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SOME OBSERVATIONS ON THE LARVAL DEVELOPMENT OF CYCLOPS LEUCKARTI CLAUS AND CYCLOPS HYALINUS REHBERG

by

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Introduction.

Whilst examining the vertical distribution of planktonic Copepoda in the Klinkenberger Put, a deep pond at Warmond near Leiden, wide about 400 m, without any connection with other water, samples were taken in October 1951, November 1951, January 1952, February 1952, and March 1952. In the samples of March 1952 a large quantity of larvae of Copepoda were found. A small part of them was in the naupliar stages; the majority, however, appeared to be present as copepodids. These copepodids proved to belong to two different subgenera, viz., *Cyclops* Claus and *Mesocyclops* Sars. In the samples only a few adult forms were found, these were *Cyclops* (*Cyclops*) *strenuus* Fischer, *Cyclops* (*Cyclops*) *vicinus* Uljanin, *Cyclops* (*Mesocyclops*) *leuckarti* Claus, and *Cyclops* (*Mesocyclops*) *hyalinus* Rehberg. As representatives of the Centropagidae (Calanoida) were found some adults and larvae of *Diaptomus gracilis* Sars and larvae of the genus *Eurytemora* Giesbrecht.

Countings of the Copepoda in the samples proved that the vertical distribution of the copepodids was in no way homogeneous, the density being the highest at the surface and at the bottom (15 m). A very low density was found at a depth of 11 meters. It was, however, difficult to determine whether these maximal occurrences manifested themselves in all the species present or that the different peaks were caused by concentrations of different species at different depths, because a scrutiny of the available literature failed to produce keys (or tables) for the identification of the copepodid stages. No enumeration of the differences between the copepodids of the above mentioned species could be found. There only exist keys to adult forms and for some species to the nauplii (Manfredi, 1923 and 1925; Amelina, 1927; Ewers, 1930).

It is comparatively simple to distinguish between the subgenera mentioned, not so, however, to find differences between the copepodid stages of the species of the *Mesocyclops* group.

It may be of importance to workers on hydrobiological subjects to be able to distinguish between the various forms if these are present as larvae, since many closely allied forms often appear to have entirely different ways of living. It is therefore that special attention is paid to this problem here. In this investigation only the species of the subgenus *Mesocyclops* are considered.

To the subgenus *Mesocyclops* belong the following species, all of which have been recorded from the Netherlands (Van Breemen, 1907): *Cyclops leuckarti* Claus, *Cyclops dybowski* Lande, *Cyclops hyalinus* Rehberg, *Cyclops oithonoides* Sars.

In the samples from the Klinkenberger Put taken in October 1952 so many copepodids were present that these samples were used in this investigation. Only *Cyclops leuckarti* and *Cyclops hyalinus* were found, the latter in great quantities, the former only rarely. Adult forms of *Cyclops* were not found in October. The adult specimens which served for comparison were taken from samples of March 1952. *Cyclops leuckarti* and *Cyclops hyalinus* both occur in summer as adults (Van Breemen). It appeared that the adults had already vanished in October, while their descendants dominated the plankton. In March the first adults reappeared.

So the purpose of this investigation was to find

1. whether the distinguishing characters of the adults of *Cyclops leuckarti* and *Cyclops hyalinus* can also be used to distinguish between the copepodids of these species.
2. whether there are additional larval characters which can be of importance as distinguishing characters between the copepodids.
3. how the sexes can be distinguished in the copepodids.
4. Moreover, special attention is paid to the remarkable development of the sixth leg in the female.

Historical notes.

Although Claus (1858, 1893) described the development of the larvae of Copepoda in general, and Dietrich (1915) studied the first copepodid stage of *Cyclops strenuus* as the successive stage of the nauplii observed by him, no attempt was made to find specific differences in *Cyclops* copepodids until Manfredi in 1923 traced the whole development of *Cyclops* *bicuspidatus* Claus, *Cyclops serrulatus* Fischer, and *Cyclops prasinus* Fischer, and in 1925 of *Cyclops albidus* Jurine, *Cyclops vernalis* Jurine, *Cyclops oithonoides* var. *hyalina* Schmeil (= *Cyclops hyalinus* Rehberg), and *Cyclops strenuus* Fischer.

