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THE GENUS *LERNAEOPODA*

INCLUDING A DESCRIPTION OF *L. MUSTELICOLA* N.SP., REMARKS ON *L. GALEI* AND FURTHER OBSERVATIONS ON *L. SCYLLICOLA*

BY

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THE GENUS *LERNAEOPODA*.

INCLUDING A DESCRIPTION OF *L. MUSTELICOLA* N.SP., REMARKS ON *L. GALEI* AND FURTHER OBSERVATIONS ON *L. SCYLLICOLA*.

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(With 7 Text-figures.)

The four commonest species of *Lernaeopoda* likely to be met with in British waters are:

L. SCYLLICOLA **Leigh-Sharpe** 1915	*Parasitology* VIII, 262[1] and XI, 18[1].
L. GALEI **Krøyer** 1837	
L. GLOBOSA **Leigh-Sharpe** 1918	*Parasitology* XI, 29[1].
L. MUSTELICOLA **N.sp.** 1919	(*desuper*).

L. MUSTELICOLA[2] N.SP.

Habitat and Record. Two specimens, ♀, were taken on *Mustelus vulgaris* ♂, the smooth hound, captured at Plymouth in August 1918. They were attached in the angle between the host's body and the pelvic fin and slightly to the left. [This location is unfortunate since the length of the attaching "arms" (2nd maxillae) I have endeavoured elsewhere to show, is a variable character not to be depended upon for the determination of species; for it is my experience that *Lernaeopoda* spp. have arms very short in this location.]

Body. The general form is best understood by reference to Fig. 1 D.

Dimensions. Length of: cephalothorax 2 mm.; trunk over 4 mm.; ovisacs 4 mm.; abdominal appendages 1 mm.; second maxillae 2·5 mm. (but may depend upon location).

Cephalothorax. Differs but slightly from that of other species in respect to form, but shows black pigmentation anteriorly and round the edges, no such pigmentation occurring in other species hitherto described.

Trunk. Slender, even narrower anteriorly than in *L. scyllicola*, without postero-dorsal protrusion, not compressed postero-laterally.

[1] See these papers for references herein quoted.

[2] Not to be confused with *L. musteli* Thomson (1889) occurring on *Mustelus antarcticus* in the vicinity of New Zealand.

Abdominal Appendages. Unusually small ($\frac{1}{6}$th of body-length), situated ventrally to ovisacs as in the rest of the genus.

Appendages (Fig. 2). According with those of other species, but the spines and processes thereon but few, basal portion of first maxillae larger, second maxillae, or "arms," noticeably short, less than half the length of the trunk, swollen basally. The bulla injured, but more concave and proportionately broader than in *L. scyllicola*. The mandibles (Fig. 3 D) resembling those of *L. galei*, under which heading they are discussed, but having a spherical base which bears a prominent hooked projection on the inner border. The maxillipedes (Fig. 4 D) are described in the comparison on p. 261.

