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L.—Some notes on the parasitic Copepod Thersitina gasterostei, Pagenstecher

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on the labrum, which is larger than the three others. The denticles on the inner lip correspond to the terminations of spirals around the lower part of the whorl. The notch on the inner edge of the columella is smooth and situated opposite the second denticle from the anterior end.

Calliostoma roseopictum. (Pl. IX. fig. 4.)

Testa parva, conica, anguste umbilicata, maculis roseis et albis picta, superne virescens et pallide cornea, ad basim lineis tribus concentricis roseis aliisque radiantibus ornata; anfractus sex, superiores tres convexiusculi, læves, dilute carnei, duo sequentes plani, subvirides, roseo plus minus picti, ultimus ad peripheriam rotunde angulatus, roseo alboque articulatus; ultimus et penultimus spiraliter regulariter striati, striis vel sulcis sex angustissimis, quam interstitiis longe angustioribus; basis infra angulum convexiuscula, versus umbilicum angustum album magis tenuiter concentrice striata; columella oblique arcuata; labrum intus incrassatum, album; apertura intus margaritacea, obsolete sulcata.

Alt. 4·3, diam. 3 mm.

The specimen here described, although very small, appears to be adult, since the outer lip is thickened within. The thread-like sulci upon the spire and the three upon the base are coloured, and contrast clearly with the ground-colour of the shell. The former are brownish and the latter more rosaceous.

The spotted lira at the periphery passes up the spire, forming a distinct margination beneath the suture.

This species is evidently closely allied to *C. marmoreum*, Pease, from the Paumotus, and may eventually prove to be a small, less elongate, and differently coloured variety of it.

EXPLANATION OF PLATE IX.

Fig. 1. *Engina fuscolineata*, sp. n.
Fig. 2. *Tritonidea difficilis*, sp. n.
Fig. 3. —— *rosacea*, sp. n.
Fig. 4. *Calliostoma roseopictum*, sp. n.

L.—*Some Notes on the Parasitic Copepod* Thersitina gasterostei, *Pagenstecher.* By Robert Gurney, M.A.

[Plates X.–XIII.]

The family Ergasilidæ, to which *Thersitina* belongs, has recently been most ably monographed by Wilson*, so far,

* C. B. Wilson, Proc. U.S. Nat. Mus. xxxix. 1911, pp. 263–400.

at all events, as concerns the North-American species ; but it appears that the genus *Thersitina*, which he was unable personally to examine, is still involved in some obscurity, owing to conflicting statements as to the structure of the single species, *T. gasterostei*. As I have had the opportunity of obtaining abundant material of this species, it seems worth while to give some account of its structure and life-history.

Occurrence.

Thersitina gasterostei is found in abundance under the gill-opercula of sticklebacks (*Gasterosteus aculeatus*) in the ditches containing somewhat brackish water in the neighbourhood of Yarmouth, but I have never found it in quite fresh water. It seems to show a decided preference for the three-spined stickleback (*G. aculeatus*), so that, in a ditch in which every specimen of that species is infested, many specimens of the ten-spined stickleback (*G. pungitius*), though the commoner of the two, may have no parasites at all, and it never has so many as the other species. On *G. aculeatus* I have found as many as forty specimens of *Thersitina* under one operculum, and it is not uncommon to find one operculum smothered with the parasites while the other is nearly free from them. The parasite is found under the posterior part of the gill-operculum, clasping the mucus which covers the skin, but not apparently fixed to the skin itself. When specially numerous, specimens may be found attached to the mucus of the gills themselves, and I have even found them clinging to the pectoral and dorsal fins and to the tail.

Breeding Periods.

Towards the end of October the adult females found are without egg-sacs and usually the ovary is also empty ; but a large number are immature, not having reached the swollen condition of the adult. It seems probable that the adults do not survive the winter, and it is very noticeable that the number of adults found decreases from August onwards. I believe that the last generation of young, hatched about the beginning of October, fix themselves towards the end of the month, and pass the winter and early spring in a more or less dormant condition. All the evidence points in this genus, as in *Ergasilus*, to the conclusion that the female is fertilized once and for all during the free-swimming stage. I have never once found a male beneath the operculum of the host, but I have seen spermatophores attached to a free-swimming

female. The large size of the receptaculum seminis also seems to confirm this conclusion. No males are to be found at the time when reproduction first becomes active in the spring, so that the spermatozoa must remain alive within the female for about five months.