Meanwhile many investigators studied the development of nauplii in different species (Manfredi, Amelina, Ewers, etc.) but only a few (e.g., Manfredi) examined their copepodid stages as well. Manfredi does not mention the characters in which *Cyclops hyalinus* differs from other species. She describes the development of the antennula, but her account of the number of segments of this appendage in stage V (fifth copepodid stage) is rather confused. Ziegelmayer (1925) studied the larval stages of the genus *Cyclops* in general. No attempt, however, was made to find specific differences. Lucks (1926) described the development of *Cyclops viridis* Jurine and *Cyclops phaleratus* Koch. Gelmini (1928) described among other things the development of the antennula in *Cyclops leuckarti*. The difference found by her in the number of the segments of the antennula in the female in stage IV from that of the antennulae of females of other species (*Cyclops oithonoides* var. *hyalina*!) have not been confirmed by the results of my investigation. Gurney (1931, 1932, 1933) gives a full account of the larval development in fresh water copepoda, but only gives keys to the adult forms. He describes (1931) the 5th and 6th leg in both male and female for *Cyclops* in general, and shows how these rudimental limbs are derivable from the normal biramous swimming-leg. In the volume in which he deals with the Cyclopoida (1933) he describes the segmentation in the copepodids, and notes how the first and second abdominal somites reunite in the female to form the genital somite in the last moult.

Metamorphosis.

The species *Cyclops leuckarti* and *Cyclops hyalinus* both belong to the only genus of the Cyclopoida. In this group the larvae pass through 10 stages: 5 naupliar and 5 copepodid stages, whilst the last stage (11th) is the adult form (Manfredi, 1923).

There is some confusion about the nomenclature of the stages. Some authors (Manfredi, Gelmini) call the second series of larval stages (6th-10th) "metanauplius", whereas others (Dietrich, Ziegelmayer) use this name for the stages 2 to 5 (inclusive) or 3 to 5 (inclusive) in the nauplius, the first or the first and second stages being called orthonauplius. In the present paper the first series of stages is called nauplius, the second series is called copepodid. The copepodid stages are indicated by Roman numbers (I, II, III, IV, and V).

In the last naupliar stage the cephalothorax is present with the antennulae, the antennae, the mouthparts (mandibulae, maxillulae, maxillae, maxillipedes), and the first three pairs of swimming-legs. Segmentation of the body is hardly to discover.

After the moult from the fifth naupliar stage into the first copepodid the parts of the furcal somite are separated and the fourth pair of swimming-legs appears. The new last somite represents the abdomen and the somite of leg 5. After the next moult all thoracic somites are separated and the abdomen consists of one somite, the anal somite, which gives rise to a new somite at every consecutive moult, until 4 abdominal somites are formed at the fifth stage (Claus, 1858). The adult male has five abdominal somites, the adult female has only four, as at the last moult the first and second abdominal somites reunite to form the genital somite with the receptaculum seminis.

The following table, showing the thoracic and abdominal somites as present in the successive stages (with the total number of the somites in brackets), is based on data from Gurney (1933).

	Thoracic somites	Abdominal somites
Stage I	1, 2, 3, and 4 (4)	last somite (abdominal + anal somite) (1)
Stage II	1, 2, 3, 4, and 5 (5)	anal somite (1)
Stage III	1, 2, 3, 4, and 5 (5)	1 and 5 (anal) (2)
Stage IV	1, 2, 3, 4, and 5 (5)	1, 2, and 5 (3)
Stage V	1, 2, 3, 4, and 5 (5)	1, 2, 3, and 5 (4)
Adult male	1, 2, 3, 4, and 5 (5)	1, 2, 3, 4, and 5 (5)
Adult female	1, 2, 3, 4, and 5 (5)	genital somite, 3, 4, and 5 (4)

Material.

The material used was collected in the Klinkenberger Put at Warmond. Samples of 7 liters were taken in October 1951 and March 1952 by means of a hand pump and were filtered through a net of bolting silk. The depth of the Put is 15 m on the spot where the samples were taken. The material studied mainly came from depths of 6, 9, and 10 m. It was preserved in formaline of 4 to 6 %.

Copepodids of stage I were not found in the samples. Stage II was represented by a small number of larvae of only one species. Therefore these two stages are not discussed here. Larvae of stage III were not abundant but occurred in sufficient number to be certain of the general validity of the characters observed. Copepodids of stage IV and V formed the majority of the larvae.

The distinguishing characters of the larvae of the subgenus *Mesocyclops* Sars.

A species of the *Mesocyclops* group can always be recognised in the IVth and Vth copepodid stages, and in the adult stage by the fifth leg, which consists of two segments of which the terminal segment bears a long outer apical seta and a slender inner spine, which can be apical or subapical in the various species of this subgenus.

In the IIIrd stage the subgenus is not so easily recognised, as leg 5 has not yet obtained its definite shape. The short furca in comparison to that of many other species, and the slenderness of the body can be used as indications. The abundance of specimens of the *Mesocyclops* group in the water from which the samples were taken was of great help. Here the group dominated to such an extent that the copepodids of stage III found in these samples certainly belonged to it, the more so as the larvae of the subgenus *Cyclops* are much bigger than the larvae of the *Mesocyclops* group, whilst other species of the genus *Cyclops* were not present in the samples. Manfredi (1925) too used this method to discriminate between the species of the larvae of *Cyclops albidus* or *Cyclops fuscus* (big larvae) and *Cyclops oithonoides* var. *hyalina* (small larvae).

