is as in *Clausidium*; but in the male of *Giardella* and *Hersiliodes* there is one basal joint with two feathered setæ, a median long joint with teeth on its inner ridge and two setæ on its internal face; finally there is a terminal segment in the form of a spine recurved towards the end and almost as long as the rest of the maxillipede.

Speaking of the family as a whole, Canu remarks:—"Maxillipèdes bien développés: les internes fournissant d'importantes différences sexuelles." I cannot help thinking that Canu has named the two pairs of maxillipèdes erroneously. Those which Claus calls "vordere" and "hintere," I call respectively "first" and "second." Canu uses the terms "interne" and "externe," yet his description and figure of the pair designated "interne" coincide with the "hintere" of Claus and my "second"; by "externe," therefore, we must conclude he refers to the "vordere" (or "obere") or first maxillipede, which he says is alike in both sexes. In *Goidelia japonica*, however, neither the first nor the second maxillipèdes are alike in the female and male: the first maxillipede is highly specialized in the female and small and unimportant in the male; the second maxillipede being, conversely, important in the male and inconspicuous in the female.

These appendages seem to offer peculiar difficulties, for Kossmann has mistaken the first maxillipede for a second maxilla, concerning which Claus observes:—"In Wahrheit aber ist Kossmann's zweite Maxille der obere Maxillarfuss, und die als Maxillarfuss beschriebene Gliedmasse der Kieferfuss des zweites Paares. Der obere Kieferfuss schliesst sich nach Form, Lager und Gebrauch am nächsten an die gleichwerthigen Gliedmassen der *Corycæiden* (*Copilia*, *Sapphirina*) an, und führt in weitere

Reduction zu den entsprechenden Maxillarfüssen der *Ergasiliden*. Ich vermag nur zwei Abschnitte zu unterscheiden ein mit mehreren Fiederborsten besetztes, in Stiletborsten wie gablig gespaltenes Endglied, und ein umfangreiches Staumglied, dessen Innenseite noch am oberen Ende einen breiten mit starker Borste bewaffneten Fortsatz entsendet. Der untere Maxillarfuss bewahrt eine vollständigere Gliederung, die sich auch an den gleichwerthigen Gliedmassen der *Corycæiden* erhält, nähert sich aber in weiblichen Geschlechte mehr den bei *Cyclopiden* (*Cyclops*, *Oithina*) beobachteten Formverhältnissen. Auf zwei langgestreckten je zwei Fiederborsten tragenden Staumgliedern, welche knieförmig gegeneinander gebent werden, folgen zwei kurze Endglieder, von denen das obere sehr starke wenn auch kaum gekrümmte Borsten trägt. Die sexuelle Umformung der männlichen Kieferfüsse, die schon bei *Corycæiden*, ferner bei *Bomolchus* und Verwandten sehr augenfällig ist, führt in unserem Falle zur Ausbildung eines sehr eigenthümlichen Klammer apparatus, welches mit der bereits besprochenen Umformung des weiblichen Abdomens in Correlation steht und die Fixirung des Männchens am weiblichen Körper als andauernde Verbindung unterhält. Die beiden unteren Glieder erscheinen aufgetrieben und besonders das zweite stark verbreitet; an Stelle der Endglieder finden wir einen beweglichen mit einer Fiederborste besetzten Haken, der dem beweglichen Arme einer Scheere ähnlich aufwärts gegen der vorausgehenden Abschnitt eingeschlagen werden kann. Am oberen Winkel des letzteren erheben sich noch drei weitere Anhänge, ein oberes Schaufelförmiges verbreitertes und gezahntes Stück und zwei demselben dicht anliegende Zahnstücke welche offenbar in die vorgebildeten Gruben des weiblichen Abdomens eingreifen."

Second Maxillipede ♂.—This is a very specialized organ in the adult, subserving as it does the function of prehension—this, in the female, is performed in all probability by the hooked first maxillipede; in both sexes, of course, the second antenna is also modified as a fixing organ.