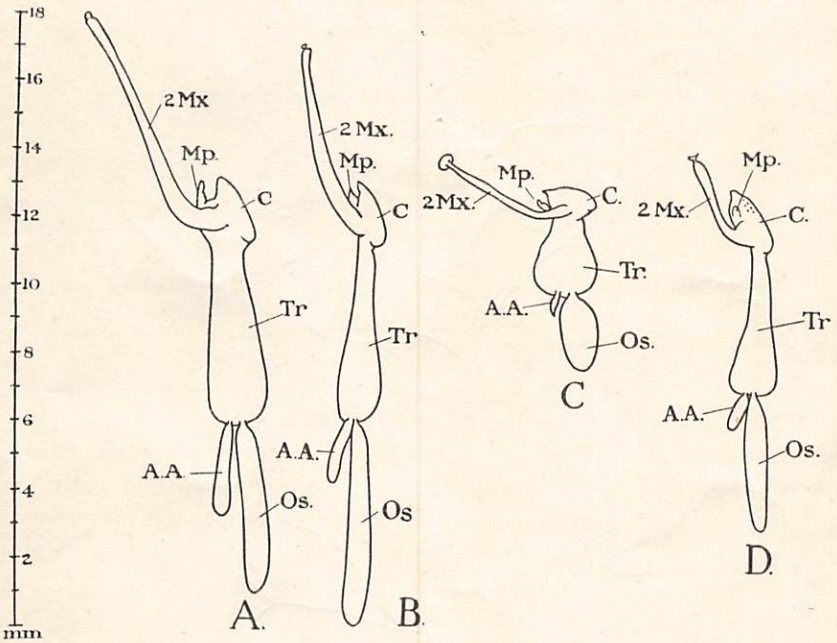


Fig. 1. A comparative scheme of the four commonest species of *Lernaeopoda* ♀ in profile: **A.** *L. scyllicola*; **B.** *L. galei*; **C.** *L. globosa*; **D.** *L. mustelicola*. *c.* cephalothorax; *Tr.* trunk; 2*Mx.* 2nd maxillae ("arms"); *Mp.* maxillipedes; *Os.* ovisacs; *A.A.* abdominal appendages. Compare (1) the contour of cephalothorax, the angle of its inclination to the trunk, and the degree of its dorsiventral compression; (2) the contour of trunk; (3) the posture of "arms."

Generic Characters (female). See *Parasitology*, VIII, 272.

Specific Characters (female). Cephalothorax pigmented with black dots. Proximal end of second maxillae swollen. Ovisacs short (4 mm., about $\frac{2}{3}$ length of trunk). Abdominal appendages short (1 mm. about $\frac{1}{6}$ length of trunk). The base of the mandible bears a hooked projection on the inner side. Basal joint of the maxillipede with three cushions of spines arranged in a ternate manner, the two upper side by side, the lower one close below them without any spine or hook between.

L. GALEI.

Habitat and Record. Two specimens, ♀, were taken on *Galeus vulgaris* ♂, the tope, captured at Plymouth in August 1918. They were attached between the claspers in the extra-cloacal region.

Body. *Vide* Fig. 1 B.

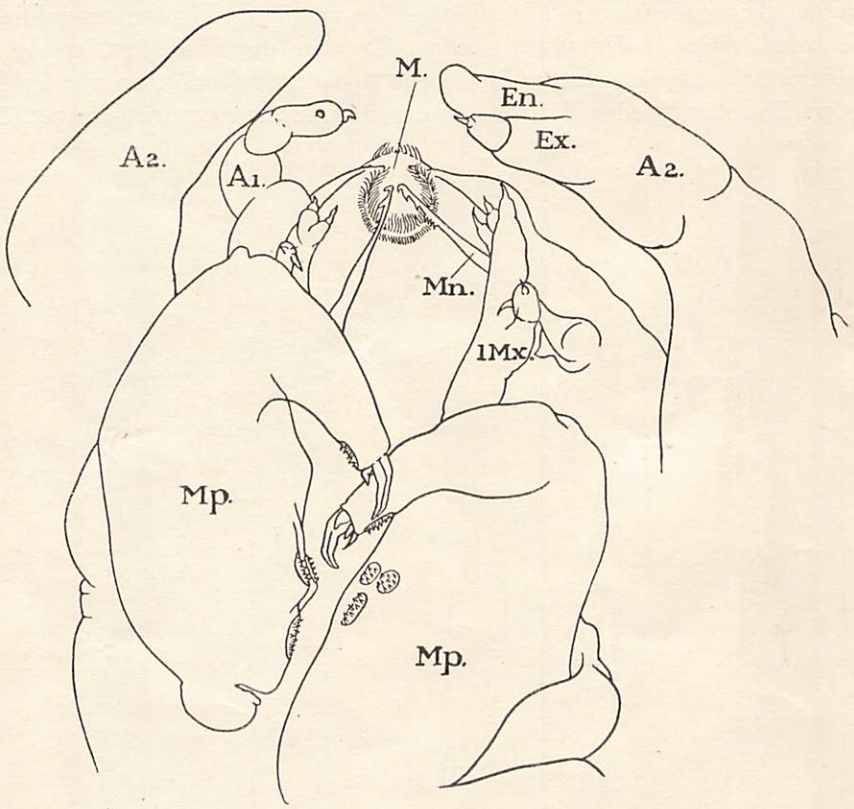


Fig. 2. *Lernaeopoda mustelicola.* The anterior end of the female in ventral aspect showing some of the appendages *in situ*. *M.* mouth; *A*1, antennules; *A*2, antennae; *Mn.* mandibles; 1*Mx.* 1st maxillae; *Mp.* maxillipedes; *Ex.* exopodite; *En.* endopodite.

Dimensions: compared with those of Wilson ("Parasitic Copepods of N. America").

