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Description of some new parasitic
entomostracans

By Alexander von Nordmann

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When this paper was written the terminology of taxonomic categories, especially that of the higher ones, was still in a state of flux, such terms have therefore been translated literally.

Descriptive terms were also not standardized. The author uses, e.g., the words "oberer" = upper and "unterer" = lower indiscriminately in this literal sense, as well as meaning "anterior" and "posterior". They have in general been translated in this latter sense, except in some ambiguous passages, where a literal translation has been used. [Trsl.]



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N A T U R A L H I S T O R Y O F I N V E R T E B R A T E S

By A l e x a n d e r v . N o r d m a n n

C o n t e n t s o f t h e S e c o n d P a r t

Descriptions of some new parasitic entomostraca

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M I C R O G R A P H I C A L C O N T R I B U T I O N S T O T H E
N A T U R A L H I S T O R Y O F I N V E R T E B R A T E S .

By A l e x a n d e r v . N o r d m a n n

F i r s t T r e a t i s e :
D e s c r i p t i o n s o f S e v e r a l
N e w P a r a s i t i c E n t o m o s t r a c a

I mentioned in the description of our marvellous Diplozoon (in the first part of this work) that my investigations of fish gills at Berlin, although at a place removed from the sea shore, were nevertheless not quite without results. They have led to the discovery of a few new parasitic forms of entomostraca and also of a few Lernaea-like creatures. They also led to an increase in our knowledge of their development, metamorphosis, and their sexual conditions. Without doubt, still better results could be obtained if such investigations were carried out at a place near the ocean where greater variety of the species of fish provides a less restricted choice and where acquisition of material is much easier.

This should be considered by those naturalists who are favoured by a suitable position of their residence, which thus opens prospects to enlarge a science that would be thankful for their efforts.

1 . L a m p r o g l e n a p u l c h e l l a *

A fine and very characteristic animal that belongs into the family Entomostraca poecilopoda Latr., which, however, because it does not fit into any

* from lampros shiny and glene eyeball.

of the subdivisions of this family, may very well constitute its own independent genus. According to its body shape and some characters, which it shares more or less with related forms, it approaches the genera Pandarus and Anthosoma of Leach, as well as Dichelestium of Herrmann, but it deviates importantly from all three in many essential details.

As for the place of residence of our Lamproglena, this is on the gills of Cyprinus jesse (= Idus idus [= I. melanotus]), where I have found it several times during the last half of the late fall. The animal becomes conspicuous mainly because the gill bars on which it has fastened itself with its first pair of legs that is armed with a strong hook, appears whitish, diseased and swollen below the point of attachment. This circumstance is repeated frequently and where it appears serves as an infallible sign that at such a place will be found a parasitic crustacean of some sort, may be a Lernaea, a Caligus-like creature, etc. All individuals examined by me, on account of the late season, were without external egg sacks, they were all built exactly alike, except for some minor features. The length of the animal is 4.2 mm; the colour in younger specimens is yellowish or dirty white, in older and mature ones it is fine orange. The head or foremost part of the body is in all specimens always lighter, the simple gut shines through greenish.

The elongated body, which narrows posteriorly, consists of four different pieces or sections (Pl. I; Figs. 1, 2, 3), of which the head piece is quadrangular. It appears, in dorsal view, to be composed of four differently shaped pieces. Of these, the most anterior piece forms a projection, rounded in a bow shape. On this is inserted, however, more towards the lower side, the double pair of antennae (Pl. I, Fig. 4). The piece that follows it has the shape of a parallelogram, it is, however, in lateral view, sloping downwards to the front. Between this part and the rearmost one there is, in the middle

[p. 3]

of the head a halfmoon-shaped piece, which is rather arched, and in front of

which can be seen the eye. This is coloured a fine rose-pink and is sometimes shaped like a square, sometimes like an M. The posterior part of the head finally is rounded at the sides, squared at the back and arched above.

The thoracic piece is in front conspicuously smaller than the head and here forms a sort of neck. This, when stretched out, is slightly notched laterally. Farther back it widens much and goes over into the middle, fiddle-shaped body itself, without being delimited from it by segmentation.

The connection between the large middle body and the hindmost extension of the body, the tail, is formed by a smaller, narrower four-cornered piece. This has at each side a projecting corner and is cut off squarely in front and rounded posteriorly. The two female genital openings are on the underside of this piece and between them are located two cartilaginous, suction-disc-like bodies, which will be mentioned again below.

The tail section is conical, rather thicker at the base; laterally it is twice slightly constricted by curves. Distad it narrows and finally ends in two blunt, pincer-like points. The animal not infrequently moves the pincers by pressing the two branches together and opening them again.

The anterior pair of antennae (Pl. I, Fig. 4c), which are inserted on the lower side of the curved end of the head, is larger, thicker, however without visible segmentation, cylindrical, thicker at the base, attenuated distally, and provided with several whorled, circular rows of very short bristles. There is, in addition, at the point a tuft of bristles, which are hardly longer than the others.

Below this pair of antennae and slightly lateral of them is inserted the second pair. These antennae (Figs. 4d and 6) are thinner, shorter, also unsegmented, with, at their points, four small bristles.

The attachment organs, which sit on the lower side of the head piece, number four. Their first pair has two strong, pointed claws, which are directed ant-

- 4 -

teriorly and extend noticeably beyond the anterior edge of the head. They each consist of two joints, a shorter and thicker basal joint and the large hook (Figs. 2 and 4a), which is slightly hollowed on its inner side. With these the animal fastens itself especially tightly to the gills of the fish. A short distance below these hooks one sees the second pair of attachment organs. These are built differently; although also two-jointed, they are smaller and armed at the point with three inwardly pointing hooks. Each hook is moved by its own muscle and the three muscles appear to be inserted at one and the same point at the base of the first joint; from there they can be followed as two rather broader muscle bands in the basal joint (Fig. 9). The hooks do not quite stand in the same plane, since the root of the central, larger hook is inserted a little higher than the two lateral ones. Worthy of note is a quite peculiar arrangement on the lower face of the head piece. One finds there narrow projecting cartilaginous ridges, which, by surrounding the bases of the four attachment organs in the shape of rings and joining below the mouth opening, form a cross-shaped framework, consisting of several separate pieces and provided in a few places with special projections. Its shape can best be seen in Fig. 4. It is not improbable that the second pair of clasping organs serves as gills.

In addition to these clasping organs, most individuals have four pairs of minute stub feet, relics of extremities, which may have been of importance to the animal during an earlier state and mode of life, which became later increasingly stunted, disappeared in part during metamorphosis and moulting and are finally as residua more or less insignificant. A similar stunting and disappearance of extremities, even of such organs of which it would be least expected, as, e.g., of that of the light sense, I have been able to observe and to follow step by step in the related Lernaea - like animals, which will occupy us in more detail below. Of these smaller extremities of our Lamproglena

two pairs are found on the neck-like part and two pairs on the fiddle-shaped middle part of the animal. They are club-shaped, thickened at the base so as to appear inflated, slightly constricted on the lower side and split into two very minute conical extensions. Of these the upper carries three, the lower two bristles, which are articulated with a rounded base in a recess (Fig. 5). The whole represents an altogether small but plump foot for swimming, as it exists in the larvae of Lernaea. The animal was able to move it slightly jerkily, in spite of it being stunted.

I indicated above that not all individuals have the same number of these small extremities. This can be explained as follows. I found accidentally a specimen of Lamproglena, which was about to moult and it did this successfully under the microscope. The discarded skin, which still partly covered the animal, had four pairs of stump feet, the moulted animal, however, had only two pairs that sat on the neck piece. When I paid attention to this during later investigations, I found among 19 specimens several who still had four and others with only two pairs. The last-named animals were, as all freshly moulted insects and crustaceans, as a rule much lighter, even almost transparent, and the yellowish coloration was caused later through the influence of light.

When one examines the animals laterally, one notices a small projection (Fig. 3a) at the step that connects the fiddle-shaped part of the body with the tail piece. This is formed by two sole-shaped yellow-brown bodies, resembling suction cups. They consist of a cartilaginous, almost horn-like mass, with raised, slightly inwardly curled edges and slightly depressed centres (Figs. 4, 7, 8). They are carried on a short stalk (Fig. 8), touch at the anterior end and diverge slightly posteriorly.

[p. 6]

This is about all that can be said about the external shape of the animal; in regard to the other organs I make the following remarks.

The mouth opening is on the lower face of the head piece between the second

pair of clasping organs (Fig. 4e); it is round with slightly projecting edges, and is functional apparently only for sucking. Of other mouthparts, maxillae, palpi, etc., there is no trace. The digesting cavity is simple, extends from the mouth, where it is at first narrower, through the entire length of the animal to the end of the tail. Here it constricts considerably and connects ^{the} with/anus, which lies between the pincer-like projections. The distension, which takes place in the fiddle-shaped middle body, might be considered as a stomach. The walls of the gut are thin and look as if they consisted of a granulated and glandular mass. During the rhythmic movements that further digestion, the gut is forced now downwards, now upwards; it expands and contracts again whereby its walls fold. Hereby the coarsely granular contents, which appear greenish in the reflected light, are kept in constant movement. The movements of the digestive canal are caused by its own ligamentous muscles, among which two are especially conspicuous. They lie immediately below the second pair of atrophied extremities that sit on the neck piece (Fig. 4i). The gut is surrounded for two-thirds of its length by a loose, large-meshed slimy organ (Fig. 4f), which is also found in all lernaeids and which may best be compared with the liver. In addition a few narrow muscle bands (Fig. 4g, h) that run laterally along the gut, the anterior part of the fiddle-shaped middle part of the body is crossed by two wider muscle bands (k, k), the ends of which spread slightly and insert on the inner thin skin of the middle body. The reproductive organs that were on account of the advanced season as yet undeveloped, consist of two rather large sacks, the internal ovaries (l). Their anterior, pointed, blind ends reach the base of the smaller, anterior section of the middle body and meander from there, first expanding, then gradually contracting, through

[p. 7]

the entire posterior part of the middle body as far as the two suctioncup-like bodies. They contained a large number of round vessels of different sizes, which change later into eggs. The two openings of the sacks are three-cornered

(Figs. 2 and 4m). Each of these is surrounded by a cartilaginous and warty protuberance on which probably hang the egg sacks or grapes. — Otherwise the internal structure of the middle body appeared to be cell-like and filled with many round vesicles, which were dispersed singly or in groups.

The powers of locomotion of the animal appeared to be very restricted, because when put into water it only bent the clasping organs in different ways and bent the tail alternately to the right and left.

2. Ergasilus *

This genus of parasites appears, at first glance, to be very similar to Cyclops and to be a form transitional between the sections Lophyropoda and Poecilopoda. It must, however, be included in the latter because the first pair of legs is transformed into true clasping organs, whereas the other extremities serve for swimming. Since this animal occurs on the gills of all our fresh-water fish and often in great numbers, I thought it to be already known and overlooked it for a long time until my friend Dr. v. Siebold called to my attention in the summer of 1830 that this genus is undoubtedly rich in species, but had not yet been investigated in detail.

I shall first detail the characters that are common to all three species that have been examined by me and then mention briefly the special differences between the different species.

The body of the animals belonging here, which is covered by a soft, fairly transparent, thin carapace composed of several segments, is in general elongated round and wider anteriorly than posteriorly and ends in two pointed projections.

[p. 8]

When one distinguishes the wider, dorsally conspicuously arched anterior part of the body from the narrower posterior part, then the former comprises head

* the name of a parasite in Plautus.

and back (sic!) [thorax] of the animal and it is covered by three shields, which have different shapes in the different species.