In the immature male the second maxillipede is merely a blunt cone made up of three segments; the basal portion is swollen and rounded (Pl. 22. fig. 18), with a small spine on the line of union between this and the next joint; this second segment is an undifferentiated ring, which in its turn bears a spine where it connects with the last segment—but this spine is on the opposite

side to the previous one. It is difficult to decide if the terminal papilla-like part is a distinct segment or only a portion of the second; it is, however, quite free of spines or hooks, and it ends bluntly.

There seems to be no stage between this and the adult form, nor can I find any stage earlier than this; apparently there are but these two stages in the male.

The adult organ possesses a very characteristic chelate organization. There is a basal joint which, compared with the next segment, is rather slender, and is directed forwards and outwards (Pl. 22. fig. 18); articulating with this is the main joint, large and strong, on the distal end of which the chelæ work. The chelæ are composed of two parts—a pad (*pd.*) and a hinged beak (*bk.*); the protruding pad on which the beak bites is on the inner surface of the limb; at its base it is surrounded by a circlet of fine setæ; the moveable beak is hinged on in such a way as to close down on this pad, it being worked by powerful muscles. There are no setæ or spines on this appendage in the adult; it is essentially characteristic of the male, there being nothing comparable to it in the female.

The two maxillipedes are so arranged that they slope forwards and inwards, almost meeting in the middle line (Pl. 21. fig. 3, *mp.*²), the chelæ thus working *in front* of the mouth-parts. The first and second joints are bent on each other, forming a very pronounced elbow, which points outwards, for the first segment slopes forwards and *outwards*, while the second slopes forwards and *inwards*, the angle between being about 60°.

Close to the basal joint is the first maxillipede, which is considerably flatter in the adult than in the immature stage; in the adult it has the form of a very flat plate of chitin, with its rounded antero-lateral border fringed with setæ.

This appendage in *Goidelia japonica* differs fundamentally from the corresponding organ in *Clausidium*, as described by Claus and Canu. These authors show that in these cases (*Clausidium*, *Hersiliodes*, and *Giardella*) it is armed at the end with a powerful recurved spine in the male (*Giardella*), rather more reduced in *Hersiliodes*, yet in no instance is it a chelate structure as is here shown to be the case. According to Claus, there is a slight resemblance in *Clausidium*, though even there nothing occurs of the nature of chelæ, and the basal joint has a stout seta, while there are numerous defensive weapons at the extremity: “an

Stella der Endglieder finden wir einen beweglichen mit einer Fiederborste besetzten Haken der den beweglicher Arme einer Scheere ähnlich, aufwärts gegen den vorausgehenden Abschnitt eingeschlagen werden kann." However, in this Echiuroid parasite there are no accessory parts to this appendage, only the clear-cut chela closing down to its simple pad. The whole organ forms a powerful prehensile apparatus, and seems to be in no way connected with the function of alimentation. Since Kossmann calls the first maxillipede the "second maxilla," the male maxillipede is, according to his figure, an unjointed upwardly-curved claw, while in the female it is a three-jointed apparatus bearing setæ of various kinds, that of the male being devoid of such processes and a much smaller organ than in the female. In *Goidelia japonica*, as has been shown, this appendage is a mere vestige in the female, and in the male is a powerful chela (Pl. 21. fig. 3, *mp.*²; Pl. 22. fig. 18).

Thoracic Legs 1-4.—In the genus "*Hersilia*" Canu says: "Première paire des pattes thoraciques très différentes des trois suivantes semblables entre elles et transformée en organes d'adhésion. Pattes des deuxième, troisième et quatrième somites thoraciques formées de deux articles et de deux rames 3-articulées. Pattes thoraciques de la cinquième paire simples, 2-articulées et aplaties."