	Leigh-Sharpe	Wilson
Length of cephalothorax	1·75 mm.	1·5 mm.
,, trunk	7	9
,, 2nd maxillae	5·5	4
,, abdominal appendages	nearly 2	2
,, ovisacs	6	10

From inspection of this table, were the dimensions of my specimens consistently smaller, one would expect that they were not fully grown.

Indeed I have seen in museums specimens alleged to be *L. galei*, far exceeding these in size.

Again in the ovisacs there are more eggs in a row than in *L. scyllicola*, viz. 29 or 30, as compared with 22 to 23 in the latter species. The individual ova are smaller than in *L. scyllicola*.

The only **appendages** of specific value are the mandibles and the maxillipedes:

The *mandibles* (Fig. 3 B) were very accurately described by Kurz, who distinguished three kinds of teeth: (1) principal teeth (Hauptzähne), much the largest, hatchet-like, usually curving backwards and alternating with (2) intermediate teeth (Zwischenzähne), which are very minute, serrate, triangular in shape, and occupy the base of the angles between the principal

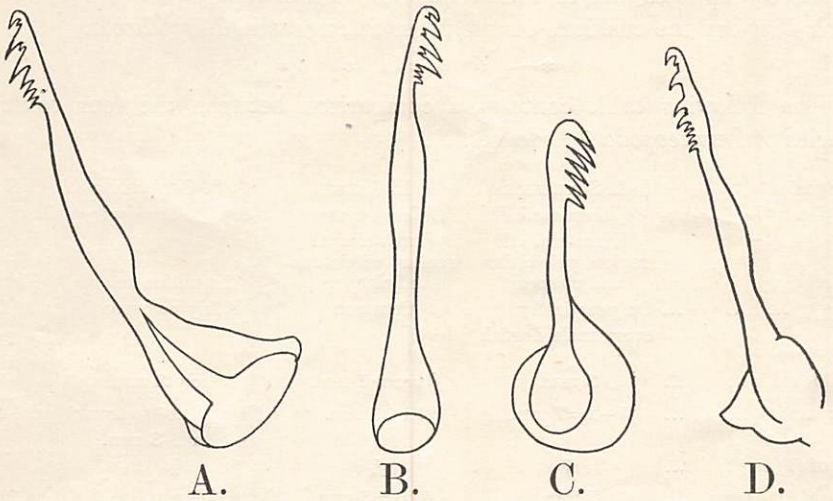


Fig. 3. A comparative scheme of the mandibles of the four commonest species of *Lernaeopoda* ♀.
A. *L. scyllicola*; **B.** *L. galei*; **C.** *L. globosa*; **D.** *L. mustelicola*.

teeth; (3) secondary teeth (Nebenzähne), which follow in a continuous sequence behind the principal teeth diminishing regularly in size towards the proximal end of the mandible. In *L. galei* there are: one principal tooth (terminal), an intermediate tooth; three principal teeth with two intermediate teeth respectively between them, one between each; three secondary teeth.

The *maxillipedes* (Fig. 4 B) in my estimation, do not agree with the figures of Scott and Scott very closely. They consist of a basal joint which I should not describe as stout but only moderately so, and a terminal joint, not very powerful, terminating in a curved claw smaller than in other species, having at its base an accessory claw which is not ventral as in other species, but is situated on a lateral projection, as figured by Scott and Scott, who have (possibly intentionally) exaggerated it, and two smaller spines at the base on the side of the concavity. The terminal joint has the usual cushion

of spines not at all clearly defined, the teeth of which appear to grade into a general roughness of the cuticle which is distributed over the joint. The basal joint not only has the two usual cushions of spines on its inner side, but is provided with three other cushions, which, as far as I know, have escaped the notice of other investigators, one on the outer edge of the proximal end, one on the outer edge of the distal end and the third a very large spinous area where the appendage joins the body. Of the usual cushions on the inner margin, the more distal one opposes a rounded cushion of spines whose exact locality is still uncertain, but which appears to be situated on the animal's body, on peculiarly shaped ridges provided for the purpose; the proximal cushion is situated on a projecting boss at the extreme base of the joint, an unusual location not found in the other species, so that it very effectively opposes and in action touches its partner. There is no spine or hook between the cushions on the inner margin as in *L. scyllicola*.

* * * * *

The following table contains a comparison between the four common species of *Lernaeopoda* ♀ (*vide* Fig. 1).