I have no observations for November or December, but in January neither larvæ nor egg-bearing females are to be found. Reproduction first becomes active about the beginning of March, and continues throughout the summer. There seems to be a distinct periodicity, indicating, as I believe, a series of five generations within the year, though, of course, these generations will to some extent overlap and obscure one another. I suppose that a mature female lays two, or perhaps three, lots of eggs, and then dies and gives place to the new generation. The general course of events is, I think, as follows:—

January.—Period of rest. No eggs. No larvæ.
March.—Reproductive period begins. Nauplii to be found, but no later larvæ.
April.—Larvæ mature, and fix themselves towards end of month.
May.—Disappearance of the winter generation? Egg-laying of new (first) generation hatched in April.
June.—Fixing and maturing of adults continue and some begin to hatch eggs.
July.—No observations, but probably the second generation hatched in June breed and their larvæ mature.
August.—Third generation fix and produce young, so that at end of month the fourth generation is nearly ready to fix.
September.—No observations. Probably fixing and ripening of fourth generation.
October.—Fourth generation still living, but ceasing to breed. Fifth generation fixing and beginning to mature.
November and December.—No observations. Probably a resting period, without production of eggs.

Structure of the Adult.

The general form of the adult female has already been adequately described *, but no account of the male has, so far as I am aware, been given. The male described and

* Scott, Eighteenth Ann. Rep. Fishery Board for Scotland, part iii. 1900, p. 146.

figured by Kröyer is an adult female in the free-swimming stage.

The male (Pl. XII. fig. *a* and Pl. XIII. fig. *f*) closely resembles the free-swimming female, but is readily distinguished from it by the possession of the large sickle-shaped maxillipedes and the form of the abdomen, the genital segment generally having a refringent appearance, owing to the contained spermatophores. The body is also somewhat more slender and the abdomen longer. The first thoracic segment is fused with the head, but the succeeding four segments are all distinct. The abdomen consists of five segments, the genital segment being as long as the remaining four together and bearing a seta on either side at its posterior angles. The fourth segment has a ventral ring of cilia. The furcal rami are, as in the female, short and conical, bearing a very long seta and three short subequal ones with a very characteristic arrangement (Pl. XIII. fig. *f*). In the free-swimming female the abdomen consists of four segments only, and the openings of the oviducts on the dorsal surface are very conspicuous. The appendages of the male do not differ from those of the female, with the exception of the presence of the maxillipede.

The Appendages.

First pair of antennæ.—Unlike *Ergasilus*, the first antenna of *Thersitina* consists of five distinct joints, of which the proportional length is, on an average, as follows :—

Joints.....	1	2	3	4	5
Length	16	7	8	6	5

The joints bear numerous very transparent setæ, one of which, on the posterior face of the third joint, is conspicuously long.

Second pair of antennæ.—These are strong prehensile appendages composed of four joints, the last joint being in the form of a strong claw with a stout accessory claw at its base. In the male the whole appendage is more slender than in the female and the accessory claw is very small.

Mouth-parts.—The mouth-parts are exceedingly difficult to follow out even in the larva, owing to their minuteness and crowded position, and there seems to be no adequate published account of them. I have found it best to boil the adult female in caustic potash before examination, since it is then comparatively easy to see the appendages in their natural positions. There are then visible three pairs of