In the genus *Giardella*, according to Canu: "Pattes thoraciques des quatre premières paires de forme normale, biramées, à rames 3-articulées; de la cinquième paire simple, 2-articulées et aplaties." Canu looks upon the head with the first thoracic segment as constituting the first metamere; the abdomen thus has five segments, the furca forming a sixth. "C'est la première somite qui porte les orifices génitaux dans les deux sexes. Chez le mâle, ces orifices sont au nombre de deux situés symétriquement sur la face ventrale à la limite postérieure du segment; ils sont recouverts par une paire de pléopodes lamelleux terminés par une longue soie. Chez la femelle, les deux ouvertures génitales sont placées symétriquement dans une situation latéro-dorsale au tiers antérieur du segment."

In the genus *Hersiliodes* the first pair of legs, according to Canu, "sont biramées et triarticulées, sans déformation et parfaitement pourvues de soies natatoires, il en est de même dans les trois paires suivantes, toutefois la rame interne de la quatrième paire est plus allongée et peu riche en soies natatoires."

According to Claus in "*Hersilia*" *apodiformis*: "von den vier zweiästigen Beinpaaren zeigt das vordere dem Cephalothorax angehörige Paar eine so bedeutende Umformung, dass Philippi diese Gliedmasse als Kaufuss in Anspruch nehmen konnte."

Kossmann says of the same species:—"Die Spaltfüsse des ersten Paares sind zu einem kräftigen Bewegung und Haftapparat umgewandelt welche im Verein mit den übrigen Schwimmfüssen unseren Copepoden ein rasches Umhergleiten auf dem glatten Panzer seines Wirthes möglich macht. Die beiden Grundglieder scheinen mit den zwei ersten Gliedern des inneren Spaltästes zu einer Masse verwachsen zu sein, ohne dass die Contouren der einzelnen Glieder verwischt sind, das eine Grundglied trägt beim Männchen eine lange Borste, welche beim Weibchen zu einem kolossalen rückwärts gerichteten Dom oder Zahn entwickelt ist. Das andere Grundglied trägt einen kürzeren, etwas nach aussen gekrümmten Zahn, der dicht neben jenem nach aussen zu liegt. Die krümmig dieses Zahnes füllt nun eine Saugscheibe aus, welche ungefähr auf der Mitte des inneren Spaltastes angebracht ist; an der Spitze des letzteren befindet sich noch eine zweite kleinere, nebst drei Zähnen. Der äussere Spaltast ist schwach entwickelt, viel kürzer als der innere, beim Männchen mit längeren und kürzeren Borsten bedeckt, die beim Weibchen durch Dornen ersetzt sind."

Goidelia japonica differs very strikingly from all these various descriptions. The first four pairs of thoracic appendages are very highly specialized, and all alike. Each limb is biramous, and possesses a basal part of two segments, which is attached to a median sternum; this sternum is nothing more than a flat plate of chitin, with a transverse notch in the centre making it appear almost bi-lobed. Posteriorly its free edge is fringed with setæ; laterally (Pl. 22. fig. 19, s) there articulates with it the first and smallest segment of the basal part of the limb (b^1); this segment is small and irregularly shaped, bearing on its inner surface one long feathered seta which runs parallel with the setose edge of the sternal plate (fig. 19). The other basal segment is three or four times as large as this joint and rounded, its anterior (or outer) surface being smooth; on its inner surface (Pl. 22. fig. 19, b^2), near the articulation with the first basal joint, there is a very powerful short spine recurved and feathered, its insertion being apparently sunk in a small pit. The inner ramus of the limb is attached on this surface near the

spine; both rami have three articulations. The inner branch bears long feathered setæ on its inner face, one on each of the first two joints, and six on the terminal joint, three of which arise laterally and three at the extreme tip (Pl. 22. fig. 19). The opposite surface is clothed with soft fine setæ. The outer ramus is also adapted for locomotion, the first joint exhibiting distally on its outer face a short, sharp spine; a corresponding spine occurs on the second joint, which has in addition a long bearded seta on its inner side. The terminal joint has the sharp stout spine on its outer face, but on its inner surface and at the tip there are four long feathered setæ (fig. 19), with a fifth one, much smaller, pointing outwards. The whole outer surface of these three joints is covered with soft fine setæ.

The thoracic appendages of *Goidelia japonica* possess no sucking-discs like those occurring in the previously-described forms.