Species	L. Scyllicola	L. Galei	L. Globosa	L. Mustelico
Host	*Scyllium canicula*	*Galeus vulgaris*	*Scyllium canicula*	*Mustelus vulga*
Location	Extra-cloacal region, pelvic fins and claspers	Extra-cloacal region, pelvic fins and claspers	Nasal fossae	Pelvic regio
Occurrence	On practically every male dogfish	Common	Fairly common	(? Common)
Length of:				
(1) Cephalothorax	2 mm.	Over 1·5 mm.	Nearly 2 mm.	2 mm.
(2) Trunk	5+2=7 mm.	7 to 9 mm.	1 (Head ⊥r to trunk) +over 2–3 mm.	2+4=6 mm
Ratio of (1) to (2) ...	$\frac{2}{7}$	$\frac{3}{14}$	$\frac{2}{3}$	$\frac{1}{3}$
(3) 2nd maxillae (arms) ... (a variable character)	7 mm.	4 to 5·5 mm.	4 mm.	2·5 mm.
Ratio of (3) to (2) ...	1	$\frac{11}{14}$	$\frac{3}{4}$	$\frac{5}{12}$
(4) Ovisacs	5 to 7 mm.	6 to 10 mm.	Over 2 mm.	4 mm.
Ratio of (4) to (2) ...	$\frac{5}{7}$ =(nearly)	$\frac{6}{7}$ =(nearly)	=(nearly)	$\frac{2}{3}$
(5) Abdominal appendages	3 mm.	Nearly 2 mm.	0·5 mm.	1 mm.
Ratio of (5) to (2) ...	$\frac{3}{7}$	$\frac{2}{7}$	$\frac{1}{4}$	$\frac{1}{6}$
Ova: Rows	4 to 6	4 to 6	6 to 8	4
No. in a row ...	22 to 23	29 to 30	12	18
Bulla	Large, stud-like	Moderately large, stud-like	Small, the second maxillae also ending in two expanded discs	Moderately lar stud-like

The point of attachment of *Lernaeopoda* spp. upon the host in its bearing on the consequent length of the "arms" (second maxillae).

Species	Host	Location	Length of "arms"
L. elongata	*Lamna cornubica*	Eyes	20 mm. (longer than the trunk)*.
L. globosa	*Scyllium canicula*	Nasal fossae	4 mm. ($\frac{3}{4}$ length of trunk) but this is a *very* small species

Species	Host	Location	Length of "arms"
L. scyllicola	*S. canicula*	High up in the extra-cloacal aperture†	7 mm. (equal in length to trunk)
,,	,,	Clasper groove‡	3–5 mm.
,,	,,	Tip of clasper	1·5–2 mm.
L. scyllicola and *L. mustelicola*	,, *Mustelus vulgaris*	Above pelvic fins; between them and body-wall	2·5 mm.

* I have not yet met with this species upon *Lamna*. My hypothesis, that those species having free play are short armed, is not supported in this instance.

† *Parasitology*, VIII, 263, Fig. 1, Position *a*.

‡ *ibid.* Fig. 1, Position *G*.

A comparison of the mandibles of the four commonest species of *Lernaeopoda* ♀ (Fig. 3).

(For a detailed discussion see under *L. galei*.)

Abbreviations: H, principal teeth; **Z,** intermediate teeth; **N,** secondary teeth.

L. SCYLLICOLA	L. GALEI	L. GLOBOSA	L. MUSTELICOLA
Heterodont The principal are serrate	Heterodont The principal are serrate	Homodont, all principal, uncinate, decrease in size proximally	Heterodont The principal are serrate
Formula:	*Formula:*	*Formula:*	*Formula:*
H1	H1	H6	H1
Z1	Z1	—	Z1
H1	H1	—	H1
Z1	Z1	—	H1
H1	H1	—	Z1
N4	Z1	—	H1
—	H1	—	N4
—	N3	—	—
Base: Somewhat triangular and flattened	*Base:* Spherical and small	*Base:* Spherical and of moderate size, somewhat flattened	*Base:* Spherical with a hooked projection on the inner side

A comparison of the maxillipedes of the four commonest species of *Lernaeopoda* ♀ (Fig. 4).

L. scyllicola. Basal joint long and slender, provided with two rounded cushions, well developed and covered with papillated spines. Proximal cushion situate at some distance anteriorly to base of joint. Between the cushions is a large mamillated, upwardly curved hook.