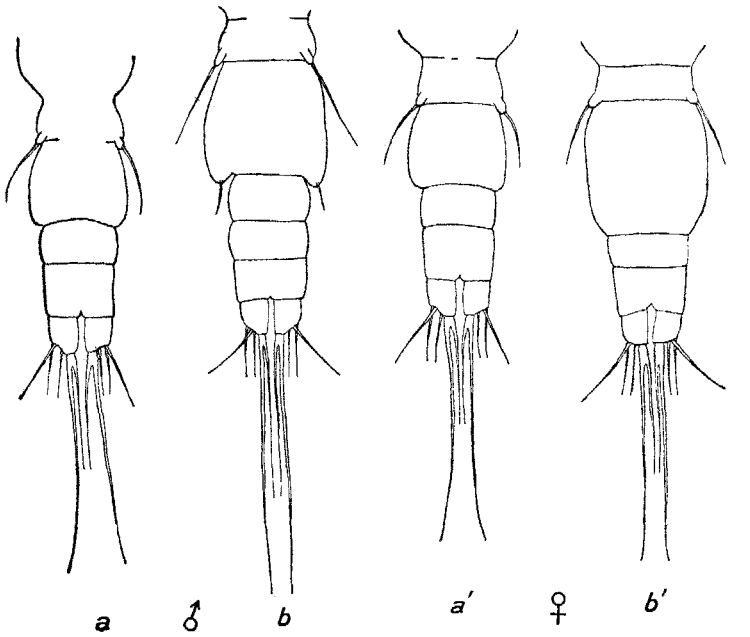


Fig. 1

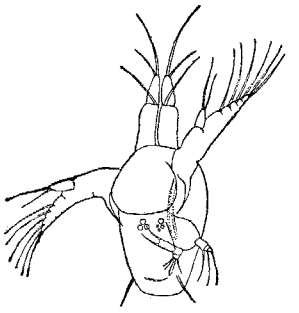


Fig. 2

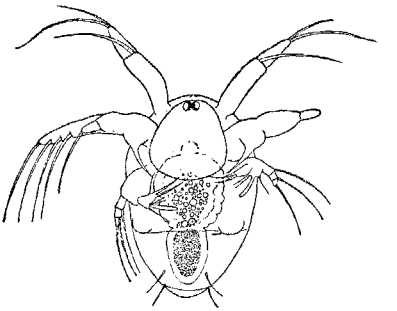


Fig. 3

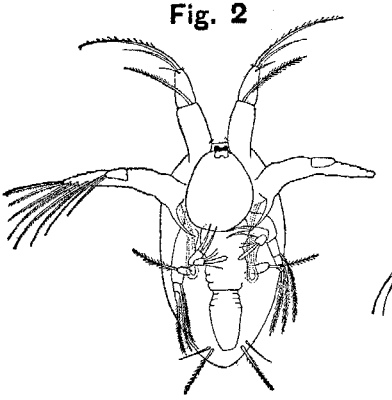


Fig. 4

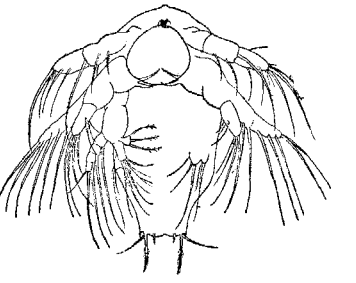
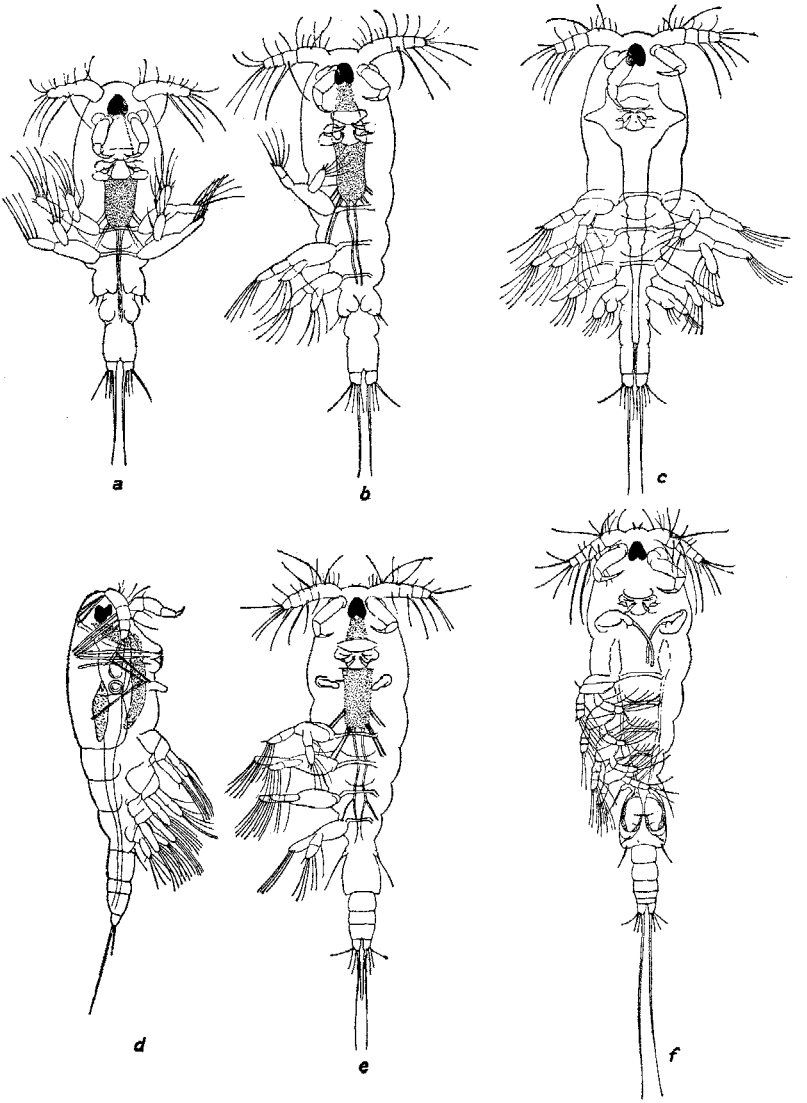


Fig. 5



appendages—mandibles, first maxillæ, and second maxillæ (Pl. XI. fig. *c*),—but in the male a pair of maxillipedes are also present (Pl. XI. fig. *a*). The mandibles are strong wedge-shaped organs with a toothed cutting-plate and an accessory toothed lobe running upwards into the mouth. This lobe is overhung by the free edge of the labrum, which is a delicate plate largely fused with the cuticle of the head.

The first maxillæ are very rudimentary, and consist of a pair of minute knobs bearing three short spines (Pl. XI. fig. *d*).