Thoracic Leg, 5.—In both sexes this is a uniramous organ, very feebly developed. It is practically the same in male and female, though in the latter (adult) it is broader and shorter relatively than in the male; in both cases it consists of three short equal segments, the first two each armed laterally with one long seta, the terminal segment carrying two (Pl. 21. figs. 2, 3).

Abdomen.—The first abdominal segment of the mature female is conspicuously larger than any of those following it. In reality it is not one segment, but is formed by the fusion of three; on its ventral surface it is pierced by a pair of genital pores (fig. 2, *g*) placed obliquely.

The abdomen in the adult male is marked with a lateral spine, borne on the first segment (fig. 3, *g*); near the base of each of these the minute genital openings are placed. The ventral border of this segment is fringed posteriorly with setæ (fig. 3); this edge is not parallel with the other rings, but slopes forwards to the centre, where there is a clearly-defined square area (*x*)—the significance of this is obscure, but it may have some sexual function to perform.

Furcæ.—The furcæ are short and offer no evidence of dimorphism between the sexes; each possesses a long inner seta and a shorter external one. The groove between the furcæ runs far forwards on the dorsal surface, and the anus opens into it on the last undivided abdominal segment. Ventrally the groove is less conspicuous, and does not continue so far forwards as on the dorsal surface.

GOIDELIA JAPONICA, nov. gen. et sp.

Diagnosis of Generic Characters.—Body flattened, segmented, and cyclopoid; sexes equal in size, dimorphism only being apparent on closer examination of the appendages; the male not attached to the female; no eyes.

1st antenna alike in female and male; composed of 5 segments.

2nd antenna alike in female and male; composed of 4 segments, forming a characteristic elbow; the three terminal segments constitute a powerful hooking apparatus.

Mandibles alike in female and male; very small and claw-like; with no accessory parts (such as occur in the other known genera).

1st maxillipede ♀ differs much in the immature stages; in the adult it is a claw-like organ with two recurved hooks (in the other genera this appendage is alike in both sexes, being very highly developed).

1st maxillipede ♂ alike in all stages; very degenerate, being only a fringed plate.

2nd maxillipede ♀ alike in all stages; very degenerate, being only a papilla (in the other genera this appendage shows sexual dimorphism, but in both sexes it is very highly developed).

2nd maxillipede ♂, different in the various stages; very specialized as a powerful chela (in the other genera there is no suggestion of a chelate apparatus).

Thoracic legs 1–4 all alike; biramous; no sucking-discs (such as occur in the other genera, where also the 1st leg is unlike the others).

Thoracic leg 5 uniramous in female and male.

Abdomen of 6 segments; in the female the first three are fused.

Furcæ show no difference in male and female; each furca bears a long and a short seta.

TRICHODINA (n. sp.). (Pl. 22. fig. 20.)

The rectum of *Echiurus uncinatus* gives shelter not only to the parasitic Copepod *Goidelia japonica*, but also to a minute Infusorian: being so excessively small, this creature would in all probability have escaped my notice had it not occurred in such abundance. I first saw it in a series of transverse sections of the whole *Echiurus*, where it was very conspicuous in all sections of the rectum, for the methylene-blue which I was using as a double stain settled far darker in these little parasites than in any

of the surrounding tissue. On examining the contents of the rectum, I found that it contained immense numbers of these Infusorians, but having only preserved material at my disposal I was unable to investigate more than the most salient features; in fact, to make out these points many different reagents and stains had to be used. On the whole, I found it best to first clear the material of corrosive sublimate by immersion in iodine solution, then stain with alum-carmines, finally clearing in oil of cloves.