Terminal joint long and slender, provided with a rounded cushion of papillated spines also well-developed, and terminating in a long abruptly-curved claw, with an accessory claw at its base ventrally, and two smaller claws at the base, on the side of the concavity.

L. galei. Basal joint not long and slender, but somewhat stout, provided with two rounded cushions covered with papillated spines. Proximal cushion large, protruding as a boss at base of joint. *No* hook or spine between the cushions.

Terminal joint slender, provided with a rounded cushion of papillated spines, and terminating in a short curved claw with an accessory claw at its base which projects more than in other species, and two smaller claws at the base on the side of the concavity. I consider that the basal joint bears accessory cushions of spines at its proximal end which are not figured by other authors.

L. globosa. Basal joint not slender, provided with two small rounded cushions covered with feebly-developed spines. Near, but distal to the proximal cushion a poorly developed spine. Cushions are widely separated.

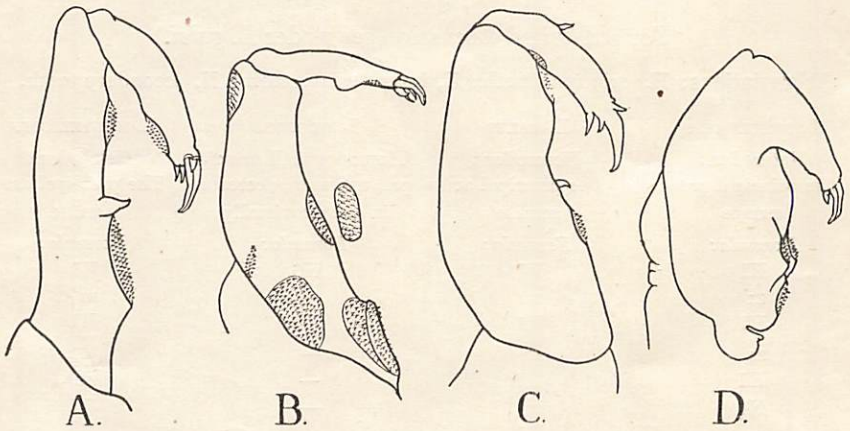


Fig. 4. A comparative scheme of the maxillipedes of the four commonest species of *Lernaeopoda* ♀.
A. *L. scyllicola*; **B.** *L. galei*; **C.** *L. globosa*; **D.** *L. mustelicola.*

Terminal joint slender, provided with a small rounded cushion with poorly developed spines and terminating in a long abruptly-curved claw, with two accessory claws at its base on the inner side and one on the outer side. A characteristic small spine is also present on the outer side of the base of the joint.

L. mustelicola. Basal joint fairly stout provided with three cushions of papillated spines arranged in a ternate manner, the two more distal ones, situated side by side, probably corresponding to a single cushion in other species. Cushions close together and without spine or hook between them.

Terminal joint fairly stout, provided with a rounded cushion of papillated spines at the extreme end of its inner margin; and terminating in a curved claw with an accessory claw at its base ventrally and two smaller claws at the base on the side of the concavity.

L. SCYLLICOLA.

Part III.

Abnormal Growths. During the spring months of 1918, I observed upon *L. scyllicola* various abnormal spherical growths in different situations upon the cephalothorax, and the anterior portion of the trunk, notably the shoulder (Fig. 5). Under the low power of the microscope fine threads were seen

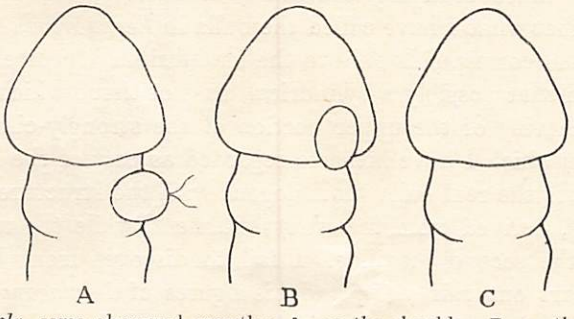


Fig. 5. *L. scyllicola*, some abnormal growths: **A.** on the shoulder; **B.** on the cephalothorax; **C** normal outline.