The second maxillæ consist of a large basal part, divisible into two joints, and a distal curved joint with a toothed end (Pl. XI. fig. *e*). This distal joint is very freely movable, and can generally be seen in active movement when the living animal is examined.

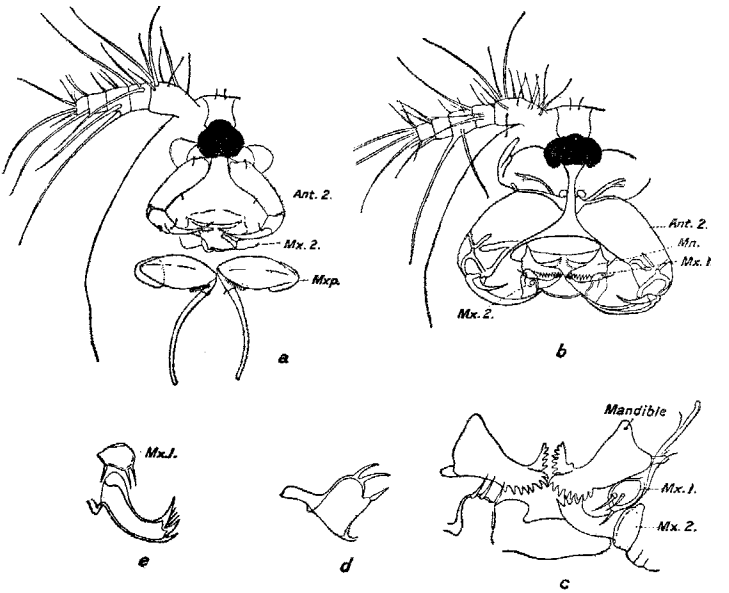
The maxillipedes appear first in the last larval stage of the male as a pair of simple knobs, and are fully developed at the next moult. In the adult male the maxillipede is three-jointed, the first joint fused with the head, but the other two freely movable. The second joint is broad and armed with a row of small spines, and the distal joint is a long curved clasping rod, sometimes showing an apparent division at the base into two joints.