The head shield [carapace], which is arched most strongly in Ergasilus gibbus and less so in the other species, forms a rounded projection. It is, however, separated from the first thoracic shield by a very shallow line that is so faint that even with the most advantageous orientation and magnification barely a trace of segmentation can be seen. The first thoracic shield is posteriorly either cut off square, or rounded, or a little excavated; it shows in its median cross-section the greatest width of the body. The second thoracic shield is far shorter and forms an irregular quadrangle, which narrows posteriorly.

These shields are followed by the narrower posterior body, consisting of three telescoped parts, which bear laterally on their undersides the second, third, and fourth pair of legs.

The tail finally is composed of three to four parts of unequal length, which narrow gradually. The last part is split longitudinally almost to the base and bears at both sides three notches, the traces of limbs (Pl. II, Fig. 6; Pl. III, Figs. 5 and 8). Each of the two points of the split part bear two or three bristles, which, although quite simple and neither segmented nor pinnate, furnish, if not exclusive, at least reliable characters for the different species by their number and length, whereby the outer bristles are always shorter than the inner. In addition, the first or second segment of the tail has on the underside two small cartilaginous hooks (called in Cyclops by Müller and Ramdohr spicula, by Jurine fulcra [supports]), which serve to support the large and heavy exterior egg sacks or grapes.

On the sides of the head, where the carapace is excavated a little, are inserted the antennae, not four, as in other genera, but only two. Their length [p. 9]

is about one and one-half to two times the width of the base of the head; they

are composed of six transparent, cylindrical segments that are fairly strongly attenuated distad, and that bear several bristles. On each of the first three, slightly thicker but scarcely longer segments there are on the inner side usually two to three, on the outer side in contrast only one bristle. The two following segments have always only one on each side. The point of the last segment, however, bears three or four bristles that often lie so closely together that they can easily be mistaken for a seventh segment. The inner bristle on the base of the fourth and the outer on the base of the penultimate segment are always slightly longer than the rest, which have about the length of a single segment.

Whether there is between the two sexes of the genus Ergasilus in regard to the structure of their antennae the same peculiar difference that Jurine* has so carefully demonstrated and figured in Cyclops quadricornus, I cannot determine, because I have not yet seen any males. I have also made some unsuccessful experiments about the sensitivity of the ultimate antenna segment.

Below these antennae stands the first pair of four-segmented legs. The basal segment is in Ergasilus gibbus very large and expanded bladder-like (Pl. III, Fig. 4); the club-shaped second segment is longer, the condylus-shaped extension of the narrower and shorter third segment fits into a depression at its end. The fourth segment is a moderately curved, strong hook, with which the animal fastens itself to its host. This pair of legs could well be called arms.

The counterpart of the second thoracic shield and of the three shields of the smaller body parts are the same number of poorly defined abdominal shields, which show sometimes ridge-shaped arching and are armed with a small curved

[p. 10]

tooth (Pl. III, Figs. 2 and 6) at least in Ergasilus gibbus at the farthest protruding point. At the bases of these parts are inserted, as already mentioned,

* Histoire des Monocles par Louis Jurine. Genève et Paris 1820, p. 3 ff.

four pairs of double swimming legs, of which the anterior ones are slightly longer than the posterior. As regards their shape, the hip bone (to use the same terms as Ramdohr*) is simple, thick, and bears the double tibia, which consist each of three segments of almost equal size. Each of the segments has a small tooth on the outer side, and the edges of the last segment are beset each with five long bristles, the inner side of each of the penultimate segments bears only one bristle. Of these bristles the second, counted from the outer edge, extends farthest; they are all pointed and their base is formed by a small knob, with which they are inserted into a round articulating pit. The animal seldom spreads them; as a rule they form a pointed brush (Pl. II, Fig. 5; Pl. III, Fig. 6).

The colour of all individuals is milk-white, occasionally with a silvery sheen, occasionally also weakly blending into yellowish. On the abdominal underside, especially on those sections that correspond to the last thoracic shield and the first tail shield, there are a greater or smaller number of dark-blue spots, which occasionally tend to reddish or violet.

The underside of the animal, although on the whole not as much arched as the dorsal side, has, nevertheless, about opposite of the first thoracic shield, an abrupt, conspicuous projection on which the mouth is situated. The animal can expand this projection still more. I have not been able to ascertain all details of the masticatory organs, but they are not as complicated by far as, e.g., those of Cyclops quadricornis. Examining the animal from the side, it is seen that the mouth consists of two lip-like projections, an upper and a smaller lower one, each of which bears a pair of needle-like masticatory points (Pl. II, Fig. 2; Pl. III, Fig. 2), which represent the outer mandibles of Cyclops, and which are, like the two projections, in continuous movement.

* Mikrographische Beiträge zur Entomologie und Helminthologie [Micrographical contributions to entomology and helminthology] Dr. C. A. Rambuhr, I, Halle, 1805.

The alimentary cavity ascends obliquely towards the head, where it is bent over. It is at first rather narrow, then enlarges into a stomach and runs straight, gradually narrowing into the gut, which opens at the base of the penultimate tail segment through the anus. Its movements are of the same kind that can be observed in Cyclops and are best visible in the stomach-like enlargement. When the animals were disturbed under the microscope, they would extrude some of the contents of the alimentary canal, which appeared turbid and finely granular, through the mouth. One notices furthermore below the first thoracic shield a small oval body that shows by its pulsations to be the central organ of the vascular system.

D e v e l o p m e n t

From December until about the middle of April all individuals of the species of Ergasilus have no external egg sacks or grapes and also generally no eggs inside the body. They are therefore especially transparent at this time, thus allowing an exact examination of their internal parts. It is very probable that copulation takes place in the same manner as in Cyclops, although, as already said, I had no opportunity to observe it. On April 19, 1829 Dr. v. Siebold found the first specimens with grapes of the species that bears his name, and on April 12, 1831 were seen the first grape-bearing specimens of E. gibbus.

The internal ovaries lie along both sides of the stomach, and in the course of egg development come to fill the largest part of the space between the two thoracic shields and the alimentary canal. Their shape varies according to the state of development of the contained eggs. At the start they form two distinctly separated tubes, blind at their upper ends. They appear to join later and then have become filled with a white mass and assumed the general aspect of a quadrangle, which has anteriorly three protruding lobes and below the second thoracic shield a deep constriction, as we have tried to present in Pl. III, Figs.

1 and 7. From their lower side start the two discharge ducts, which, at first wider, then narrower, lead in a moderately sinuous course to the external egg sacks.

In spite of determined attempts I failed to observe the moment when the eggs descend into the grapes. Ramdohr, who had succeeded in observing this in C. quadricornis, says* "at the time when the eggs move from the ovaries into the grapes, there is first seen in front of the narrow ducts in the tail a clear, transparent pellicle, which swells up like a soap bubble; immediately an egg streams through these ducts in which it resumes its spherical shape. This is followed in short intervals by the others, so that the grapes swell up alternately, or at the same time within the time of 5 minutes". The observation Ramdohr's that the ovaries do not empty their contents at once into the grapes agrees with my experience in so far that in Ergasilus one can still see more or less developed egg groups in the ovaries when the grapes are already filled with eggs. This appears to indicate that no further copulations are necessary for the formation of new grapes.

The grapes are, to begin with, entirely white and in the species examined by me, at least one and one-half times as long as the whole animal.. However, in E. gibbus occur specimens in which the grapes are three times the length of the animal, so that one must marvel how such a small animal can carry a disproportionate load of this size. In the genus Cyclops one finds grapes of considerable size, although the animals, always in lively movement, are constantly changing their positions; to the grapes are often added entire colonies of hundreds of vorticelles that attach themselves either to the animals themselves, or to the grapes. Rösel, who according to the trends of his time never missed to point out the startling and marvellous in the economy of the world of small animals, did, as is well known, in order to make this plain to his contemporaries,

* loc. cit., p. 3.

figure in the third volume of *Insektenbelustigungen* [Fun with insects] on Plate 89, two specimens of Cyclops that were thus loaded with vorticelles. On various Ergasilus species and on several Lernaea-like creatures, which are sessile parasites on palate, fins and other body regions of fish, one finds not rarely vorticelles and a whole army of polygastric infusoria and rotifers.

The envelope of the grapes is an extremely thin, initially perfectly transparent sack, the walls of which, when they have reached their greatest expansion, are hardly perceptible. As long as the eggs are in the ovaries, their granular and homogeneous mass is surrounded by a fine pellicle; the formation of a second outer envelope takes place, as in the lernaeans only in the grapes. During the gradually progressive development of the eggs the two envelopes separate more and more from each other, whereby the outer one appears to become slightly harder; the eggs themselves become gradually bluish so that they appear greenish when seen through the outer envelope, which has become yellowish in the mean time. The blue colour indicates already at an early stage the eye and the middle part of the body of the embryo.

According to Ramdohr, C. quadricornis carries the eggs for 5 days in the grapes. In Ergasilus this lasts longer. However, I cannot give the exact time and mention here only that, according to an observation that was repeated three times, the embryo of E. sieboldii requires 50 to 60 hours from the first appearance of the bluish colour to the eclosion from the grapes. That the development is slightly retarded through the low temperatures of a late season was shown by observations I made in November 1830. The death of the grape-bearing females, which occurs as a rule 18 to 24 hours after the animals have been removed from their natural place of residence, does not disturb the development of the young, not even when the grapes are removed from the mother.

After the embryos have become fully mature, one sees them, prior to the emergence from the two egg envelopes, move, until at first the thin wall of the grape tears in several places and finally the outer egg envelope tears, and the

young, which are still enclosed in the inner envelope only, fall out. The empty outer envelopes of the eggs remain in the grape, which still hangs together here and there. They form, by shrinking more or less, irregularly six-sided cells (Pl. II, Fig. 3). Especially noteworthy is here the phenomenon that after the bursting of the outer envelope, the still intact second envelope expands by about one-half its initial circumference through the movements of the contained embryo before it itself bursts. I have observed a much stronger and thus much more conspicuous expansion during the development of a Lernaea-like animal.

During their first stage the larvae of E. gibbus and E. sieboldii are very similar and can hardly be distinguished. Their body is in general egg-shaped, but anteriorly slightly excavated at the sides, posteriorly it is cut off square with a slight, rounded projection, which bears on each side a short bristle (Pl. II, Fig. 7). On analogy with C. quadricornis, they should possess only four extremities. This, however, is not so, because they have, without prior moulting, six. Of these the first, which could also be considered to be antennae, is simple, cylindrical, has three hardly visible traces of segments and bears at its point two bristles of unequal length. The third, of similar build, has three bristles at each end. The two middle extremities are in contrast slightly longer and thicker; they are split at the end and bear 4 to 5 bristles on the longer extension, but only three bristles on the lower and smaller one (Pl. II, Fig. 9). On the head, the round blue eye is conspicuous, and there is an oval, also bluish spot on the middle part of the body. The outer covering of the animal consists of a thin shell, through which can be seen a convolution of larger and smaller vesicles and a granular mass. — The famous author of Zoologia danica, Müller, would have put our little animal into the genus Nauplius.

Although the larvae, like other entomostraca swam around lively in the water, they survived for only 8 to 10 hours, their further metamorphoses,

which should follow their first moult, remained unknown to me. However, one could obtain partial information about this, if it were possible, as with the larvae of Lernaea, to find by prolonged searching the animals in their natural environment. I shall therefore call attention, in a few words, to the special differences between the various species of this genus that are known to me.

(a) Ergasilus sieboldii*

This, the most common species, is often found in large numbers on the gills of Esox lucius, Abramis brama, and Cyprinus carpio, most likely also of several other fishes. However, I hardly dare to include here the species found on the gills of Osmerus eperlanus as being fully identical.