The differences between the adult forms of *Cyclops leuckarti* and *Cyclops hyalinus* and their usefulness to distinguish between the larvae of both species.

The most important characters in which the adults differ are:

1. The antennula of the female. The antennula consists of 17 segments in both species. In *Cyclops leuckarti* the last two segments bear a broad hyaline membrane which is serrated in both segments, but the membrane of segment 17 shows one or more notches in its anterior part. *Cyclops hyalinus* also has a hyaline membrane on the last two segments of the antennula, but these are not as conspicuous as in *Cyclops leuckarti*, and the membrane on the last segment has no notches anteriorly.

2. The maxilla in male and female. The basis of the maxilla of *Cyclops leuckarti* is conspicuously ribbed. The basis of the maxilla of *Cyclops hyalinus* only shows a few minor protuberances, but is definitely not ribbed.

3. The basal segment of leg 1 in male and female has a long inner seta in *Cyclops hyalinus*, which does not occur in *Cyclops leuckarti*.

4. Leg 4 in male and female. The endopodid of leg 4 has two apical spines. In *Cyclops hyalinus* the inner apical spine is about twice as long as the outer spine, whereas in *Cyclops leuckarti* there is not much difference in length. Here the inner spine generally is a little shorter or occasionally

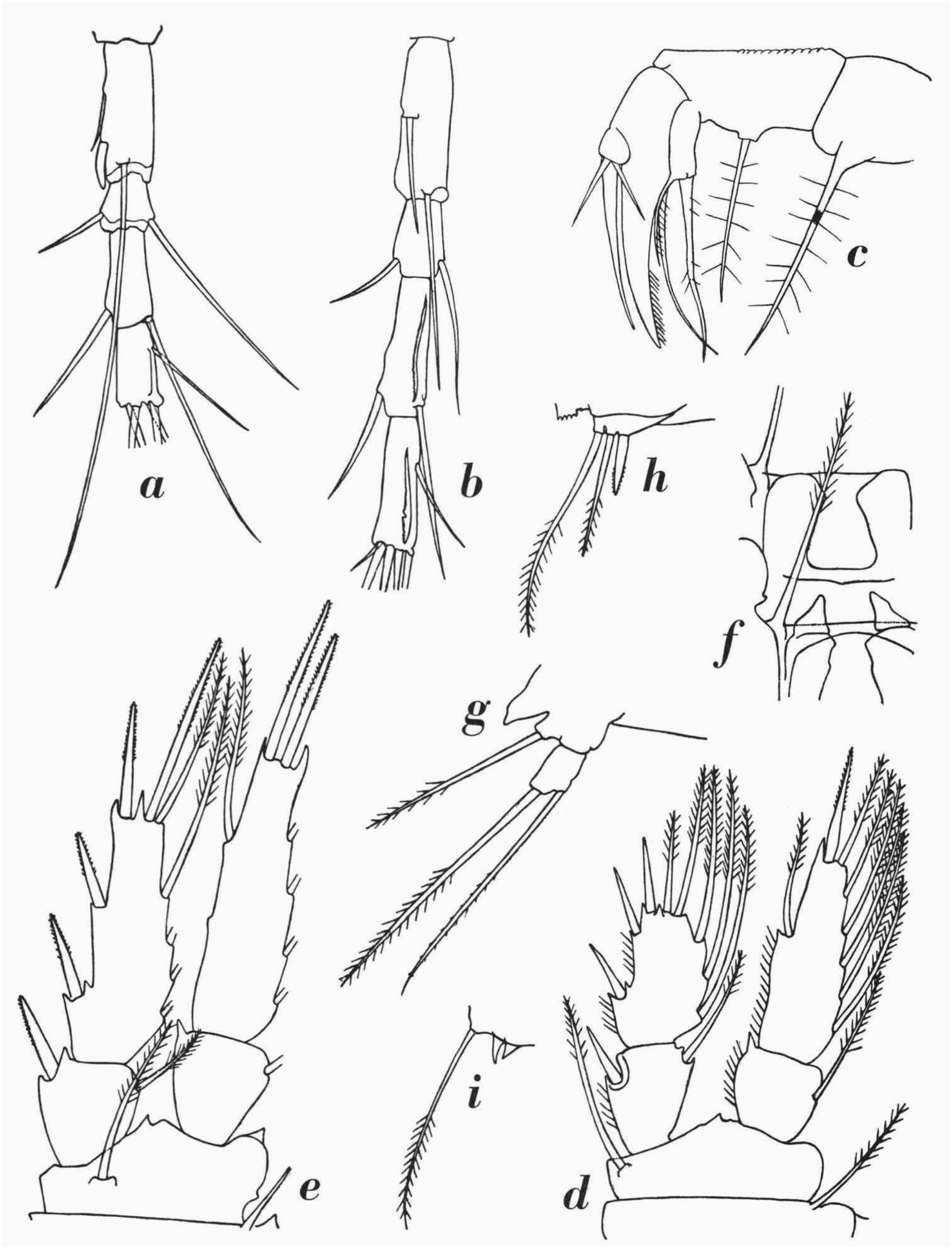

Fig. 1. *Cyclops leuckarti* Claus, stage V.
a, antennula ♂ ; *b*, antennula ♀ ; *c*, maxilla ♂ ; *d*, leg 1 ♂ ; *e*, leg 4 ♂ ; *f*, uniting membrane of leg 4 ♂ ; *g*, leg 5 ♂ ; *h*, leg 6 ♂ ; *i*, leg 6 ♀.
a, b, d, e, h, × 400; *c*, × 335; *f*, × 665; *g*, × 365; *h, i*, × 565.

a little longer than the outer spine. The uniting membrane of leg 4 of *Cyclops leuckarti* bears a pair of pointed processes, which in *Cyclops hyalinus* are rounded and provided with small denticles.

5. The long inner spine of the second segment of leg 5 in male and female is inserted apically in *Cyclops hyalinus,* and clearly subapically in *Cyclops leuckarti.*

6. Leg 6 of the male of *Cyclops leuckarti* consists of a stout inner spine, a middle seta longer than the inner spine, and a long outer seta. Leg 6 of the male in *Cyclops hyalinus* consists of an inner spine, more slender than in *Cyclops leuckarti,* a middle seta which is of the same length as the inner spine or shorter, and a very long outer seta.