According to Dr. Scott, the mouth-parts consist of mandibles, maxillæ, and two pairs of "maxillipedes"; and in his more recent account* he appears to confirm his original description.

I have examined a number of specimens, and have in no case found more than three pairs of appendages in the female, so that it is clear that these appendages do not differ in number or position from those of *Ergasilus*. Wilson (1911, p. 283) has given reasons, with which I fully agree, why the two pairs succeeding the mandibles should be designated as maxillæ and the pair following them in the male as maxillipedes or thoracic appendages. A full discussion of the mouth-parts of *Thersitina* and *Ergasilus* will be found in Wilson's paper.

The swimming-legs.—The first three pairs of legs have both rami three-jointed and of approximately the same length. The two basal joints are very broad and the legs of each pair are united by a strong chitinous bar attached at its ends to the first basal joint. The second joint bears a seta on its outer face and two rows of small spines on its inner edge.

* 'British Parasitic Copepoda' (Ray Society, 1913), p. 42.



The outer edge of the joints of the inner ramus is fringed with a row of delicate spines. The numbers of setæ borne by the different joints are shown in the following table:—

Joints.	Leg 1.		Leg 2.		Leg 3.		Leg 4.	
	R.E.	R.I.	R.E.	R.I.	R.E.	R.I.	R.E.	R.I.
1....	—	1	—	1	—	1	—	1
2....	1	1	1	2	1	2	5	2
3....	5	4	6	4	6	4	—	4

The fourth pair have the outer ramus two-jointed and shorter than the three-jointed inner ramus.

The fifth pair of legs are simply small knobs bearing a single terminal seta.

Wilson states (1911, p. 271) that in males and immature females of the Ergasilidæ a pair of rudimentary legs are to be found on the genital segment, but I have not found any trace of them in *Thersitina* at any age or in either sex.

Internal Anatomy.

The internal structure, so far as I have been able to study it, does not differ from that of *Ergasilus* as described by Wilson. The only point in which there appears to be any important difference is in the nervous system. I have not been able to follow its arrangement in the adult female, but in the free-swimming female and in the male the greater part of it is fairly easy to see. Whereas in *Ergasilus* there is, according to Wilson, a double ventral nerve-cord with ganglia corresponding to each of the swimming-legs and an additional ganglion in the genital segment, in *Thersitina* the nerves of the first three pairs of swimming-legs arise from the posterior angles of the great postœsophageal ganglion, which also sends off a pair of slender cords which run back parallel and close to each other for a considerable distance before sending off nerves to the fourth pair of legs and continuing on into the genital segment (Pl. XIII. fig. *e*). I have not been able to detect any separate thoracic ganglia.

Larval Stages.

The nauplii can readily be obtained by isolating females with very advanced eggs, but the eggs will not hatch when so isolated unless the nauplii are already visible and active within them. The nauplii will live for some time in water not specially aerated, but I have not been able to keep them thus up to the Cyclopid stage. No doubt it would be easy to keep them to maturity with a proper system of aeration. Unfortunately my water-supply does not admit of a satisfactory arrangement.

The First Nauplius.

When first hatched the nauplius is of the usual Cyclopid form and only ·11 mm. in length. It is very transparent, but has conspicuous blue pigment round the gut (Pl. XII. fig. 2).

The first antennæ are two-jointed, with a single seta at the apex of the first joint and two setæ of unequal length at the apex of the second joint.

The second antenna consists of a stout stem bearing a minute one-jointed endopodite and a large exopodite with a row of six setæ. The stem is constricted, though not segmented, into two joints, and has a large masticatory hook at its base.

The mandible consists of a broad basal segment and two short branches. The endopodite is indistinctly two-jointed, the basal joint bearing a large masticatory lobe armed with two stiff setæ. The distal joint bears three setæ and a large thick æsthete. The distal end of the body is provided with the usual pair of setæ. The anus is apparently imperforate.

The Second Nauplius. (Pl. XII. fig. 3.)