The body is oval, the second thoracic shield distinctly smaller than the first, the entire thorax moderately arched. The arms reach from the end of the head to the end of the second thoracic shield. Of the bristles of the last tail segment the outer ones are half as long as the inner ones, but slightly longer than the split extensions on which they sit. The grapes, which narrow distad, are usually as long as the animal, occasionally slightly longer. The animal itself has a length of 1 to 1.4 mm.

Illustrations of this species with details are to be found on Plate II.

(b) Ergasilus gibbus

It apparently occurs exclusively on the gills of Anguilla vulgaris.

The more elongated body is laterally excavated between the first and second thoracic shields; the head protrudes and is distinctly divided from the first thoracic shield (Pl. III, Figs. 1 and 2). The other, strongly arched shields are also divided by saddle-like depressions. The antennae are shorter than in the preceding species. The arms are thinner than in the preceding species and reach only the end of the first thoracic shield; their basal segment is sur-

* Dr. E. v. Siebold, at present physician in Heiligenbeil, East Prussia.

rounded by a disproportionally large, spherical shell (Figs. 4 and 3). The abdominal segments are also arched and armed with a small tooth. The bristles of the tail have among them the same proportions as in E. sieboldii, but the inner, larger ones are only slightly longer than the last, split tail segment (Fig. 5). The grapes of most individuals^{are} disproportionately long, often one- or also three-times as long as the whole animal, otherwise cylindrical.

(c) Ergasilus trisetaceus

Of this species I found only once three specimens on the gills of Silurus glanis, but in company with E. sieboldii.

In size this animal is equal to the two preceding species. It is distinguished from them by its two thoracic shields being wider and by the base of the head projecting more to both sides (Pl. III, Fig. 7). These, however, are characters that are obvious only when one compares all three species side by side. A better diagnostic character is the fork-like split of the last tail segment. It bears on each of its points three bristles, of which the inner is three times as long as the middle one, but only twice as long as the outer one (Pl. III, Fig. 8). —

According to a letter to my friend Professor Wiegman, Dr. Siebold has found a fourth species on one of our freshwater fishes, but I have no details about this.

3. Caligus

Because I have below cited a form that comes very close to the various Caligus species, namely, Lernaea pectoralis Müll. as representing a genus of its own, I deem it necessary to state the characters of the genus Caligus as follows.

The body consists of two main parts, the larger shield-shaped head part and the narrower, either quadrangular or heart-shaped abdomen, which

are connected by a short and narrow thoracic piece, on which is inserted the seventh pair of legs. Of the seven pairs of legs the first three are jaw-shaped, the fourth and seventh pairs are simple, the fifth and sixth pairs are split and beset with pinnate bristles. At the anterior base of the two antennae are two large eyes.

Of the species belonging here, only two are, as far as I know, described in detail, namely Caligus curtus (= Monoculus piscinus L.) of O. F. Müller (in Entomostraca seu insecta testacea, p. 130, Pl. XXI, Fig. 1 and 2) and C. mülleri of Leach (in Encyclop. Brit. Suppl. 1, p. 405, Pl. 20), of which also Desmarest gives a copied illustration in Considérations générales sur la classe des crustacés, Pl. 50. I have not seen the first species, but I have seen the second together with several other forms, the investigations of which have led to an extension of the genus through the addition of new species.

(a) Caligus bicuspidatus.

The three specimens that are in front of me, had been collected by Tilesius during a journey around the world and are at present in the collection Rudolphi. Unfortunately, there is no indication of the host species.

This species is characterized by a broad shield of the forebody, which shield is heart-shaped (Pl. XI, Fig. 1). The length of the largest specimen is almost 12.6 mm, the greatest width 7.6 mm, whereas the smallest specimen has a length of only 8.4 mm and a width of 6 mm. The anterior part of the head forms a fairly large triangular projection, which is rounded at the front, flat and which is expanded crossways; its two inner sides are connected to the underside of the head. A small notch, below which can be seen a small round area, divides this threecornered projection into two parts; on its anterior margin on each side is located an eye and on its extreme points are inserted the antennae.

[p. 18]

The eyes are hemispherical, rather large in proportion to the animal, surrounded by a semicircular cartilaginous arc, and protrude with the barely not-

- 18 -

iceably arched cornea a little from the frons. Under very high magnification one could see a very great number of very fine striations running from the centre to the periphery of the cornea, the striations disappearing gradually towards the edge of the cornea, which there remained clear and membranous transparent (Fig. 2). Even in the specimens preserved in alcohol a trace of blueish pigment could be seen. — Whereas the remainder of the triangular projection of the frons showed neither hairs nor bristles, the space between the eyes and antennae was covered with several small scale-like appendages, whose sides bear many bristles. — The antennae are short, one-segmented, cylindrical, and bear at their points several fine small hairs.

The large, heart-shaped head shield is of membranous, half-cartilaginous consistence, moderately arched above, hollowed below like a spoon, amber-yellow, otherwise fairly smooth, and covered on its upper surface with a few small hooks that are visible only under highest magnification and that run parallel to the outer margin; similar hooks have been observed on the shield of Argulus foliaceus. On its underside it is strengthened by two pairs of strong ribs, which extend to the outer margin where they are bent downwards. In other species these ribs are split fork-like. At the anterior and upper head margin the shield shows three fields, separated by slightly deepened furrows, of which the middle one projects farthest. The most prominently arched part of the shield, the back, consists also of several smaller fields or divisions, of which I shall mention only the two lateral small ones, which are triangular and produced into a point, because they are found in all Caligus species. They lie at the place where the two rounded wings of the shield are inserted into the thorax. On the posterior part of the wings of the shield one sees on each side a small round depression.

The abdomen of the animal consists of five different segments that are inserted into one another, of which the first is the largest of all and

it is anteriorly wider than posteriorly; the second, smaller, of lozenge shape, is anteriorly and posteriorly strongly constricted, and provided at both sides with projecting corners, which bear the seventh pair of legs. The segment that follows now constitutes the abdomen proper, it is rounded anteriorly, posteriorly squarely cut, and ends at each side in two small, bristle-bearing points, which are specific for this species and have suggested the species name. On this segment hang the grapes. Since they were lacking in the three specimens and since this segment is anyway relatively too small, I must consider the specimens to be not fully developed females, if not even males. The abdomen has on the underside two leaf-like appendages, which bear at the point and on the outer margins several hairs; these project slightly when seen from above (Fig. 3).

The fourth segment is smaller by one-half than the preceding, of oval shape, notched in the centre of the posterior margin, and bears at its end two small, cylindrical projections, each of which is beset with five pinnate bristles. The three central bristles are, as in all other Caligus species, the longest and equal in length the last two segments.

I had the opportunity to study the organs for obtaining food in Caligus, the next following genus, Binoculus, Cecrops, and Dichelestium. By comparing them it was found that they are in general built after the same pattern and thus follow the analogies of the genera Lernaeopoda, Clavella, Tracheliastes, Brachiella, and other lernaeal sections. The mouthparts in Lamproglena will probably be similar.

The sucking proboscis in Caligus bicuspidatus lies a short distance distad of the first hook-shaped pair of legs, or almost between the second pair. It forms a small conical protuberance and consists of a fairly strong horn-like mass. It is enlarged at the base and sends out two small wing-like appendages, structures that are repeated in almost all related animals. Their outer margin is surrounded by two bow-shaped cartilaginous ridges, which leads one to spec-

[p. 20]

ulate that these should be interpreted as the ends of an upper and lower lip, which in Hemiptera form the rostrum, which here, however, are fused.* Beyond these ridges follows a short skin, which is incised very finely and which gives the impression as if the proboscis were bearing a ring of thin and short bristles. In the sucking cone lies a pair of chewing organs, maxillae, of quite the same construction as we have found them in Dichelestium, Binoculus and in most of the lernaeans and which will be described in detail below. At the base, at the sides of this proboscis can be seen two small, horny, and pointed projections, the palpi.

As regards the organs for grasping and swimming, I have already mentioned above, that the first three pairs are jaw-shaped. In detail, each of the seven pairs of extremities, which may summarily be called feet, is built differently. Disregarding size and other, less important characters, one can see certain analogies only between the first and third and between the fifth and sixth pairs.

The first pair, which corresponds to the upper jaws of the lernaeans, sits not far from the anterior edge of the head shield, is the relatively smallest of all, and consists of a shorter basal segment and the larger, club-shaped second segment; this is armed at its end with a double hook, the points of which are turned inward (Fig. 4). Slightly below and towards the lateral margins of the head shield is on each side a small simple hook, which, however, cannot by any means be considered to be a foot or jaw.

The second, longer and narrower pair is situated closely in front of the third pair; it also is composed of three segments, of which the second has the shape of a hip; on its end is articulated the longer and narrower third segment, which bears about half-way along its length a prong that is directed inwards and divides into two thin points, which are of unequal length and independently articulated. To judge by its small stature, this pair of extremities can hardly

* see below about the construction of legs and jaws in the lernaeans.

serve for grasping, it must therefore be considered as true jaws. In its natural position the long and narrow third segment is always bent inwards and lies with the two points over the oval mouth opening (Fig. 5).

The third pair, which follows now, is in two specimens of C. bicuspidatus very large and thick, in the third specimen it is about two-thirds smaller, otherwise it resembles the first pair, it is of strong, horn-like consistency, two-segmented, and provided with a strong, inwardly bent hook, the point of which fits into the space between two opposite small hooks (Fig. 6). It is the same pair of extremities that in Brachiella and Clavella sits close under the proboscis, in Trecheliastes, however, it has shifted far backwards to the base of the long neck.

The three following pairs of legs are built on the same plan in so far as the all bear pinnate bristles, are gill feet and serve the animal for locomotion; however, they differ from one another in many respects. For instance, the fourth pair is more elongated, consists of three segments, of which the first is short, the second is spindle-shaped, bears at its end a small point, and is beset along the entire lower margin with fine short hairs; the third, shorter segment is cylindrical, however, slightly thicker in the middle, bears at its point four small hooks that are articulated separately, and on the lower border three pinnate bristles, of which the inner one is the longest (Fig. 7).

On the fifth pair we see first a short basal segment, bearing on its lower margin one pinnate bristle, then the large, four-cornered hip, on the anterior edge of which is fastened the double tibia, each branch of which is three-segmented. The first segment of the upper tibia is slightly longer, has a large hook, but only one bristle; the second segment is four-cornered and bears on the upper end a point and on the lower edge also one bristle; the end segment is trimmed square at the base, rounded at the front and bears three points and five bristles, which decrease in length towards the outer margin. The lower

tibia is built like the upper, except that the larger hooks on the first segment and the points on the other segments are lacking (Fig. 8).

The space between the first segment of the posterior body part and the wing of the head shield is filled on each side by a triangular piece that is rounded in front and scale-like; both of these pieces are fused with a larger and thinner lamina, which covers the base of the abdomen and bears the sixth pair of legs. In the last named the structure of the fifth can be recognized, notwithstanding the fact that the segments disappear, because the small basal segment and the hip fuse into the three-cornered scale, and of the double, three-segmented tibiae only two one-segmented appendages remain. Of these the upper is longer, of irregularly conical shape, constricted at the base, finely hairy at the upper edge and beset with three points and five bristles. The strong hook of the first tibial segment sits directly on the scale. The lower tibia consists of a considerable round enlargement, bears also five pinnate bristles and in addition a sixth on a small projection of the base, which shows a trace of segmentation. The lower edge of the scale and of the lamina, which is connected with it basally, is densely covered with small hairs (Fig. 9).