In how far can these characters be used for the copepodid stages?

1. The last three segments of the antennula of *Cyclops leuckarti* and *Cyclops hyalinus,* as in all other species of *Cyclops,* are present in the first copepodid where they are formed out of the third segment of the naupliar antennula. The membrane of the last two segments, however, can hardly be found in stages III and IV, and is clearly visible only in the Vth stage. In stages III and IV the membrane may be found in *Cyclops leuckarti* but not in *Cyclops hyalinus.* In stage V the membrane is distinct in *Cyclops leuckarti* (fig. 1*b*), and in *Cyclops hyalinus* hardly to be found (fig. 2*c*).

2. As the maxilla comes into existence in the last naupliar stage and reaches its definite shape in the first copepodid, we can find this appendage in every copepodid stage. Of stages I and II there are no observations. In *Cyclops leuckarti* the ribs are not as clear in stage III as in stages IV and V. In stages III, IV, and V the ribbed edge of the basis of the maxilla is present, and can be used for identification (figs. 1*c* and 2*d*).

3. The basis of leg 1 is formed also at the moult from last nauplius into the first copepodid. Of stages I and II there are no observations. The character of the inner seta on the basis of leg 1 can be used in the stages III, IV, and V (figs. 1*d* and 2*e*).

4. In stage I the somite of leg 4 is formed. Only after the next moult the leg itself begins to grow out of the somite, and in stage III leg 4 has a basis, an endopodid and an exopodid, which both consist of one segment. (The development of leg 4 in *Cyclops hyalinus* is shown in figs. 3*a* and 2*f, g, h*). In stages III, IV, and V of *Cyclops leuckarti* the endopodid of leg 4 bears an inner apical spine which is about as long as or shorter than the outer spine (fig. 1*e*). In the IIIrd stage the inner spine of *Cyclops hyalinus* is about 3 or 4 times the length of the outer spine (fig. 2*f*), in stage IV about 2½ or 3 times the outer spine (fig. 2*g*), and in stage V the inner spine is 1½ or 2 times the outer spine (fig. 2*h*). The uniting