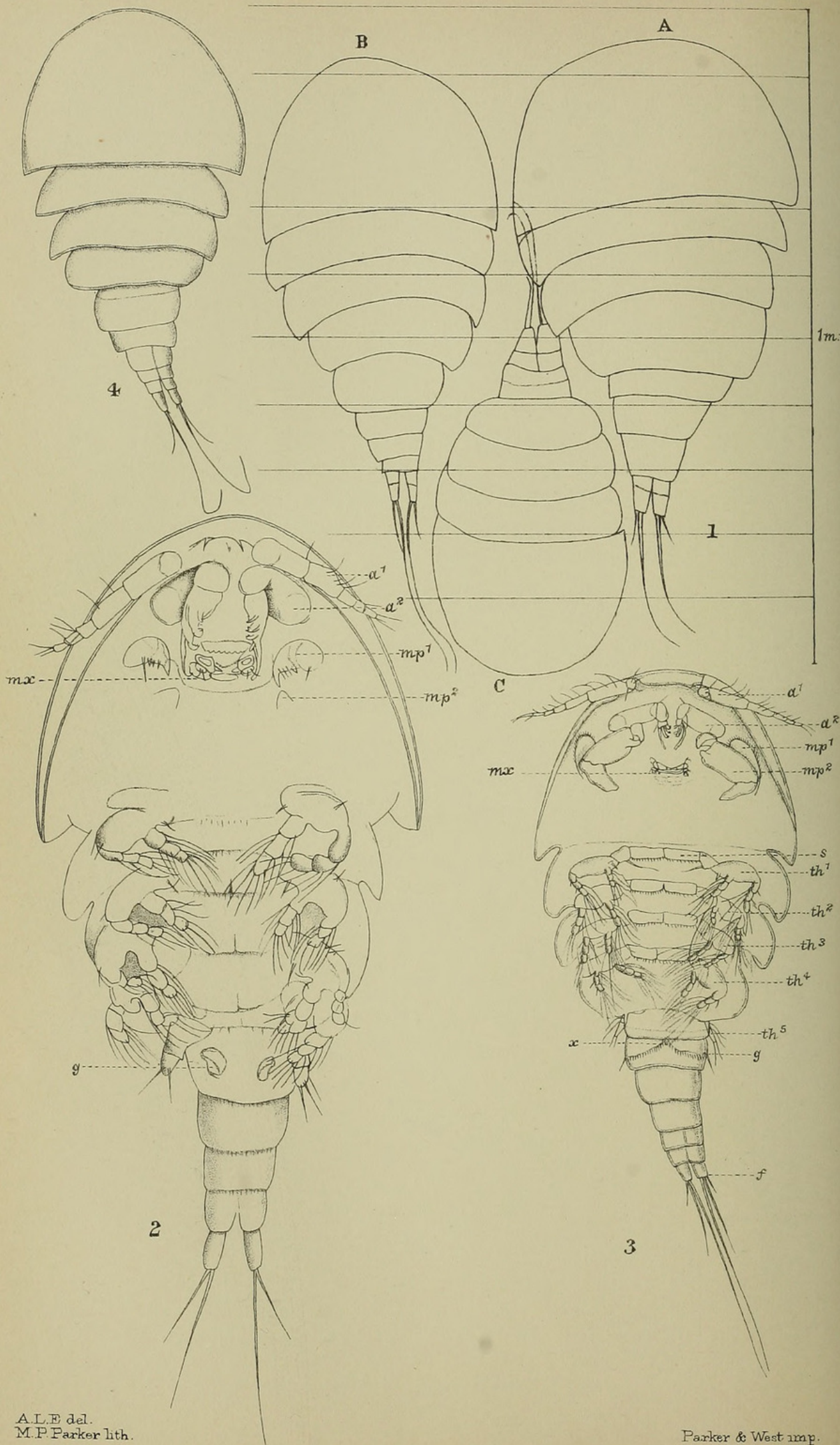
As is seen in fig. 20, the form of the body is quite spherical when looked at from above (as in i.) or from below; ii. shows a lateral view. It is not easy to say without watching living specimens, or at least examining fresh material, which is the anterior and which the posterior end. Above and below there is a circlet of cilia; at one end they encircle a depressed pit-like area around which there seemed to be signs of a skeletal ring of spines or hooks (ii., *h*). At the opposite end the cilia surround a dome-like protuberance—which may, however, have been thus forced out as a result of *post-mortem* contraction. In the rim in which the set of cilia are inserted, I saw, in many specimens, indications of a gullet, or œsophagus; this would point to the fact that this is the anterior end, which would go first in swimming. Situated just beneath this crown of cilia there is an enormous darkly-staining nucleus; it is very long and constricted at intervals so as to look like a string of beads (*nc*).