Six days after hatching the nauplii showed very little change. The length was ·16 mm., or a growth of ·05 mm.

The appendages remain as before, except that in the case of the mandible the exopodite is distinctly three-jointed and the endopodite has the appearance of a simple masticatory appendage of the basal joint. It consists of the previous masticatory lobe and a minute knob bearing the large æsthete and three setæ. Behind the mandible are seen beneath the skin the rudiments of a fourth pair of appendages. The posterior end of the body has now two pairs of setæ.

The antennal gland is present in the form of a long slender tube running back behind the mandible and returning on

itself to open at the base of the second antenna. The anus is still imperforate.

The Third Nauplius. (Pl. XII. fig. 4.)

Seven days after the nauplii had entered the second stage some were found to have moulted into a third stage and to measure about ·17 mm. In this stage the first three pairs of appendages are practically unchanged, but a fourth pair is now present in the form of simple cylindrical processes with a single apical seta. These appendages may represent the second pair of maxillæ. The anus still appears to be imperforate. The blue colour surrounding the gut is now, and remains in later stages, a distinctive and easily recognized character. The maxillary gland is first seen at this stage.

Later Nauplii.

After the stage described above all my nauplii died off with the exception of one individual which, one month after hatching, had reached a size of ·25 mm., but had no more appendages than before. In this stage the first antennæ have numerous setæ and are distinctly three-jointed (Pl. XII. fig. 5). The second antenna differs from the preceding stage in having two basal masticatory hooks instead of one, while the mandible has lost the characteristic flat æsthete of the inner ramus. At some distance behind the mandible is a fourth appendage in the form of a bilobed plate bearing six setæ. Immediately behind this appendage a line is seen across the body which marks the division between thorax and abdomen, so that this appendage is evidently the second maxilla, and not a thoracic appendage. I have not been able to find any trace of a first maxilla. Further back the first pair of swimming-legs can be faintly seen beneath the skin in some specimens.

I have not found any nauplii either larger than the one here described or with any additional appendages, so that it seems probable that this, the fourth, Nauplius stage changes directly into the first Cyclopid stage.

Cyclopid Stages.

Between the last nauplius found and the free-swimming adult condition I distinguish five stages, probably corresponding to as many moults. As figures are given of these stages, it is only necessary to add a short summary of the changes that characterize them.

Stage 1. First Cyclopid (Pl. XIII. fig. *a*) :

Antenna 1 indistinctly four-jointed.
Antenna 2 five-jointed as in the adult, but without accessory claws.
Mandibles and maxillæ as in the adult.
Leg 1 with indications of two joints in each ramus.
Leg 2 with one-jointed rami.
Leg 3 simple papillæ.
Leg 4 indicated beneath the skin.
Body : four thoracic segments distinct ; posterior region unsegmented.

Stage 2 (Pl. XIII. fig. *b*) :

Antenna 1 distinctly four-jointed.
Antenna 2 and mouth-parts as before.
Legs 1 to 3 with two-jointed rami.
Leg 4 simple papillæ.
Body : five thoracic segments distinct ; abdomen unsegmented.

Stage 3 (Pl. XIII. fig. *c*) :

Antennæ and mouth-parts as before.
Legs 1 to 3 with two-jointed rami.
Leg 4 with rami one-jointed.
Leg 5 indicated by a seta, but no papilla.
Abdomen of two segments.

Stage 4 (Pl. XIII. fig. *d*) :

First differentiation of sex.
Appendages as before, with the exception that the fifth pair of legs is present and in the male the maxillipede is present as an unjointed papilla.
Abdomen three-jointed (Pl. XII. fig. 1, *a*, *a'*).

Stage 5 (Pl. XIII. fig. *e*) :

In the male maxillipede with indication of joints.
In both sexes leg 4 two-jointed.
Abdomen four-jointed (Pl. XII. fig. 1, *b*, *b'*).
In the female the first abdominal segment has increased in size.

Stage 6 (Pl. XIII. fig. *f*, ♂):

Free-swimming adult.

In both sexes the adult form is assumed for all appendages, and the abdomen in the male becomes five-jointed.