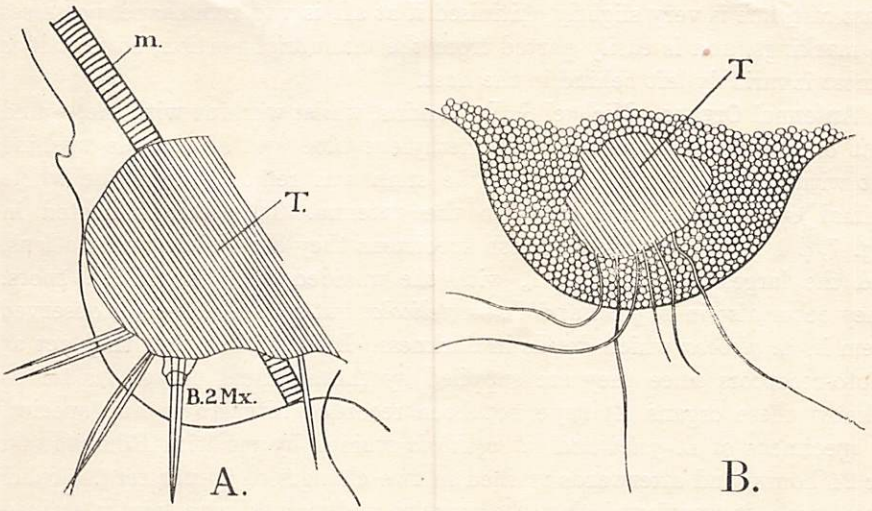


Fig. 6. Some abnormal growths or tumours under a high magnification. **A.** *L. mustelicola*; **B.** *L. scyllicola* (a microscopic enlargement of Fig. 5 A.). *T.* tumour; *m.* muscle; *B2Mx.* base of the second maxilla.

protruding from these growths. Upon the base of one of the second maxillae, and somewhat between them, of one of the specimens of *L. mustelicola* previously described (*vide ante*) a similar growth is present, in which the projecting threads are much stouter and straighter (Fig. 6 A). In a permanently mounted eosin-stained preparation under a $\frac{1}{8}$th-inch objective these growths resolve themselves into a solid mass of tissue embedded among the round

oily-looking tissue cells, which make up the body of the host, from which the filamentous processes arise, and penetrate the cuticle projecting far beyond the surface of the animal. The central mass of the growth does not exhibit any structure, neither do the tapering filaments. The growths may have arisen from abrasions or wounds caused by the embrace of the male, the filaments possibly represent a vegetable growth that gained entrance to the wound.

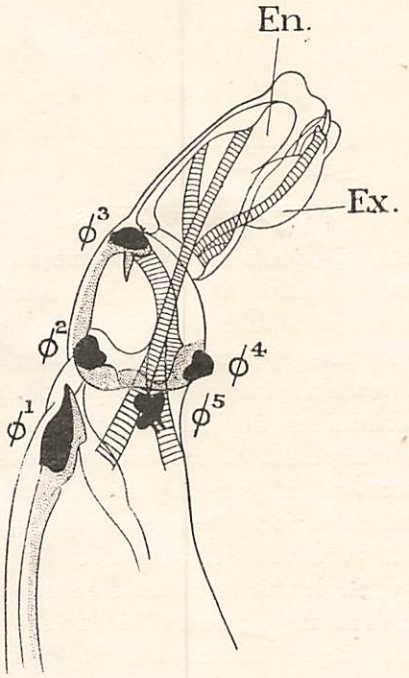
The Bulla. Since studying *Clavella* (*Parasitology*, XI, 120, fig. 4) it appears to me that what I have called the bulla in *Lernaeopoda* (*Parasitology*, VIII, 268, fig. 4 A) corresponds only to the manubrium ("pedicel" of Wilson) of *Clavella*, and that possibly a cylindrical mass of tissue which fits into the saucer-like concavity of the upper portion of the strongly-chitinised organ in *Lernaeopoda*, which I have hitherto regarded as part of the host (wound-healing tissue), is the real bulla (homologous with the structure so called by me in *Clavella*), derived from the frontal filament, while the manubrium is derived from the second maxillae. I fail to discover from Wilson's text whether he bears out this view, and his figures of *Lernaeopoda* afford no explanation. His figures of enormous bullae in *Salmincola* (e.g. *S. inermis* with a bulla as large as the whole animal) seem to confirm my opinion. This mass of tissue is very slightly chitinised if at all, is vague in shape, possesses no markings, and is easily parted from the manubrial portion, so that it is almost invariably left behind in the host.