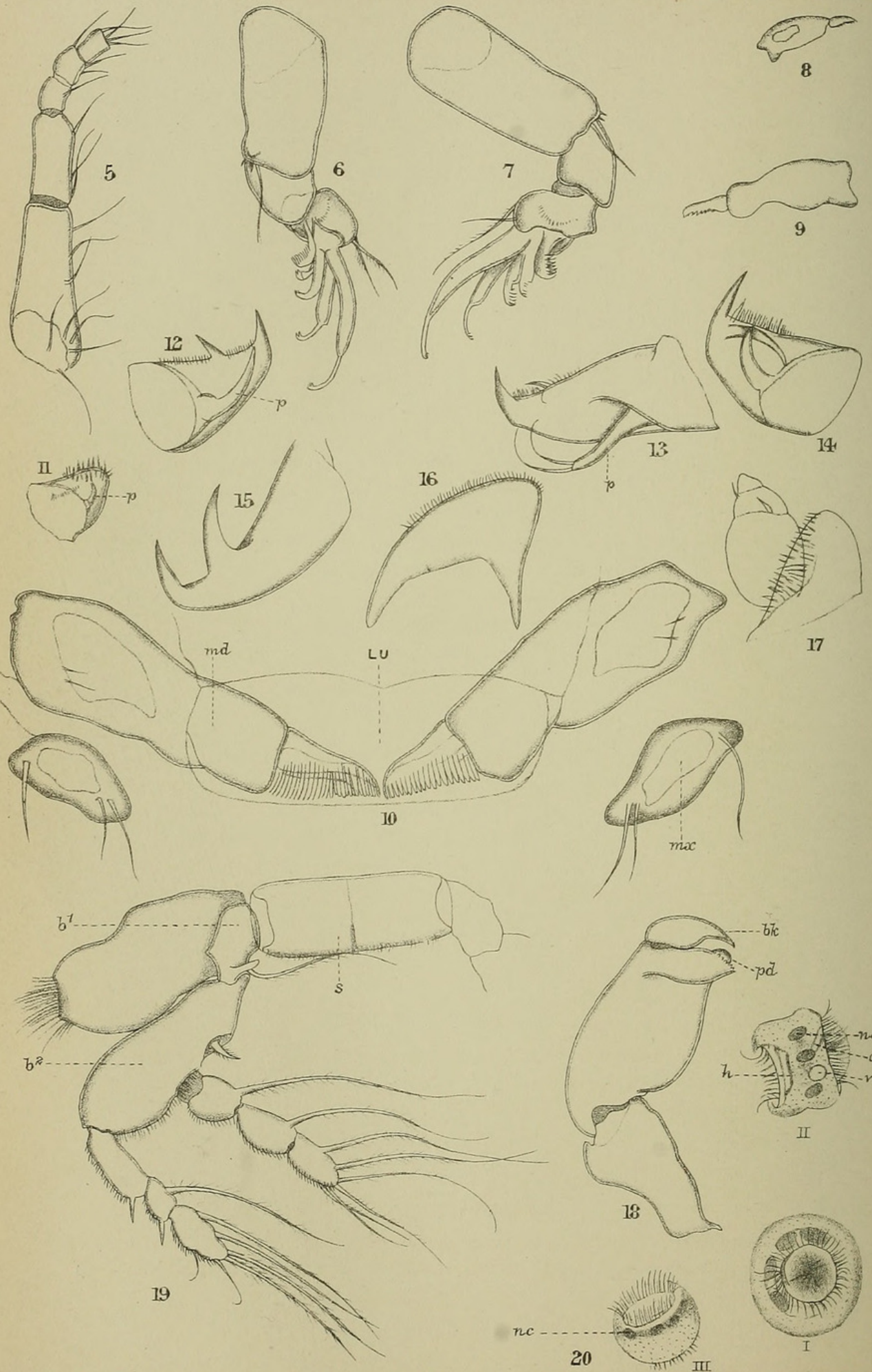
A clear spot was present near the nucleus, which may be the contractile vacuole, or a reservoir (*vc*).