The seventh pair of legs, relatively the longest, resembles the second; of the three segments that compose it, the basal segment is large and club-shaped, it contracts at the front end into a point and the entire outer margin bears a row of very small hooks; the second, thinner one has a rhomboidal shape and also a long point; at the end of the third, four-cornered segment are three longer points, and towards the inside a roundish projection that is surrounded by a dense ring of very small bristles. One of the points is especially long, slightly curved and beset with a mass of small thorns, which are the more crowded together, the closer they come to the end and to the base of the point (Fig. 3).

I have described the legs in so much detail, because this will allow to be more concise in the description of the other Caligus species, which do not show important differences in regard to these structures.

(b) Caligus mülleri Leach

This species has been found so far on various species of Gadus, G. callarias, and G. aeglefinus; it has been figured fairly correctly by Leach and after him by Demarest. The length of the mature animal varies between 8.4 and 10.5 mm, the greatest width of the head shield is 4.2 mm. The small and cylindrical grapes*, which appear segmented, attain in the largest specimens a length of almost 12.6 mm. In regard to the body shape, C. mülleri resembles the previous species, but is distinguished from it by the smaller width of the head shield (Fig. 10). The grape-carrying abdomen is slightly longer than one half of the head shield, it is rounded in front and square behind, because the corners are

* Of the little-known genera Nogaus and Risculus, which appear to stand near Caligus and have been described by Leach in insufficient detail, Desmarest says (Consid., etc., p. 340 and 343) that the grapes in some species are split, in others are characterized by special appendages. I do not want to dispute this statement, since the grapes of certain lernaeans, as Lernaea branchialis, by being peculiarly tangled and twisted, show a strikingly divergent structure, but I cannot refrain from making the following remarks. The body of the parasitic entomostraca serves, as that of every other animal living in water, in turn for other parasites as abode. Thus a distinct Vorticella, of which specimens measured almost 0.7 mm, had attached itself in grape-like groups to the abdomen of Caligus elongatus, which probably came from the South Seas. In addition to these infusoria, each of the grapes or egg sacks bore five or six parasitic specimens of a trematode, which came closest in shape to the trematode Axine bellones, which occurs on the gills of Belone belone, as it has been figured by Oken in his Zoological Atlas, Plate XI. Each of the specimens was 1 to 1.4 mm long, in shape cylindrical, tapering towards the ends, was curved and had at, probably the posterior end, a large, circular and cup-like enlargement, a suction cup, with which it had attached itself very tightly to the grapes. The plate-like enlargement did not show special suction cups or other clasping or suction

rather square. The two pointed projections are lacking, there are instead only two small short hairs, which occur in all species examined by me. On the upper surface of the abdomen are four indented points.

It can only be ascribed to insufficient observation, when Leach claims that this species can be distinguished from C. piscinus mainly by the lack of the bristles on the last tail segment; although in two of the five specimens at hand the brittle bristles have broken off, the remaining stubs give a clear indication that they had been present. Demarest figures the animal also without tail bristles, but he apparently did not see the animal himself. Furthermore, the illustration of the second pair of legs in Demarest (Consid. sur la classe des crustacés, Pl. 50, Fig. 4a) must be corrected, because it is not six-segmented, but only three-segmented. Whether this species is actually different from C. piscinus (or C. curtus Müll.) can be decided only later, when the opportunity arises to compare the specimens occurring on Gadus merlangus. On comparing our illustration with that of Müller (Entomostraca, etc., Pl. XXI, Figs. 1 and 2), there appear to be several details that support their distinctness.

(c) Caligus elongatus

This species has also been discovered by Tilesius and it is at present also in the collection Rudolphi. The determination of the fish species is lacking.

The length of the entire animal is 6.3 mm, of which 3.1 mm apply to the fore-

organs, it rather appeared quite smooth, with gradually thinning out margins. On the narrower head I could see, not far from the edge, one or two areas that were roundish and conspicuous by their yellowish colour; internally I could see a lighter, fairly large intestine. The removal of the animals from the grapes was difficult, because in most of the specimens the suction cups became torn and on looking at them less attentively, one could easily mistake the animals for extensions of the grapes. Could not Leach have been misled during examination of the grapes in Nogaus and Risculus by such parasites? —

part of the body and the same to the hindpart. The base of the head shield is 2.1 mm wide; therefore the animal belongs to the smaller species. The head shield is oval and is in relation to the preceding species considerably smaller (Pl. XI, Fig. 11). Near the posterior margin of the thorax there is a roundish, elevated area, marked with four darker figures, laterad to this are small, triangular and [p. 24]

acuminate pieces. The grape-bearing, thick abdomen is fourcornered, elongated, at the front hardly narrower, but rounded, at the back squared. On its upper surface it has six small indented dots, of which the last two are more distant from each other than the others. The following segment is about half as long as the abdomen, not oval, but conical, it bears the last two short tail projections, which have five pinnate bristles, of which the three central ones are almost as long as the conical segment (Fig. 12). The tibia of the seventh pair of legs is not two- but three-segmented, and the longer point at the end of the last segment is by far not as long as in C. bicuspidatus; it also lacks the numerous small thorns (Fig. 13). The grapes, coloured vivid yellow, are relatively short, and hardly surpass the tail bristles; the individual eggs are disc-shaped and packed tightly. On the underside of the abdomen is visible a darker median line, laterally of which lie the internal ovaries, which are tubular and filled with a granular mass, the unripe eggs. The third pair of legs is especially thick, and armed with a sabre-shaped, strong hook, which is bent inwards.

(d) Caligus minimus Otto

Although I cannot approve the specific name, because we may in future surely find still smaller Caligus species, to which could be applied the epithet minimus with greater justification, I shall not change it, for fear of increasing the synonymy of these animals. Besides, this species of which only a single specimen is preserved in the Zoological Museum* at Berlin, may not yet have been described.

* In the same Museum are preserved at present most of the species of these

C. minimus is found on the palate of Perca labrax.

[p. 26]

This species is in body form quite similar to C. mülleri and differs from it mainly through its much smaller size. The length of the animal without the grapes is only 4.2 mm, and the greatest width of the head shield or forebody is only 2.1 mm. The two halves of the front projection are protruding especially strongly; the marginal eyes are very large; the outline of the head shield is, when disregarding the front projection, almost circular (Pl. XI, Fig. 14). The square-shaped hindbody is narrowed in front and a little smaller and hardly a fourth part shorter than the head shield. The third pair of legs is conspicuous through its thickness; in contrast the seventh pair of legs is small, its tibia thinner and narrower than in the other species, and ^{one} of the points (spurs) of the last segment so much elongated that it is about three times as long as the other two. The tail segment, of the same shape as in C. mülleri, is equal in length to the fourth part of the abdomen; its bristle-bearing projections are slightly shorter, the three central bristles are, as usual, the longest.— The entire outer margin of the head shield is much attenuated, membranous and translucent, which may be caused only by the alcohol, although I have not observed a similar transformation in other species.

The colour of the animal, a deep yellowish red-brown had not changed in the preservative.

(e) Caligus diaphanus

It occurs on Trigla hirundo, especially at the corners of the mouth of this fish, where Dr. Mehlis found a considerable number of them.

Of this species I know two forms, which show in their bodily structure sev-

animals, which I have described in this and the preceding part; they can be used by future investigators of related objects as types and for comparison.

eral not insignificant character differences and of which the specimens with the narrower abdomen might be either not fully mature females, or perhaps more likely, the males. The size of both forms is equal, with a length of about 4.2 mm and a greatest width of the head shield of about 1.6 mm. In both forms the outline of the head shield forms a regular circle, the front projection is less [p. 27]

protruding, and the marginal eyes slightly smaller than in the preceding species. The entire forebody is rather translucent on account of its loose and thin texture and therefore well suited for the examination of its parts. Below and between the large and thick third pair of legs one can see in the median line of the forebody a small forked projection, which I have found later also in all preceding species. The two ribs, which re-enforce the head shield, have their origin at the two sides of the forked points and run straight to the edge of the shield, where each is divided into two thin arms, which spread upwards and downwards. The antennae are cylindrical and only at the end beset with 8 to 10 short, non-pinnate bristles. The grape-bearing abdomen, which is strongly arched and swollen in several older specimens, is shorter by one-fourth and slightly narrower than the head shield; it is triangular and bears at the two posterior corners four short hairs (Fig. 15). The internal ovaries render it especially opaque and give it a yellowish-white colour.

The tail part is in grape-carrying specimens composed of two segments and the bristle-bearing projections, of which the first segment has the length of the triangular abdomen and a conical, sometimes spindle-shaped form. At its base, not far from the place where the grapes are attached, can be seen a small roundish body, which consists of a yellowish, cartilaginous mass, the use and significance of which I do not understand. Although I conjectured at first that they might be the microscopic males, similar to those in the lernaeans, a close microscopical examination did not give a clue to their nature. In any case, they are not animals (in Lamproglena pulchella there are to be found at the same spot

two cartilaginous suctioncup-like bodies [see above, p. 5]).

The succeeding segment is short, almost square, and carries the two small projections, on whose point sit five pinnate bristles, as in the other species.
[p. 28]

In old specimens the grapes are almost twice as long as the tail, they are cylindrical, hang anteriorly on a short and narrow stalk; they are filled with eggs, which are stacked in a single row. In some specimens the eggs are spherical, in others disc-shaped. However, most specimens lacked grapes.

The other form of this species is characterized especially by the fact that the abdomen (on which otherwise hang the grapes) is strikingly narrower, as well as altogether smaller, and that the tail consists, without the last, forked extension, of three segments, of which the two anterior ones carry a few small hairs. The shape and relative lengths of the segments can best be seen in Pl. XI, Fig. 16. In one specimen I could see plainly that the upper tibia consisted of three segments, in so far as the first is formed by the short member that is armed with a strong hook and that sits directly on the scale, and the two others, which are inserted slightly lower, show a similar structure as the upper tibiae of the fifth pair of legs in Caligus bicuspidatus.

(f) Caligus pharaonis

This Caligus, which differs from the other species in the shape of the body and especially in the relative sizes of abdomen and forebody, originates in the Red Sea. I found it on the gill covers of Chrysophrys (Chaetodon) bifasciatus Hemp. and Ehrenberg in the Berlin Museum.

The very small forebody is heart-shaped (Fig. 17), the two wings of the shield are spread far apart at the base and are considerably excavated at the inner sides. The first, and especially the third pair of legs is closer to the frontal projection than usual, so that the third pair projects beyond the frontal margin when stretched out toward the front. The proboscis, which is also slightly displaced towards the front, is conical, its laterally inserted palpi

are shorter than it. The second pair of legs is small. The grape-bearing abdomen is triangular, much wider, and twice as long as the forebody. The grapes are [p. 29]

cylindrical, 4.2 mm long. The conical tail part exceeds the length of the entire remaining body by 0.5 mm and consists of only two segments, of which the first is the longer, whereas the second is very short and square. The forked last tail segment has six short pinnate bristles.

The length of the entire animal is 4.9 mm, the colour a dirty light greenish-brown.

When we emphasize the distinguishing characters specific for the six species described, we obtain the following diagnoses:

G e n u s C a l i g u s

A. With a short tail piece

1. C. bicuspidatus mihi. Forebody large, wide; the (grape-bearing) abdomen below produced at both sides into two points; the tail bristles as long as the two tail segments. Length 8.4 - 12.6 mm.
2. C. mülleri Leach. Forebody less wide; the abdomen almost quadrangular, rounded in front; tail bristles short. Length 8.4 - 12.6 mm.
3. C. minutus Otto. Forebody circular; abdomen quadrangular; tail and bristles very short. Length 4.2 mm.