Systematic Position.

Wilson* has already discussed the relationship of *Thersitina* and *Ergasilus*, and has come to the conclusion that the two genera are distinct; and with this conclusion I am in agreement. The differences between the genera are, however, very small, the most important being the inclusion of the second thoracic segment in the globular cephalothorax of the adult female and the structure of the antennæ. The mouth-parts differ somewhat in structure, but are the same in number as in *Ergasilus*.

The genus contains but one species, *T. gasterostei* (Pagenstecher), since *T. biuncinatus* (Gadd) is certainly indistinguishable from it.

EXPLANATION OF THE PLATES.

Plate X.

Thersitina gasterostei, mature female. Leg 1 on right side and legs 2 and 3 on left omitted.

Plate XI.

Fig. a. Ventral view of male (adult).
Fig. b. Ventral view of female (free-swimming adult).
Fig. c. Mouth-parts of adult egg-bearing female. The second maxilla of the right side removed and the first maxilla somewhat displaced.
Fig. d. First maxilla isolated.
Fig. e. First and second maxillæ isolated.

Plate XII.

Fig. 1. Abdomen of larva in stage 4 and 5. *a*, *a'*, stage 4, male and female; *b*, *b'*, stage 5, male and female.
Fig. 2. First Nauplius immediately after hatching.
Fig. 3. Second Nauplius six days old.
Fig. 4. Third Nauplius eleven days old.
Fig. 5. Fourth Nauplius.

Plate XIII.

Figs. a–e. Five Cyclopid stages.
Fig. f. Adult male.

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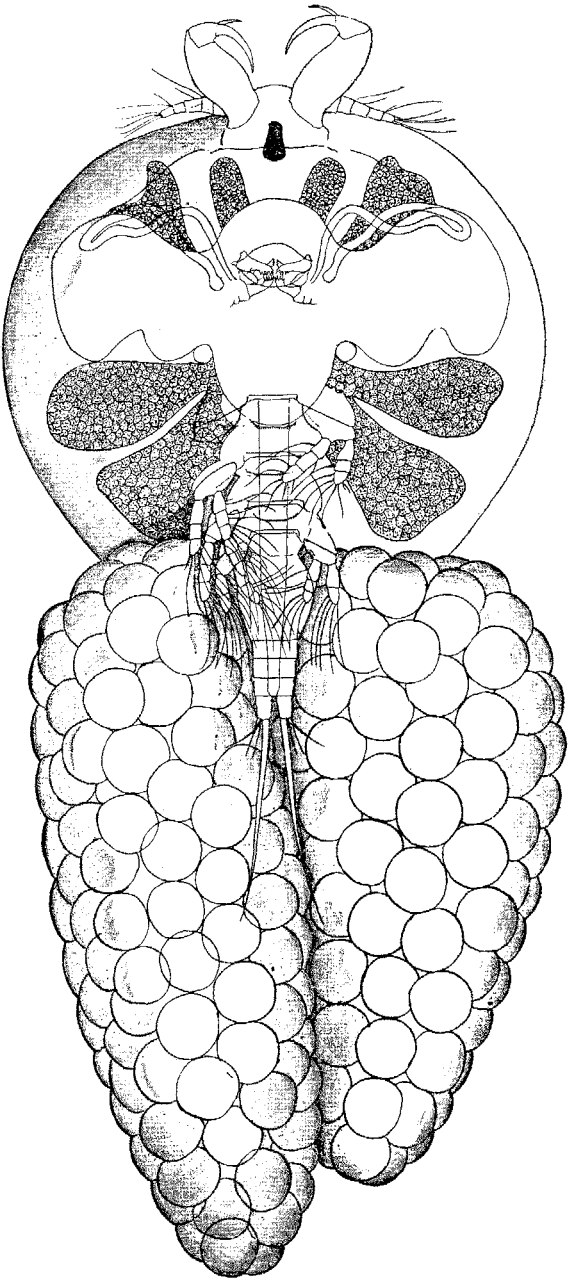
* Wilson, Proc. U.S. Nat. Mus. xxxix. 1911, p. 349.



THERSITINA GASTEROSTEI.