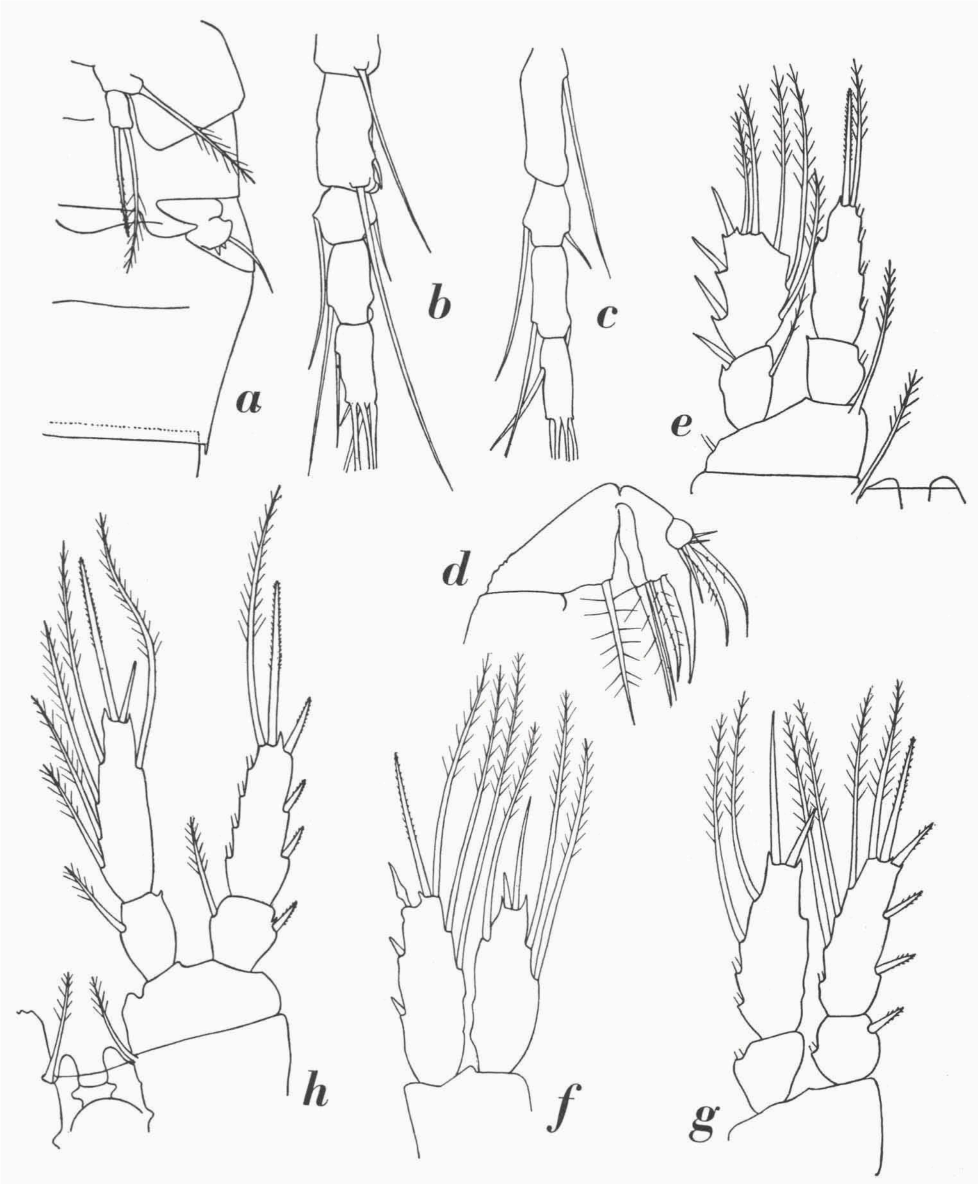

Fig. 2. *Cyclops hyalinus* Rehberg.
a, adult ♀, leg 5 and genital somite; *b-e, h*, stage V; *b*, antennula ♂; *c*, antennula ♀; *d*, maxilla ♂; *e*, leg 1 ♂; *h*, leg 4 ♂; *f*, stage III, leg 4; *g*, stage IV, leg. 4.
a, c, × 335; *b, d, f, h*, × 400; *e*, × 380; *g*, × 365.

membrane is present since stage III. In the IIIrd, IVth, and Vth stages this distinguishing character is very useful (figs. 1*f* and 2*h*).

5. The somite of leg 5 is formed in stage II. In the next stage the fifth leg is initiated, and it reaches its definite shape not before stage IV. (Leg 5 of *Cyclops leuckarti* in stage V is shown in fig. 1*g*, the development of leg 5 in *Cyclops hyalinus* is drawn in figs. 3*a*, *b*, *c* and 2*a*). In stages IV