B. With elongated tail piece

4. C. elongatus mihi. Forebody oval; abdomen quadrangular, elongated; tail conical. Length 4.2 mm.
5. C. diaphanus mihi. First form: forebody circular; abdomen triangular, its first segment conically cropped. Length 3.9 mm.
Second form: abdomen conical; tail four-segmented, small.
6. C. pharaoni mihi. Abdomen larger, tail longer than forebody. Length 4.9 mm.

All Caligus species are differentiated from the related lernaeans by, among other features, that they do not parasitize sluggishly and sessile, but, like

Argulus foliaceus, can swim quickly in the water by vibrating their gill legs,
[p. 30]

and that they also can run nimbly over their hosts. I hope to be able to investigate the internal anatomy and the development of these animals during a forthcoming sojourn on Heligoland.

Remarks. In regard to the synonymy, I would add only that Baster (Opuscula subseciva, Harlem 1764, II, p. 137, Pl. VIII, Figs. 9 and 10) has described and incorrectly illustrated two Caligus species, of which the one found on a pleuronectid has a certain resemblance to our C. bicuspidatus; however, the coarseness of the figure does not allow to make a definite decision. The other Caligus Baster had found on Asellus aquaticus. Müller cites both figures as representing C. curtus. Gunnerus, Fabricius, and even Linné made the same mistake in considering the tail bristles of Caligus to be antennae.

4. Lepeophtheirus *

Into this genus, which I have erected, belongs so far only one species, namely, as I mentioned already above, Lernaea pectoralis Müller, illustrated in Zoologia danica, Pl. XXXIII, Fig. 1.

Lepeophtheirus pectoralis

That Lernaea pectoralis should be removed from the lernaeans and placed into Caligus was already recognized and expressed** by Blainville and Cuvier, and this becomes clear as soon as one looks at Müller's figure.

The abode of the animal is the pectoral fins of various species of Pleuronectus, as P. rhombus, flesus, a.o., on the former Dr. Mehlis found a number of specimens and kindly put them at my disposal later.

* from lepos - scale and phtheir - louse.

** Cuvier, Regne animal., III, p. 258. Blainville, Dict. des sc. natur., XXVI, p. 129.

Of this species I have in front of me two forms, which show in structure and shape of the abdomen almost the same differences as Caligus diaphanus. The [p. 31]

size is in both forms the same, and the whole animal is 5.2 mm long, the width of the head shield is slightly more than 2.1 mm and that of the abdomen 2.1 mm exactly. The outline of the forebody is almost circular, however, slightly wider distad (Pl. XII, Fig. 1). Number and position of the legs as in the preceding genus. The proboscis is short and thick, conical; the palpi as long as the proboscis, two-segmented and with a split point. The anterior edge of the proboscis is surrounded by a circle of fine and short cilia; the maxillae, which are hidden in the proboscis, are bent over at the point and finely toothed on the inner side, they are small and minute (sic!). Distad of the third pair of legs one sees the small, two-pointed projection, which has been mentioned also in Caligus.

The frontal extension with the laterally inserted antennae resembles that in Caligus, however, with the important difference that there is no trace of the large eyes at the margins. This lack of organs of sight appears to me to be important enough to justify the erection of the genus Lepeophtheirus. On the central projection of the head shield I do see two small, roundish, lighter areas, which lie side by side, but they appear to me to be depressions and not eyes. Quite apart from this, their different position would alone provide sufficient justification to separate this animal generically from the preceding.

The seventh pair of legs is extremely small, with a rather thick basal segment, and a two-segmented tibia, on the last segment of which are three points.

The grape-bearing abdomen is large, thick, three-cornered, with a median longitudinal lighter line, which is especially distinct on the underside. The tail piece has the same shape as that of Caligus mulleri, it consists of two segments and the bristle-bearing extensions. Between the last two is the anus.

The grapes are five-sixth as long as the whole animal and are cylindrical.

Each of the disc-shaped eggs lies in a separate, closed compartment, which is [p. 32]

formed by two membranous cross walls, so that after the emergence of the young the empty grape envelope retains a segmented aspect.

In the other form, which lacks grapes, and which is also more transparent, the abdomen is smaller than in the preceding, of heart shape, and considerably flattened (Fig. 2). On the underside are two leg-like, flask-shaped, flat appendages, which have on the inner side a few constrictions and carry towards the anterior margin four very short, small hairs. The tail piece is oval, half as long as the abdomen, and has only one segment. On the tail segment are two blackish dots.

Among the available 14 specimens of L. pectoralis are only three that belong to the second form, it appears therefore to be much rarer and may represent the males.

5. Binoculus Fabricius

Dinemura Rafinesque-Schmalz, Latr.*

In most zoological handbooks the species that belongs into this genus and which has already been described by Müller and Herbst, has been listed under Caligus. This is more than unnatural, because it presents sufficient characters to constitute its own genus. To Müller's species I can now add a second one.

(a) Binoculus sexsetaceus

The Berlin Museum has three specimens of this interesting animal, which have been presented to it by their discoverer, Professor Otto. He named it Caligus heptapus, a name that I cannot preserve, because the seven pairs of legs is a character that is shared by the whole family of the caligids and that can therefore under no circumstances be applied to a single species.

* Rafinesque, Latreille, and Cuvier write the name less correctly Dinemoura.

Dinura or Dinuris would be better.

I do not know on which species of fish the three specimens were found.

The body of the animal can be considered to consist of three different pieces, namely the head shield, the breast piece and the large hindbody. A proper head is lacking, as Müller has already remarked in regard to the species described by him. That the animal belongs to the larger parasitic crustaceans can be seen from the following measurements: length of the head shield along the middle line 3.1 mm, greatest width 5.2 mm, length of the breast piece 2.1 mm, greatest width 3.1 mm, length of abdomen 6.3 mm, greatest width 3.1 mm, length of one of the lower lamellae of the abdomen 2.1 mm, width 1.6 mm, length of the thread-like appendages 14.7 mm.

The head shield has the shape of a heart, or rather a horseshoe, is hollowed below, convex above (Pl. XII, Figs. 3 and 4). Seen from above it appears to consist of three pieces, because the two wings are separated by two parallel seams that reach to the anterior margin and thus delimit a square piece. At the anterior edge of the shield is a lateral projection of the frons (Fig. 5a) of the same nature and shape as in Caligus, however, with this difference that the antennae are not inserted at the points of the two lanceolate halves of the projection, but at the base and appear to be connected with the anterior edge of the head shield.

The antennae are relatively short, two-segmented and bear on both joints several small bristles (Fig. 5 b). After removal of one of the lanceolate projections one sees a bristle that sits on the anterior edge below the point of insertion of the antenna. The position of the eyes, or the organs that must be considered as such, is different from that in Caligus. They lie not on the projection of the frons, but on the underside of the anterior edge of the head shield directly below the point where the antennae are inserted; they are convex, project laterally and are pear-shaped. The mouth parts are rather complicated. The proboscis lies between the second pair of legs, is conical, rather pointed, and has a broad, cropped, roll-shaped base (Fig. 6). The mouth opening

is oval and rather large. The maxillae, which lie in the proboscis (Fig. 6aa), have a peculiar shape, since they are composed of two extremely long and thin, stalk-like bodies, that extend deeply to the base of the proboscis and are armed at the anterior end with nine inwardly bent small teeth. In addition, the anterior edge of the proboscis is prolonged into two thin, horn-like, bowed points, which embrace the exterior of the mouth opening and correspond as it were to mandibles, perhaps as in the coleoptera. I doubt, however, whether they should be considered as such.

There are two pairs of parts that could be compared with palpi; they sit at the sides and at the base of the proboscis. The larger pair, more than half as long as the proboscis, is two-jointed (Fig. 6bb); the basal segment is irregularly cylindrical, with one small bristle at the root and two or three at the point; the second segment is smaller and bears anteriorly only one, but slightly heavier bristle. The other pair of palpi stands beside the larger first one, is seldom distinct and form a small pointed projection (Fig. 6cc).

Of the seven pairs of legs three are inserted on the lower, concave face of the head shield, the other four pairs of gill legs sit on the breast piece.

The first pair, not far from the upper edge of the frons, is small but thick, with a basal segment that is at the root rather narrower, anteriorly wider and rounded; this is followed by the other segment, which is half egg-shaped and bears an outwardly directed hook (Fig. 7).

The second pair is more elongated and consists of two long, club-shaped segments and two unequal horny hooks that are adapted for clasping and form a chela. The upper hook is not specially articulated but is a direct prolongation of the second segment, as it appears in the pincer legs of the decapods; it is curved moderately, narrower at the root for a distance, then wider and is garnished on its entire inner side with many very short thorns. The other movable hook is shorter by one half, bent only slightly at the point and beset with

two rows of stronger thorns along the inner as well as the outer margin. The space between the two hooks bears a tuft of rather long hairs (Fig. 8). The whole is a repetition of the leg structure, as we know it in several decapods, among which I shall here only mention Grapsus penicilliger as example.

As main clasping organ the animal uses the formless, two-segmented third pair of legs, which are armed at the point with two opposed, horny hooks of a dark-brown colour.

The pairs of gill legs, provided with pinnate and two-jointed tibiae, are spread apart the wider the more posteriorly they stand, this is caused not only by the halves of their leaf-shaped simple basal joints increasing in size but also because in the space between them develops a flap that gradually increases in size.

The first pair of gill legs (Fig. 9) therefore has the smallest basal joint, which is smaller at the root, then enlarged, irregularly rounded and beset with short cilia on its inner margin. On the outer tibia the first segment is large, rounded in shape, and has laterally on the anterior edge a moderately strong thorn; the other segment, which is smaller and egg-shaped, carries towards the outside four thorns that increase in size, towards the inside, however, three rather long and pinnate bristles. The thorn just mentioned that stands closest to these bristles carries on its inner edge also cilia, but very short ones. The two segments of the inner tibia are shorter, the upper is threecornered, rounded off, unarmed, the lower has three pinnate bristles.

The basal segment of the second pair of legs (Fig. 10) is already considerably larger, quadrangular, rounded and is connected to the other half by a small rounded flap, below which sits a pinnate bristle. The first segment of the outer tibia is of elongated, quadrangular shape, very finely serrated along its entire edge and carries towards the outside one thorn and on the inner side one long pinnate bristle that is inserted beside a knob. The second, smaller segment is like the corresponding one of the first pair of legs, egg-shaped, but armed with

three thorns and five pinnate bristles. The first, smaller segment of the inner
[p. 36]

tibia lacks the thorn, it also has only three pinnate bristles on the inner side, whereas the second, larger, at the edge irregularly notched segment has eight long, pinnate bristles. After removing gently the second, or one of the subsequent pairs of legs, one sees above the flap that connects the large basal segments an egg-shaped, lighter area, the edge of which is cartilaginous.

The structure of the following pairs of legs is analogous to that described and shows a slight difference only in so far that of the third pair the second segment of the inner tibia has six and the corresponding segment of the fourth pair five pinnate bristles.

When one examines the thorax on which the gill legs are inserted one sees that it consists of two shields, of which the posterior is smaller and forms the segment of a circle. On its underside is a cartilaginous, yellow structure anteriorly of the the four pairs of gill legs, the posterior end is prolonged into a point, which resembles the proboscis, whereas the anterior end is forked. The upper part of the large, anteriorly rounded, posteriorly split abdomen is covered by two square and slightly rounded scales or lamellae, which are connected by a smaller rounded scale with the second thoracic shield; they resemble those at the posterior margin of the abdomen, except that the latter are considerable larger, oval in shape and bear on their posterior, notched end four bristles. Below the split part of the abdomen is another single quadrangular lamella.