Antennal Organs. Michael G. L. Perkins, whilst working with me, found that on staining the female with methylene blue and afterwards washing out with 90 per cent. alcohol all the stain was removed from the whole animal except from five spots in the antenna. These are indicated in Fig. 7, ϕ 1 to 5. In perfectly fresh specimens they are visible under a lens, and the largest of them, ϕ 1, with the unaided eye, as pinkish spots. They occur also in *L. galei* and *L. mustelicola*, but so far I have not observed them in *L. globosa* which dwells in darkness. It is possible that they act as photo-receptors since they are supplied by the antennal nerve. As far as I know these organs (?) have not been recorded hitherto in any species. In specimens of *L. galei* and *L. scyllicola* stained by me with Romanowski for 24 hours, and afterwards washed in two changes of 90 per cent. alcohol for a week, it was found that the muscles and tissues were faintly stained with eosin, while nowhere did any traces of methylene-blue linger except in the five places mentioned. These places superficially appear to be chitinous, but it is noticeable that none of the rest of the chitin (represented by stippling in Fig. 7) is so stained, neither is methylene-blue a stain for chitin.

The blue staining parts appear to represent organs below the chitin, these organs having a selective affinity for methylene-blue.

The Mandibles. On further examination I find that the mandibles, as previously figured by me in Part I, Fig. 3 C, are inaccurately drawn. I was for some time perplexed since it appeared to me that two types of mandibles

existed in this species. I am now certain that the true type of mandible is that which is figured in Fig. 3 A of the present paper, which closely approximates to that of *L. galei* except in regard to the secondary teeth, and in this respect I am not positive that one is not lost in *L. galei*. There are however but three primary teeth instead of four. My error was due to the fact that the terminal tooth was lost, as is not infrequently the case, and apparently the next principal tooth also; the organ being slightly turned on its side the intermediate teeth were unrecognisable, and what I considered to be teeth increasing in size posteriorly are really the secondary teeth. The wearing



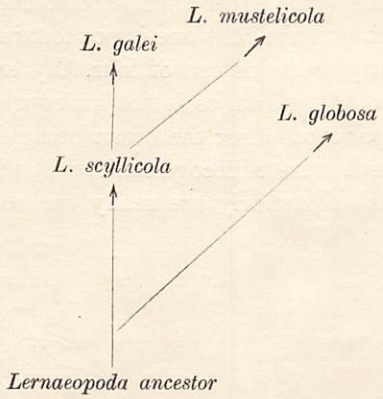
2 ANTENNA

Fig. 7. *L. scyllicola*, a detailed enlargement of the antenna (Romanowski): *Ex.* exopodite; *En.* endopodite; ϕ1–5. (?) photoreceptors.

away of distal teeth is not to be wondered at if they have to pierce the skin of the dogfish where it is covered by dermal denticles.

Relationship. It appears to me that *L. scyllicola* and *L. galei* approximate to one another very closely, much more so than any other of the four species which I am at present considering. My opinion based upon the comparison of these species is that from the common *Lernaeopoda* stock, from which *Lernaeopodina* may have differentiated very early, *L. scyllicola* represents a central and most typical form from which *L. galei* and *L. mustelicola* subsequently descended, while I am inclined to think that *L. globosa* branched off from the stem prior to the evolution of *L. scyllicola*. The following diagram

represents my view of the mutual relationship existing between these four species:



Note on the Males.

Dr Charles Branch Wilson has kindly sent me a communication calling attention to the relative position of the second maxillae and maxillipedes in the males of the Lernaeopodidae. On consulting Fig. 38, Pl. XXXVI, of his paper on the development of *Achtheres ambloplitis* (*Proc. U. S. Nat. Mus.* xxxix) it appears that it is the long *posterior* pair of appendages that correspond to the second maxillae in the females, and not the short anterior pair. In the subsequent development of the male these long maxillae remain posterior, while the short maxillipedes migrate forward between the bases of the maxillae and become anterior. Hence in the adult male the short, stocky anterior pair of mouth parts represent the migrated *maxillipedes*, and the longer and slenderer posterior pair represent the second maxillae which have remained where they were first formed. This, he shows us, is most clearly observed in the larval history, and if true of *Achtheres* it follows from analogy that it is probably true of the other genera including *Clavella*.

(My best thanks are due to Miss E. C. Humphreys for her kind assistance with the figures.)

Erratum.

Parasitology, xi, 120, five lines from the bottom of the page:
For "first maxillae" read "second maxillae."