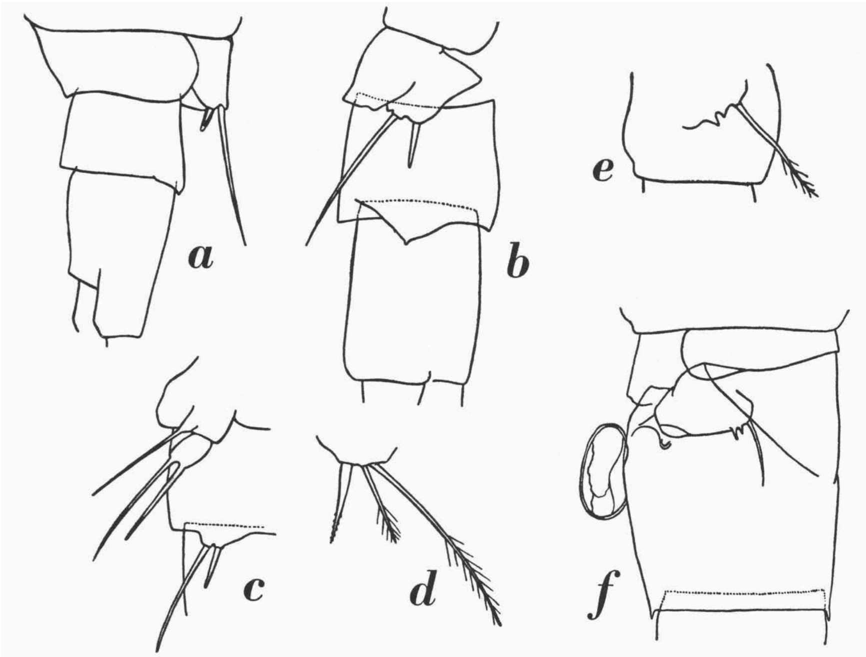

Fig. 3. *Cyclops hyalinus* Rehberg.
a, stage II, abdomen of 2 somites; *b*, stage III, abdomen of 3 somites; *c*, stage IV, leg 5 and leg 6 ♀; *d*, stage V, leg 6 ♂; *e*, stage V, leg 6 ♀; *f*, adult ♀, genital somite with spermatophore.
a, *b*, *d*, × 465; *c*, × 535; *e*, × 400; *f*, × 270.

and V the difference in the insertion of the inner spine on the terminal segment of leg 5 can be used to identify the species.

6. In stage III the somite of leg 6 is formed (fig. 3*b*). In stage IV it consists of one seta and a spine (fig. 3*c*), and in the Vth stage the leg is complete (figs. 1*h* and 3*d*). Only in stage V the character of leg 6 in the male can be used for identification.

In this way it was possible to identify the species to which the copepodids belonged by using the distinguishing characters as in the adults. Moreover, larval characters could be found in which the copepodids are mutually different.

Larval characters which can be used for the specific identification of copepodids.

1. The antennula of the male of both species in stage V is divided in 11 segments, of which the 8th segment bears a spine. There is a stout spine in *Cyclops leuckarti* (fig. 1*a*), and a slender spine in *Cyclops hyalinus* (fig. 2*b*).

2. Leg 6 of the female in copepodid V consists of two very short triangular inner spines and an outer seta. In *Cyclops leuckarti* the innermost spine is smaller than the middle spine (fig. 1*i*), and in *Cyclops hyalinus* the innermost spine is bigger than the middle spine (fig. 3*e*).

The identification of the sexes in the copepodids.

In the IIIrd copepodid stage the sexes cannot be distinguished. In the male and female the antennulae are similar and the secondary sexual characters (leg 6, number of abdominal somites) have not yet come into existence. In the IVth stage of *Cyclops hyalinus* the antennulae show a difference in the male and the female. Manfredi (1925) claims that the antennula has 9 segments in stage III, again 9 in stage IV in both sexes, and 10 or 11 segments in male or female in stage V.

Gelmini (1928), however, assumes *Cyclops hyalinus* to be one of the "normal cases" (*Cyclops bicuspidatus, Cyclops strenuus,* etc.) in which the antennula has 9 segments in stage III, 10 segments in the female and 9 segments in the male in stage IV, and 11 segments in male and female in stage V. On the other hand the antennula of *Cyclops leuckarti* is stated to have 11 segments in the female in stage IV instead of 10 segments as in the other species.

	Manfredi, *C. hyalinus*		Gelmini, *C. hyalinus*		Gelmini, *C. leuckarti*	
Stage	female	male	female	male	female	male
III	9	9	9	9	9	9
IV	9	9	10	9	11	9
V	10 or 11	10 or 11	11	11	11	11

Among the copepodids of stage IV of *Cyclops hyalinus* in my samples from the Klinkenberger Put there were larvae with 10 segments in the antennula, and also larvae in which the antennula consisted of 9 segments. So this does not agree with the statements of Manfredi. Moreover, I found that without any exception all the males and females of stage V had 11 segments, which again does not confirm Manfredi's results.

Measurements of the first abdominal somites of the larvae of stage IV proved that the difference in number of segments in the antennula runs parallel to a slight difference in the proportional lengths of the first and the second abdominal somites, and in the lengths of the anal somites, a difference which becomes much more distinct in the different sexes in stage V.

Stage IV

	antennula of 10 segments		antennula of 9 segments	
	length in μ	relation abdominal somites 1 : 2	length in μ	relation abdominal somites 1 : 2
abdominal somite 1	48.3	1.11	49.7	1.20
2	43.4		41.3	
anal somite	83.7		77.0	

Stage V

	female		male	
	length in μ	relation abdominal somites 1 : 2	length in μ	relation abdominal somites 1 : 2
abdominal somite 1	50.1		53.2	
2	52.5	0.95	47.3	1.12
anal somite	71.8		62.3	

Accordingly the here noted relation possibly indicates a difference in the sexes in this stage, confirming that, as Gelmini maintains, the larvae with 10 segments in the antennula are females, and those with 9 segments are males.

Of *Cyclops leuckarti* I only found copepodids in stage IV with an antennula consisting of 10 segments, which does not agree with Gelmini's data. I did not find antennulae of 9 segments but there were not many of this stage in the samples (in about 5 specimens the segments were counted) so they easily can have been overlooked. I have, for the moment, no reason to assume that the segmentation of the antennula in stage IV of *Cyclops leuckarti* differs from the so-called "normal cases", to which *Cyclops hyalinus* belongs.