Anteriorly of the abdominal lamellae sit two peculiar, cartilaginous, brown-coloured, tubular bodies, which lie crosswise one over the other (Fig. 11), since, however, the part where they cross is thinner and more transparent, they appear, at first glance, to^{be} four in number. Miller, who did not miss them in Binoculus productus, speculated that they belong to the male genitalia; according to this assumption the animals would have to possess the organs of both sexes, because the three specimens in front of me have also egg-containing grapes. The males of

Binoclus will certainly be found in future and I would consider these bodies to be organs, which, although not serving for clasping, nevertheless may serve to prevent sliding off the slippery skin of the fish.

Between the abdominal lamellae and the lamella lying below the split end of the abdomen are inserted the long paired appendages, which each consist of three closely spaced, thin, straight, cartilaginous, yellowish threads; each appendage is drawn out into a point and does not show a trace of segmentation; these appendages must, therefore, by no means be confused with the grapes, as has been done by some writers. Similar tail appendages are found in several lernaeans, as, e.g., in Brachiella thynni and Pennella, which will be described below.

In all three specimens the grapes seem to be damaged, so that it is impossible to determine their actual length. Their structure shows many peculiarities; they are inserted to both sides and slightly distad of the crossed cartilaginous bodies mentioned above; they consist of three short, cylindrical tubes, which are coherent, but separated by longitudinal walls and compartmented by thin cross walls. The relatively large eggs are round and do not lie regularly in the spaces formed by the cross walls, but each egg has a far larger diameter, so that it extends beyond several cross walls, which consequently had been ruptured here and there. This could, without doubt, be explained by the fact that the inner egg envelopes of the embryos, which were ready for eclosion, had already enlarged*. In one of the specimens the larger number of eggs had already fallen out, and the embryos still in the grapes showed a body form very dissimilar from that of the mother; this suggested that the young of Binoculus in some ways resemble those of the lernaeans Ergasilus and Cyclops and are provided

[p. 38]

* A fact, which I have already touched upon on p. 14. I shall have occasion to return to it below under the development of Lernaea percarum.

in their earliest stages like these with long swimming bristles on their legs*.

* On account of the confusion between the thread-like appendages and the grapes, which they resemble often, it could perhaps be explained that several writers will give little or no credit to the observation of Dr. Surriray, which he made, although with insufficient accuracy, about the development of a Caligus species. I have had the same experience when I presented to Berlin naturalists the drawings of Lernaea cyprinus and their quite dissimilar young. The discoverer of the formerly unsuspected high organization of the infusoria, Professor Ehrenberg, especially expressed to me his doubts. Surriray's account of the young of a Caligus, which occurs on the gill covers of Belone belone, is to be found in Annales générales des sciences physiques (Brussels), III, p. 343, in the following words: "This embryo was so different from its mother that the observer was led to believe that these ovaries belonged to quite a different animal; the larvae swam in the fluid with rather feeble alternating contractions and expansions of the whole body. This was oval, without eyes, neither the beginnings of a tail, nor any constriction of its middle, as it occurs in the mother, five pairs of legs in the shape of bristles at the posterior end of the body, whereas there was not a trace of the well-visible hooks that serve the adult for clamping itself to the scales of the fish. All these embryos, contained in a flattened membrane, are piled one on the other in the tube, and although one cannot see them except edge on, one can already see some slight movements in the most advanced ones."

Cuvier, in Regne animal., IV, p. 196, where he cites Surriray, doubts the facts described and, supposing that an error had occurred, and since he had not been able to see any eggs in the grapes of Caligus specimens preserved in alcohol, he considers with Jurine Jr. the appendages on the abdomen of these animals to be respiratory organs. That however, according to Surriray, the young of Caligus lack organs for the perception of light, is to me more improbable, since on analogy with Cyclops, Ergasilus, Tracheliaestes and other lernaeans, they positively must exist.

(b) Binoculus productus

Caligus productus Müller, Entomostraca, p. 132, Pl. XXI, Figs. 3 and 4.

Binoculus salmoneus Fabr., Fauna groenl., p. 264.

Dinemura producta Latr. Cuvier.

Distinguished from ^{the} preceding species by the thin and thread-shaped appendages of the abdomen being much longer, namely about 67 mm, and consisting of only two simple strands.

Müller's description is detailed and better than his illustration, which is, especially in regard to the gill legs, very unsatisfactory. The third large pair [p. 39]

of legs on the lower side of the head shield is lacking, and the thoracic shield bears, instead of the gill legs, a few membraneous lamellae. I also find that Müller represents the long thread-like appendages of the abdomen as being segmented, which is definitely incorrect and probably results from Müller's having mistaken them for organs that correspond to the grapes of a Caligus, which is figured on the same plate.

The animal is supposed to occur on a shark and a Salmo species.

Desmarest (Considér. génér. sur l. cl. des crust.) is in doubt about the systematic position of this animal and does not include ^{it} in Caligus, but places it provisionally after Anthosoma*.

6. Cecrops latreilli Leach

This is certainly one of the largest parasitic crustaceans, which is found

* The animal that Geoffroy (Histoire abrégé des insectes, Paris 1764, II, p. 660, Pl. 21, Fig. 3) figured and described under the name Binocle à queue en plumet, which is 4.2 mm long, does not belong here, but must form its own genus in the family poecilopods, because the antennae are five-segmented and the body shape is entirely different. Linné has incorrectly placed it under Caligus piscinus. Cf. Dumeril Dictionnaire d'hist. natur., article Binocle, and Desmarest, Consid., p. 357.

in large numbers on the gills of Orthogoriscus mola. I presume the descriptions by Desmarest and Leach to be familiar, to which I add a few remarks in regard to the results of investigations of the mouth parts and other parts of the body of this animal that have hitherto attracted little attention.

Length of the largest grape-bearing female 21 mm and its largest width 11.5 mm, length of male 10.5 mm, greatest width 7.8 mm. The antennae are small and minute (sic!), and consist of an unevenly thicker, cylindrical basal segment, on the anterior edge of which stand several short bristles, and the much thinner, also cylindrical second segment, which bears on the posterior margin one, and at the point seven to eight unequal bristles. The first and third pair of legs is armed with a simple strong hook; the second pair in contrast has, what could hardly be [p. 40]

expected, in both sexes a peculiar build. I find it in the male to be much smaller, consisting of a flask-shaped, thick basal segment and the by far smaller second segment, which bears at its end a very small, separately inserted, lanceolate prolongation, which may be considered as a third segment and which is beset with rows of small bristles or thorns on its entire surface. In the female in contrast the second leg forms in a way a so-called chela, in so far as its second segment consists of two thin end points that are armed with very many thorns; the lower endpoint is smaller and is shifted more than usual towards the middle of the segment. This circumstance must not be overlooked in the examination of similar objects; it probably will provide in future much information about the sex of individual animals, which show no differences in other body parts.

Latreille calls the first three pairs of legs jaw feet (pieds machoires), as I have done frequently in Caligus.

The other four pairs of legs are still more different in the two sexes and are enlarged into curiously shaped, thick and folded lamellae with two or three lobes, on which the much stunted and minute end segments are hardly visible and displaced laterally; this is especially true of the sixth and seventh pair of

legs of the female, so that, to judge by this, the females have little or no swimming ability. The fourth pair of legs, although small and stunted in both sexes, is little changed as far as shape of the individual parts and their relation are concerned, it can be compared with that of the preceding genus, however, with this important difference that the swimming cilia of the bristles disappear already. In the same degree in which the genus Cecrops loses its ability to change its abode, it approaches the numerous group of the lernaeans, which are built in a peculiar and often strange manner. The mouth parts conform with those of related genera as follows. The proboscis, which lies between the first [p. 41]

and second pair of legs, is conical, slightly enlarged at the base and very pointed. It has at the sides only two palpi, which are as long and almost thicker than the proboscis. They are cylindrical, distally a little wider, rounded, and beset at the margin with three to four regular rows of very small thorns. At their base can be seen a very small, roundish joint that is connected to the proboscis. The maxillae are unusually long and thinly stalked and armed at their ends with 11 small teeth that are bent inwards.

The underside of the abdomen is covered by a membranous lamella, which is shaped differently in the two sexes and according to the different conditions of the animals. In the male it is smaller and consists of two unequal parts; in young females it is noticeably thicker and has an evenly quadrangular, elongated shape, whereas in the grape-bearing specimens it is square, shows in the centre a considerable hollow, and forms on the surface towards the abdomen a large hollow container through the edges being bent over towards the middle; in these containers are stored the grapes. At the posterior outer edge of this lamella are two roundish, thin projections, which are armed with a few short bristles towards the outside.

The grapes are quite different from those of the preceding genera; they consist of two large bundles of thin twine-like threads, which are wound in and around each other, have, on account of cross walls, a segmented aspect and contain

an infinite number of small disc-shaped eggs. A similar structure of the grapes we find in, e.g., Lernaea branchialis.

7. Dichelasthium sturionis Hermann

Hermann's* description of this animal that is already much closer to the lernaeans than the preceding genus has been revised and compared carefully with [p. 42] actual specimens. This showed that Hermann made his investigations carefully and his description, except a few points, especially in regard to the mouth parts, deserves to be called excellent.

There are no longer seven pairs of proper legs, but only five; to this might be added perhaps the pair of appendages on the third body segment, which is hardly recognizable as such and is unsegmented and shapeless, but might possibly be a sixth pair.

The first pair, which sits on the anterior edge of the rhomboidal head shield, is the largest and longest, consists of four indistinctly defined segments and its end has the shape of a chela. The next two pairs are in general as in Cecrops, with this exception that the second, longer and narrower of the second pair bears on the outer side a few irregular knobs and at the point three separately articulated extensions, of which the longest represents a simple hook, which is armed on the inner side with a very small acumination; the second, smaller one bears a double row of saw-like teeth; the third and smallest finally, which is a little distant from the point, forms a conical protuberance. The hairs, seen between the first and second extension, are of some thickness and could, with some justification, be considered as apparently flattened thorns.

The fourth, smaller, and the fifth, larger pair of legs, are inserted on the second body segment and correspond to the pairs of pinnate gill legs of Caligus

* Jean Frédéric Hermann, Mémoire aptérologique. Strasburg 1804, p. 125, Pl. V, Figs. 7 and 8.

and Dinemura. Their basal segment is triangular, rounded and carries at the side of the anterior end a small thorn. The tibia is double, the outer consists of two segments, of which the first, longer and clubshaped, bears at the side a thorn, the second, smaller and rounded, bears five bristles. The inner tibia has only one elongated roundish segment and two bristles. The outer margin of each segment is finely serrated, and of the pinnae on the bristles only hardly noticeable traces are left. The sixth pair of stump legs, which sits laterally on [p. 43] the third body segment, diverges outwardly and has been mistaken by some writers for grapes, which is, without doubt, incorrect, because there are on its outer, rounded edge several small horny points, which give these appendages the significance of legs.

The organs belonging to the mouth parts differ also from previous conceptions. Hermann and following him, Desmarest attribute three pairs of palpi to the animal, which would constitute a considerable anomaly in regard to the analogous parts of the preceding genus, the more as in consequence of this supposition the maxillae, which lie in the proboscis, disappear and must be considered as the third externally situated pair of palpi. I myself was for a long time of this erroneous opinion, which had its cause in the, only too often occurring less careful treatment of these minute objects.