So far as I can form an opinion from the material at my disposal, this is a new species of *Trichodina*, a peretrichous Infusorian related to *Vorticella*. The common species is found creeping about the surface of *Hydræ*; but I find that a representative of the genus has been met with (by Rosseter *), living an endoparasitic life in the viscera of the newt; very few were found in the testes, but myriads occurred in the renal organs—it is stated that long dearth of water in no way hurts them. This Japanese species may be identical with the form occurring in the newt, for it also leads a truly entozoic life within the rectum of its host; but as this alone is not sufficient to justify the application of a new specific name, I prefer to leave the question of species open, pending a fuller knowledge of the creature and of the habits of the accepted species of the genus.

Cambridge, Nov. 1900.

* Journ. R. Micr. Soc. vi. (2) pp. 929-933, 1 pl.





A.E. del
M.P. Parker lith.

Parker & West imp.

A NEW ENTOZOIC COPEPOD.

EXPLANATION OF PLATES 21 & 22.

Reference Letters.

A=adult ♀. B=adult ♂. C=immature ♀. a^1 =first antenna. a^2 =second antenna. b^1 =first basal segment. b^2 =second basal segment. $bk.$ =beak. f =furca. g =genital pore. h =hooks. $l.l.$ =lower lip. $l.u.$ =upper lip. $md.$ =mandible. $mp.^1$ =first maxillipede. $mp.^2$ =second maxillipede. $mx.$ =maxilla. $nc.$ =nucleus. α =oesophagus. $pd.$ =pad. p =palp. s =sternal plate. $th.^{1-5}$ =thoracic legs 1-5. $vc.$ =vacuole. x =curious glandular patch between 1st and 2nd abdominal segments in the adult male.

Goidelia japonica.

[Figs. 1-19 drawn with the *camera lucida*.]

Fig. 1. Outline-drawings of:—

A. Adult ♀. B. Adult ♂. C. Immature ♀.

Superposed on a correspondingly magnified millimetre-scale, the divisions of which are to 1/10 mm.

2. Stage B of 1st maxillipede ♀, drawn from the ventral face, and magnified considerably more than figs. 3 & 4.
3. Adult male from the ventral side, showing the peculiar modification of the two basal abdominal segments.
4. Dorsal view of young female.

[Figs. 5, 6, 7, 8 all drawn on the same scale to show relative sizes.]

5. First antenna.
6. Second antenna, ♀.
7. „ „ ♂.
8. Mandible showing terminal claw.
9. „ on an enlarged scale.
10. Mouth-parts *in situ*, showing the upper and lower lips, mandibles, and maxilla.

Figs. 11, 12, 13, 14, 15.—Stages in the development of the first maxillipede ♀—all drawn on the same scale.

11. Stage A, showing the undifferentiated condition.
12. „ B (ventral view).
13. „ B (dorsal view).
14. „ C, showing the new hooks folded up within.
15. „ D, adult organ.
16. First maxillipede ♂.
17. Second maxillipede ♂, immature stage with chelæ undifferentiated: the first maxillipede is shown *in situ*.
18. Second maxillipede ♂, adult chelate form.
19. One of the first four thoracic legs, showing its relative position to the sternal plate.

Trichodina ? sp.

Fig. 20. *Trichodina*, showing the curious beaded nucleus in various positions, with the two circlets of cilia and the clear vacuole (contractile vacuole?).



Embleton, Alice L. 1901. "Goidelia japonica-a New Entozoic Copepod from Japan, associated with an Infusorian (Trichodina)." *The Journal of the Linnean Society of London. Zoology* 28(181), 211-229.

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