According to Gurney (1933) in stage V the antennula appears to be composed of 10 segments in the male instead of 11 segments as in the female, but I only found male and female copepodids of *Cyclops hyalinus* with 11 segments in an abundance of larvae of this stage. So in this respect I follow Gelmini in suggesting that in stage V the antennula of both sexes consists of 11 segments.

However, the sexes can be accurately distinguished in this stage. In the first place the antennula, although it is divided in the same number of segments in both sexes, is shorter and somewhat stouter in the male. If not both sexes are represented, the sexes can be recognised by the 9th and 8th segments of the antennula. In the male the 9th segment is as long as wide, or shorter than it is wide; the 8th segment bears a spine (figs. 1*a* and 2*b*). In the female the 9th segment is longer than wide, and the 8th segment bears no spine (figs. 1*b* and 2*c*).

Secondly, leg 6 is different in the sexes. In the male leg 6 is situated at the caudal edge of the first abdominal somite and consists of an inner spine, a middle seta, and a long outer seta (figs. 1*h* and 3*d*). In the female the same limb lies in the middle of the first somite, and consists of two small triangular spines and an outer seta (figs. 1*i* and 3*e*).

The characters of the antennula and of leg 6 can be used to distinguish the sexes in the Vth stage of *Cyclops hyalinus* as well as of *Cyclops leuckarti*.

The segmentation of the body and the development of leg 6 in *Cyclops hyalinus*.

When dealing with the metamorphosis it has already been pointed out that all thoracic somites are formed when the copepodid reaches the IInd stage. By that time the abdomen consists of one somite, the anal somite, which will give rise to the other abdominal somites in the consecutive stages. In stage III the anal somite divides and two abdominal somites appear, the anal somite and the somite of leg 6. The leg itself does not appear before the next moult (with 3 abdominal somites) on the caudal edge of the first abdominal somite, as a papilla with an outer spine and a long inner seta. It has the same shape in the male and in the female.

In the male leg 6 develops to an inner spine and two setae, still on the caudal edge of the somite, which appear in stage V, and do not alter at the next moult (fig. 3*d*).

In the female, however, the 6th leg moves to the middle of the first abdominal somite at the moult from stage IV into stage V. In stage V it does not resemble at all the 6th leg of the male in the same stage, since it consists of two tiny triangular spines and an outer seta (fig. 3*e*).

What can be the reason for the transfer of this rudimental limb from the caudal edge to the middle of the somite? One can suggest that it could have something to do with the fusion of the first and second abdominal somites to form the genital somite in the female. If this fusion would take place between the IVth and the Vth stages, the transfer of leg 6 would give no surprise, as the caudal edge of the former first abdominal somite would, with the limb, lie in the middle of the newly made genital somite.

Ziegelmayer (1925, p. 561) indeed maintains that the fusion occurs before the Vth stage: "In Stadium IV beginnt Segment 1 mit 2 zu verschmelzen; dieser Prozess ist im folgenden Stadium abgeschlossen". He derived this from measurements, which are, however, not to be found in his paper. His idea about the segmentation of the body in Cyclopoida is not very acceptable either, as it does not agree with the reality. He surmises that there are 5 abdominal somites in stage IV, which are reduced by the fusion to four in the next stage, and that at the moult from stage V into the adult nothing alters the situation. In this way he reaches the number of 4 abdominal somites in the adult female.

Gurney (1931) suggests that the fusion does not take place before the last moult. He does not mention, however, the queer place of leg 6 in stage V. The number of abdominal somites given by him correspond with the reality.

	Ziegelmayer	Gurney
Stage IV	1 + 2 + 3 + 4 + anal = 5	1 + 2 + anal = 3
Stage V	genital + 3 + 4 + anal = 4	1 + 2 + 3 + anal = 4
Adult	genital + 3 + 4 + anal = 4	genital + 3 + 4 + anal = 4

The only possibility to solve this problem was to measure the abdominal somites of the various larval stages. The result of the measurements was decisive.

Given are the average lengths of the abdominal somites of at least 10 male and female specimens of the same stage, in microns:

	female or male	female			male		
stage	III	IV	V	adult	IV	V	adult
length abdomen	116.3	175.4	219.2	280.4	168.0	205.5	235.2
abdominal somite 1	43.1	48.3	50.1	140.7	49.7	53.2	71.4
2		43.4	52.5		41.3	47.3	60.2
3			44.8	57.8		42.7	42.7
4				46.2			32.9
anal somite	73.2	83.7	71.8	35.7	77.0	62.3	28.0

Obviously the fusion occurs during the last moult because in the female the first abdominal somite does not very much increase in length from the IVth into the Vth stage, and because in the adult female it is about as long as the first and second abdominal somites in the male, in which no fusion has taken place (fig. 4).