The rather long and thick proboscis is conical and sits, as in the preceding genera, between the second pair of legs; it is cartilaginous at the point and shows there a trace of upper and under lip. The roundish mouth opening is surrounded by a short and thin skin, which is incised fringe-like and notched. The long-stalked maxillae consist of three distinct joints, of which the central is the longest, the third, which bears 11 strong teeth that consist of a yellow horny mass, is the shortest. At the base of the maxillae lies a strong bundle of muscles that is compounded of a number of single fibres. When one removes the maxillae their ends, armed with small teeth, which in the proboscis are bent over inwardly, bend over slightly outwardly. The pair of palpi next to the proboscis is of the same length as the proboscis, thick, lanceolate, and split at the end into two

long, thin, pointed branches, whereas the second, outer pair is shorter by two-thirds; it consists of two segments and bears two short points of unequal length. At the base the maxillae are connected to the palpi, so that on excising the palpi, the maxillae are being withdrawn uninjured from the proboscis through the cut that had been made at its base, which leads to the temptation to suppose, as Hermann did, that there are three pairs of palpi present.

[p. 44]

The six specimens of Dichelesthium in front of me lack the grapes or egg sacks.

The antennae are, as Hermann has seen correctly, seven-jointed, tapering, and beset with a few short bristles at the point only. The specimens, preserved in alcohol show no trace of eyes.

The species is found on the gills of Acipenser sturio.

Nicothoë astaci of Audouin and Milne Edwards* might be placed ahead of Dichelesthium and in its neighbourhood the genus Nemesis of Risso and Roux**.

* Annales d. sciences natur. IX, p. 345, Pl. VIII. Isis 1831, Heft XI, p. 1228.

Nicothoë astaci has, according to the investigations of the workers cited, on the thoracic shield two eyes, and two eleven-jointed antennae. It has a body consisting of several rings, which end in two bristles. The fifth ring of the thorax is produced at each side into a large, wing-shaped, rounded appendage; on the narrowed abdomen hang two large, oval egg sacks. There are six pairs (?) of mouth parts, namely, the mouth, two pairs of accessory jaw-shaped maxillae, and the soft mandibles. The animal is supposed to have five pairs of organs that have been considered to be legs,^{of} which the first pair has as end segment three hooks, arranged stepwise one above the other, whereas the end joints of the other four pairs are split into two- or three-segmented, bristle-bearing, oar-shaped pieces.

The explanation of the mouth parts is, as anybody can see, different from ours and that given by Hermann (in describing Dichelesthium). It would perhaps not be so if Audouin and Edwards had recognized the correct position of the maxillae,

8 . Epachthes * * *

The discovery of this peculiar animal form that provides the finest transition to the lernaeans was very welcome, the more so as it fills the gap in the sequence of the here treated parasitic crustaceans, which otherwise could have only been

because these are most likely as in Dichelesthium and the related genera.

** Polydore Roux Crustacés de la Méditerranée et de son littoral. Marseilles, 1827-8, Pl. XX. The genus Nemesis, of which two species occur on the gills of two species of shark, has been characterized by Roux, as I know from Cuvier, Regne animal. IV, and Latreille, Cours d'entomologie, 1831, as follows:

The body, of the form of a parallelepiped, is narrow and elongated and consists of five large, almost square, and of four smaller sections or segments, which, together with the last of the preceding segments, form the conical abdomen, which ends in two short bristles. The first segment, or the head shield, is elongated, almost egg-shaped, knob-like arched, and bears two seven- to eight-segmented, bristle-bearing antennae, a short, three-segmented sucking proboscis, and three pairs of legs, the first and third hook-shaped, the second membranous and toothed at the end. No visible eyes. On the second segment sits another pair of legs, similar to the preceding, and in addition two (double?) prolongations, which run downwardly into three short, finger-like extensions; the two following seg-
[p. 45]

ments with stunted legs of the same nature, so that the total number of legs is 14. On the fifth segment hang the roundish egg sacks and two long thread-like, cylindrical, weakly girdled appendages.

The first pair of legs on the head shield is considered by Roux to be a second pair of antennae that are modified to clasping organs; I do not like to concur.

*** from epachthes - irksome.

completed with the genus Lernanthropus* of v. Blainville, which I know only from his description.

Epachthes paradoxus

The three specimens that I have at my disposal I found on the gills of a species of Mugil, which came from the Cape of Good Hope and had been sent to the Berlin Museum by that industrious collector Krebs. All three specimens are well preserved, although they sat for more than three years on the fish, which had become almost rotten, and it was thus possible, to carry out the examinations [p. 46] of the external parts in some detail.

The full length of the animal is almost 8.4 mm, of which the four appendages of the abdomen take up one-half; the greatest width of the abdomen is barely 2.1 mm.

* It is well known that Mr. v. Blainville has gone to much trouble in trying to devise memory aids in regard to the names of genera belonging to a certain family, by forming combinations consisting of a main stem word denoting the family as the main genus plus a second word. Here belong under, e.g., the annelids, the combinations with the word Bdella: Iatrobdelta, Hypobdelta, Pseudobdelta, Geobdelta, Branchiobdelta, Ichthyobdelta, Pontobdelta, Glossobdelta, Epibdelta; under the cephalopods: Onychoteuthis (after Lichtenstein), Pteroteuthis, and Sepioteuthis; as well as the genera of the lernaeans formed by him. Although Mr. v. Blainville has perhaps attained his goal by this method, it has led to the rejection of several earlier, accepted names on the one hand, and on the other to quite remarkable combinations. What is, for instance, the meaning of, e.g., Lernaeopoda, or even Lernanthropus (from Lernaea and anthropos)? In this regard these names are hardly any better than the incorrect ones of the prolific and industrious writer Lesson, or the senseless words formed through transposition of certain vowels and consonants by the otherwise respected naturalist Leach, as, e.g., Canolira, Conilera, Rocinel, Cirolana, Nelocira, Olencira, Anilocra, from C, L, N, R, and A, E, I, O.

The animal consists of the head piece and the large abdomen (Pl. XII, Fig. 12). The former is square, slightly rounded, with rounded posterior corners and slightly produced anterior corners, so that the anterior edge of the frons forms a cropped projection on which the antennae are inserted laterally. These are short, six-jointed, tapering towards the apex; the individual joints, as well as the end are beset with a few very short bristles. Above the head shield is fairly arched, which results mainly from the longer edges being bent over slightly inwards. Below it bears, as in all preceding genera, three pairs of legs; the first, larger pair is more distant from the others because it is shifted towards the front; it consists of a thick, club-shaped basal segment and a strong and pointed hook, which is articulated with it, its root is surrounded by two small, cartilaginous half-rings that touch in the centre; the second pair is the smallest and weakest of the three, otherwise it is of the same kind, namely, provided with a single end segment, armed with a hook.

The position of the mouth parts is also not different from that of the preceding genus. They are built as follows: in the conical proboscis, which is swollen at the base, and not far from the end, lie the maxillae, which ^{are} long-stalked and armed at the point with several small saw teeth. The proboscis is surrounded by two pairs of palpi, of which the inner are thin and filiform, the outer consist of a small, roundish basal segment, armed with a short, lateral thorn, and a second thick, conical segment, with three unequal, short points at its end (Fig. 13). Below the mouth parts can be seen a triangular, anteriorly forked, cartilaginous

[p. 47]

piece, which appears to bear at its end the fourth pair of legs.

The dissimilarly greater abdomen is also elongated quadrangular, but wider behind than in front and excavated at the sides. In analogy with Dichelesthium, Cecrops, etc. it should bear four pairs of swimming legs; of these, however, only the fourth remains, whereas the other three have either disappeared completely, or are represented by the peculiarly shaped, membraneous appendages, into which they may have been transformed. The fourth pair of legs, which is

extremely minute, stunted, and is composed of two or three segments, of which the penultimate is elongated oval and bears at the lower edge a long bristle, the last segment is smaller, roundish and beset with five very short bristles (Fig. 14).

The two thick membraneous appendages are inserted in the middle of the abdomen, they are soft and without a trace of segmentation, they form two strongly projecting, bow-shaped and slightly plicate bodies, they are inserted on the abdomen with their inner points, which touch each other, their equally pointed outer ends project over the sides of the abdomen. On the posterior part of the abdomen are inserted also four other long appendages, which taper and are pointed; of these the inner are slightly shorter, the outer are bent slightly inwardly at their points of insertion. Between the two former one sees the tail-like prolongation of the abdomen, which consists of a short, oval segment; this has two projections, which are short, tapering and bear at their ends two barely visible points.

The gut can be followed for part of its course through the abdomen, it is straight, rather wide and appears to have thin walls. At the base of the tail are two pear-shaped, cartilaginous, yellow-reddish bodies of the kind that occur in several lernaeans and which we have also found in some of the animals described above. The protruding part of the abdomen to which they belong is in the [p. 48]

middle excavated towards the outside and also cartilaginous. Not far from it are the two round mouths, surrounded by cartilaginous edges, of the internal ovaries, which lie to both sides of the gut and do not appear to contain developed eggs, grapes are missing as well in all three specimens.

The colour of the animal is a yellowish white, the outer covering soft and rather translucent.

I have already mentioned above that this animal is nearest to the genus Lernanthropus* described by v. Blainville.

* Dict. des sciences nat., XXVI, p. 128. "Genus Lernanthropus: body oval, little

elongated and divided into two parts; a cephalo-thoracic shield and an abdomen extended posteriorly by a large scale projecting from the end of the abdomen; two very strong hooks below the front; three pairs of very small transverse hooked appendages below the thorax itself; one pair of simple arms, swollen, and a second pair, split and gill-like, below the abdomen. The egg sacks long and cylindrical."

LEGENDS TO PLATES

Plate I

Fig. 1. Lamproglena pulchella Mihi, dorsal view, magnified, actual length 2.8 mm.

Fig. 2. Ventral view of the same animal.

Fig. 3. Lateral view, (a) projection of one of the suction cup-like bodies.

Fig. 4. Ventral view of the three anterior body segments of Lamproglena, more highly magnified. (a) the first, large pair of legs, armed with a hook; (b) the second, smaller pair of legs with three claws; (c) the anterior, longer, and (d) the posterior, shorter antennae; (e) the roundish mouth opening, which lies between the cross-shaped structure composed of small cartilaginous ridges; the eye is visible anterior to the mouth opening; (f,f) the long gut, surrounded by a reticular liver-like organ; (g,h) small, longitudinal muscle bands, and (i,k,k) broader, transverse muscle bands, of which (i) is responsible for the peristaltic movements of the gut; (l) internal ovaries with blind anterior ends, unfertilized condition; (m) excretory openings through which the eggs pass from the ovaries into the long, filiform grapes (which are not figured here). On the fiddle-shaped middle body one sees the unevenly spaced four pairs of swimming legs.

Fig. 5. A swimming leg at much greater magnification.

Fig. 6. The posterior pair of antennae.

Fig. 7. and 8. The suction cup-like, cartilaginous bodies in anterior and lateral view.

Fig. 9. One of the second pair of legs with the three claws and their muscles.

Plate II

Fig. 1. Ergasilus sieboldii Mihi, dorsal view, magnified. Actual length 1.2-2.1 mm.

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Fig. 2. The same, lateral view, without grapes; on the projecting part of the abdomen the mouth opening with two pairs of short masticatory points.

Fig. 3. One of the grapes, depicted at the moment when the mature eggs fall from the outer envelope and the young animals are about to emerge.

Fig. 4. One of the anterior legs, used for clasping and armed with a hook.

Fig. 5. One of the swimming legs, with non-pinnate apical bristles.

Fig. 6. The tail segments of Ergasilus.

Fig. 7. The larva of E. sieboldii after eclosion from the egg envelopes.

Fig. 8. The embryo, still enclosed by the egg envelopes, but ready to emerge.