So the queer change in the position of leg 6 in the Vth stage is not yet explained. In the adult female (figs. *2a* and *3f*) leg 6 is placed close to the opening of the oviduct and consists of a seta and two very small inner spines. It might be suggested that a histological change had taken place already in the Vth stage before the genital somite comes into existence, and that we must see the transfer of leg 6 to the middle of the somite in connection with that histological change. But there is no evidence for this suggestion before a histological investigation is made. Claus (1893, p. 10) has a similar idea as he sees the transfer of the 6th leg in the female "in nothwendiger Beziehung zu der Entfernung der seitlichen, bis zur Rückenfläche auseinander gerückten *späteren* weiblichen Genitalspalten", but he does not mention what actually happens to the somite in the last larval stage.

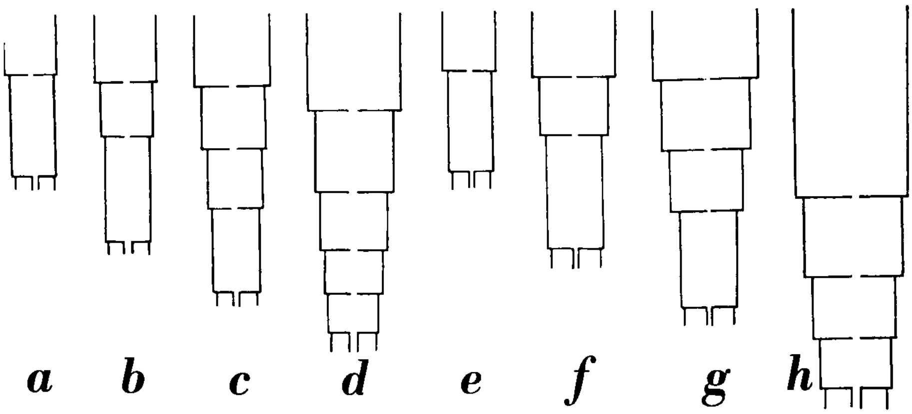

Fig. 4. Diagram showing the development of the abdomen in *Cyclops hyalinus* Rehberg. *a-d,* males, stages III, IV, V, and adult; *e-h,* females, stages III, IV, V, and adult. × 175.

Conclusions.

1. In three different copepodid stages of *Cyclops leuckarti* and *Cyclops hyalinus* the species can be recognised by the following characters:

Stage V

	Cyclops leuckarti	*Cyclops hyalinus*
antennula, ♀	hyaline membrane distinctly visible	not distinctly visible
antennula, ♂	8th segment with 1 stout spine	with 1 slender spine
maxilla, ♀ and ♂	edge of basis ribbed	not ribbed
leg 1, ♀ and ♂	basis without inner seta	basis with inner seta
leg 4, ♀ and ♂	endopodid with inner apical spine somewhat shorter than the outer apical spine or of equal length	inner apical spine about 1½ or 2 times the outer apical spine
membrane leg 4, ♀ and ♂	with pointed processes	with rounded processes
leg 5, ♀ and ♂	outer spine of terminal segment inserted subapically	inserrted apically
leg 6, ♀	inner spine shorter than middle spine	longer than middle spine
leg 6, ♂	middle seta longer than inner spine	shorter than inner spine or of equal length

Stage IV

	Cyclops leuckarti	*Cyclops hyalinus*
antennula, ♀	hyaline membrane present	not present
maxilla, ♀ and ♂	edge of basis ribbed	not ribbed
leg 1, ♀ and ♂	basis without inner seta	with inner seta
leg 4, ♀ and ♂	endopodid with inner apical spine somewhat shorter than the outer apical spine or of equal length	inner apical spine about 2½ or 3 times the outer apical spine
membrane leg 4 ♀ and ♂	with pointed processes	with rounded processes
leg 5, ♀ and ♂	outer spine of terminal segment inserted subapically	inserted apically

Stage III

	Cyclops leuckarti	*Cyclops hyalinus*
antennula	hyaline membrane present	not present
maxilla	edge of basis ribbed	not ribbed
leg 1	basis without inner seta	with inner seta
leg 4	endopodid with inner apical spine somewhat shorter than the outer apical spine or of equal length	inner apical spine about 3 or 4 times the outer apical spine
membrane	with pointed processes	with rounded processes

2. In the copepodids of stages IV and V the sexes can be distinguished by characters of the antennula and of the 6th leg.

3. The transfer of the 6th leg from the caudal edge of the first abdominal somite to the middle of this somite might be explained by the fusion of the first and second abdominal somites to form the genital somite between the IVth and Vth stages, as Ziegelmayer (1925) maintains. This is, however, not so; measurements show that the fusion of the somites 1 and 2 takes place at the last moult, as Gurney (1931) has postulated.

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