Fig. 9. The second pair of larval legs in anterior and lateral view.

P l a t e I I I

Fig. 1. Ergasilus gibbus Mihi, enlarged dorsal view. Actual length 1.5-2.1 mm.

Fig. 2. The same, lateral view, without grapes.

Fig. 3. One of the anterior clasping legs with the inflated, bladder-shaped cover of the basal segment.

Fig. 4. The anterior body part of the same animal with the frontal eye, antennae, and the bladder-shaped inflated covers of the basal segments of the clasping legs.

Fig. 5. The tail segments of E. gibbus with the short bristles.

Fig. 6. One of the swimming legs of the same animal.

Fig. 7. E. trisetaceus at the same magnification as the preceding species.

Fig. 8. Its tail segments.

P l a t e I V

Fig. 1. A. Actual length of a female of Achtheres percarum Mihi.

B. The same, enlarged.

Fig. 2. Lateral view of it, without grapes.

Fig. 3. One of the three-segmented antennae with several points.

Fig. 4. One of the anterior legs modified into jaws.

Fig. 5. The mature embryo, enclosed in two egg envelopes and ready for eclosion.

Fig. 6. The mature larva after rupture of the outer egg envelope and the inflation of the inner envelope, which takes place immediately afterwards.

Fig. 7. The larva, with two pairs of swimming legs and one eye after eclosion.

Fig. 8. The larva after the first metamorphosis, with two antennae, three pairs of clasping legs and two pairs of swimming legs.

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Fig. 9. The two swimming organs of the first instar larva; the clasping legs are visible through the outer covering.

Fig. 10. The antennae of the second instar larva.

Fig. 11. The last two body segments of the same young animal.

Fig. 12. A spirally bent tube, lying inside the body of the larva, of greater (A) or smaller (B) length according to the age of the embryo or the young animal.

P l a t e V

Fig. 1. Achtheres percarum ♂, much enlarged, actual length 1 - 1.4 mm.

Fig. 2. The same, lateral view.

Fig. 3. One of the posterior clasping legs with the chela-like point and the muscles in the basal segment, of which two (a) are distinguished by their cartilaginous consistency.

Fig. 4. The anterior pair of clasping legs, fastened in the centre to ^acartilaginous body (a), which is connected at the base to a ledge (b), also of a harder substance.

Fig 5. The organ of attachment on the arms of the ♀ of Achtheres percarum. (a, a) the anterior parts of the opposed arms that have fused in such a way that the seam is still visible; (b) a lighter canal, which extends to the point of the arms where there is a hook-shaped cartilaginous projection; (c) the lower part of the suction cup-like, cartilaginous body by means of which the parasite anchors itself to its host; (d) the rough knobs in the hollow of the suction cup.

Fig. 6. The antennae, palpi and mouth parts of a ♀ specimen of A. percarum shown

highly magnified. (a) the oval mouth opening, surrounded by a ring of bristles and situated at the end of the proboscis; (b,c) traces of a split lip in the mouth cavity (later observations have thrown doubt on this interpretation); (d,d) the maxillae in the mouth cavity, armed with teeth on their anterior and inner ends; (e) a cross-shaped cartilaginous frame work surrounding the mouth opening; (f,f) two other cartilaginous ridges, extending posteriorly; (g,g) the palpi armed with several points; (h) the oesophageal canal; (i,i) the three-jointed antennae; (k,k) the first pair of legs modified into jaws, each leg bears at its point a larger end-joint armed with many hooks (n,n), on the inner side of which is articulated a body (o,o) armed with a hook, thus the whole structure forms a chela.

Fig. 7. Internal parts of the abdomen of a gravid ♀ of A. percarum after the outer skin covering and the eggs of the left side had been removed. (A,A) a part of [p. 147]

the outer anterior skin cover with two longitudinal muscles; (B,B) two transverse muscles situated higher; (C,C) and (D,D) longitudinal and transverse muscles forming a lattice-like tissue; (E,E) a liver-like organ that surrounds the anterior part (F) of the gut; (G,G) radially spread muscle bands serving to retract the last body segment; (H,H) a strong muscle band with three arms each at the ends, which, fastened to the gut, produces its rhythmic lateral movements. (I,I) [(J,J) in the figure] nerve cords, in actuality closer together and situated below the alimentary canal; (K) a tube containing the fluid serving to produce the external egg sacks, at the other side covered by the eggs; (L,L) excretory openings for the eggs; (M) egg masses ready to descend into the grapes, they are surrounded by the envelope, which has been removed; (N) the gut with its regular transverse creases. Should have been depicted further above the muscle band [?]; (O) the anus and to both sides of it a round cartilaginous body; (P,P) the turned-over edge of the outer skin cover.

P l a t e V I

Fig. 1. Lernaeocera cyprinacea, actual size.

Fig. 2. Dorsal view of the same, magnified. (a) the anus; (b) a part of the internal ovaries; (c) the alimentary canal, surrounded by the reticulate and lobed liver organ; (d) the posterior enlargement of the gut.

Fig. 3. (a) the fore body part of the same animal, with the mouthparts facing the observer, magnified; (b) the same part in dorsal view, less highly magnified.

Fig. 4. A piece of the gut with the vascularly branched liver.

Figs. 5 and 6. The larvae of L. cyprinacea at the first stage of their development after bursting of the egg envelopes, with two pairs of swimming legs and one red eye, organs that the animal all loses later and thus assumes the simpler shape of the mother.

Fig. 7. A leg of the larva with the swimming bristles.

Fig. 8. Peniculus fistula Mihi, actual size.

Fig. 9. The same animal, magnified.

Fig. 10. The same, more highly magnified. On the neck- and thorax-shaped body part are inserted four pairs of stunted swimming legs; the centre of the whole animal is traversed longitudinally by the alimentary canal, which is accompanied by the liver, the two sinuous internal ovaries and two nerve cords, the last-named [shown] farther apart than in actuality. Posteriorly on the abdomen a part of the grapes divided into cross compartments.

Fig. 11. The most anterior part of the animal with the hook-shaped clasping organs.

Fig. 12. The same part in lateral view, with the torn-off part of the attaching

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organ, by means of which the animal fastens itself to the fin rays of Zeus aper.

Fig. 13. A part of the neck-shaped body part of Penisculus, with three pairs of rudimentary swimming organs, strongly magnified.

Fig. 14. A part of the grape of the same animal with the eggs lying in the cross compartments.

Plate VII

Fig. 1. Tracheliastes polycolpus Mihi. The ♀, magnified. Actual size with the grapes 10.5 mm.

Fig. 2. Lateral view of the same, without grapes.

Fig. 3. The head of it, very strongly magnified. (a) the proboscis with the bristle-bordered mouth opening; (b, b) the anterior jaws (jaw-legs) with a hook (c), at their distal end a cylindrical projection (d); (e, e) the maxillae; (f, f) the stunted antennae; (g, h, i) various muscles; (k) the anterior part of the much widened alimentary canal.

Fig. 4. One of the maxillae.

Fig. 5. One of the jaw-like, stunted extremities, inserted on the animal against the rule very far posteriorly. Cf. Fig. 2.

Fig. 6. The anterior part of one of the external egg sacks or grapes with embryos far advanced in development, the heads regularly oriented to the outside.

Fig. 7. The larva of T. polycolpus after emergence from the egg envelopes.

Fig. 8. The larva after the first metamorphosis. In the interior of the body can be seen, as in the preceding figure, the spiral tube mentioned above in the larvae of Achtheres percarum.

Plate VIII

Fig. 1. Brachiella impudica Mihi. Dorsal view of ♀, magnified.

Fig. 2. The same in ventral view, without grapes. (a, a) two small ♂♂, attached to the ♀ genital pores, which appear at this magnification only as warts.

Fig. 3. (a) Actual size of the ♂ of B. impudica, here shown too significant.

Fig. 3. The same ♂ in lateral view, highly magnified.

Fig. 4. B. bispinosa Mihi, dorsal view of ♀, magnified.

Fig. 5. Lateral outline of the same parasite, without grapes.

Fig. 6. Its magnified antenna.

Fig. 7. A posterior jaw-shaped leg of the same.

Fig. 8. Anchorella uncinata (= Lern. uncinata Müller) Dorsal view of ♀, magnified.

Fig. 9. The same in lateral outline and without grapes.

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Fig. 10. The attaching organs of A. uncinata. (a, a) the two stunted and fused arms, between which can still be seen a suture; (b) a spherical, hard body, with which the parasite anchors itself to its host; (c) a part of the tissue of the fish enclosing the ball (b).

Fig. 11. Representing the same after the fish tissue^(c) has been removed from the ball (b), which is connected to the fused arms (d, d) by the short stalk (a).

Fig. 12. Antennae, palpi, and mouth parts of Anchorella. (a) the round mouth opening, surrounded by a circle of bristles; (b, b) the toothed maxillae; (c, c) the palpi; (d, d) the antennae; (e, f, g) various parts of the posterior pair of jaw-shaped legs; (h, h) the anterior jaws (jaw legs).

P l a t e I X

Fig. 1. Chondracanthus triglae. Dorsal view of ♀, magnified. 1. (a) actual length.

Fig. 2. The same animal in ventral view, without grapes, at the end of the abdomen two small ♂♂, which appear here wart-like.

Fig. 3. The head-shaped part of the same parasite with which it penetrates the gills of the fish to the basis of the neck. (a, a) two clasping organs armed with hooks; (b, b) the stunted antennae. The mouth parts are far distant from these and lie at the base of the neck.

Fig. 4. An antenna of the same animal, strongly magnified.

Fig. 5. C. cornutus (= Lernaea cornuta Müller). Dorsal view of ♀, magnified.

5. (a) actual length.

Fig. 6. The same in ventral view, without grapes.

Fig. 7. The anterior head-shaped part of the same animal, greatly magnified.

(a, a) the pair of clasping legs, armed with hooks; (b, b) the antennae; (c, c) the most distad (third) pair of legs modified to jaws. Ahead of and between them lies the mouth opening with maxillae, palpi, and the middle, also

jaw-shaped legs, which could not be included in the drawing on account of their observation having been delayed.

Fig. 8. The ♂ of C. cornutus greatly magnified, similar in every respect to that of C. triglae.

Fig. 9 a. Actual size of this pygmy ♂.

Fig. 9. The same ♂ in ventral view. The round mouth opening is visible in about the middle of the body. (a,a) the maxillae; (b,b) the palpi; (c,c) the second and (d,d) the third pair of extremities; (e,e) and (f,f) traces of rudimentary swimming legs; (g,g) the most anteriorly pair of legs; (h,h) the antennae, organs of sexual stimulation.

Fig. 10. The mouth parts of the same animal, still more strongly magnified. (a,a) the maxillae; (b,b) the palpi.

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P l a t e X

Fig. 1. The ♂ of Anchorella uncinata (cf. Pl. VIII, Fig. 8) strongly magnified.

1. a. Actual size.

Fig. 2. The same in ventral view.

Fig. 3. Ventral view of the projecting, snout-like head part of the same animal, still more strongly magnified. (a) the mouth opening, surrounded by bristles; (b,b) two palp-like bodies; (c,c) three antennae; (d,d) two cartilaginous ledges extending posteriorly.

Fig. 4. A variety of the ♀ of A. uncinata, parasitic on the gills of the cod, actual size (= Lernaea adunca Ström?).

Fig. 5. The same, magnified.

Fig. 6. Pennella sagitta (= Pennatula sagitta auct.). ♀ magnified. Actual length without the two filiform grapes

Fig. 8. A part of the head-like body part with the unsegmentedgrowths.

Fig. 8. Four pairs of stunted swimming legs, inserted on the thorax of Pennella.