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THE EYE OF THE PARASITIC COPEPOD, SALMINCOLA EDWARDSII OLSSON (LERNÆOPODA EDWARDSII OLSSON).

NATHAN FASTEN,
DEPARTMENT OF ZOÖLOGY, UNIVERSITY OF WASHINGTON, SEATTLE.

CONTENTS.

INTRODUCTORY REMARKS.

The material from which the following studies were made consisted of numerous free-living larvæ of *Salmincola edwardsii* (*Lernæopoda edwardsii*) Olsson, a parasitic copepod of the family Lernæopodidæ, which infests the common brook-trout, *Salvelinus fontinalis*. In three former papers (Fasten '12, '13, '14) the author has discussed the economic importance, the behavior and the fertilization process of the parasite. In this publication, the structure of the eye will be described.

Wilson (1911) in his paper on the development of *Achtheres ambloplitis* Kellicott, one of the Lernæopodidæ observes that the eye is rudimentary in character and is only developed during the metanauplius stage, while the organism is still surrounded by its embryonic membranes. Wilson says, "the extremely rudimentary eye (*e*) can now be distinguished inside the coils of the attachment filament. It is made up of three ovate ocelli, two dorso-lateral and one inferomedian, which are entirely separated from one another and devoid of pigment. The structure of each ocellus has also degenerated until all that remains is a more or less granular mass, staining deeply in hæmatoxylin and containing near its anterior end three lighter spots. No trace of lenses can be found in any of the sections and the entire

structure disappears during the next stage." In a later paper (Wilson, '15), on the Lernæopodidæ, this same author states the following: "The eye in this whole family is extremely rudimentary, appears only for a short time during the development stages, and then entirely disappears." In *Salmincola edwardsii*, which also belongs to this family of Lernæopodidæ, the eye is well developed and resembles to a marked degree the visual organ of the free-living marine copepod *Eucalanus elongatus* Dana, worked on by Esterly ('08). Furthermore, during the metanauplius stage, the eye of *Salmincola edwardsii* makes its appearance and attains its full development in the free-swimming larval form, the so-called first copepodid stage.

Methods.

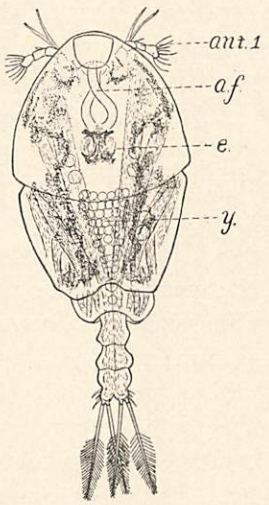
Entire mounts as well as sections of the larvæ were used for this study. Various fluids, such as Bouin's, Gilson's and 5 per cent. corrosive-acetic were tried for fixation, but the last-mentioned reagent yielded the best results and was used almost exclusively.

The entire mounts were made in the following manner. The organisms were placed in 5 per cent. corrosive-acetic fluid for ten minutes or longer, and then they were washed in many changes of water. After this they were run up through the various grades of alcohol, being left about ten minutes in each, and finally they were cleared in xylol and mounted in balsam. Larvæ thus treated yielded beautiful results, showing little change from the normal condition. Those which were allowed to remain in the fixative longer than ten minutes, generally had most of their pigments dissolved out, thereby making it possible to obtain a fine view of the external structure of the eye.

The larvæ to be sectioned were also fixed in the corrosive-acetic mixture. After dehydrating, clearing and infiltrating, the organisms were permanently imbedded in paraffine for sectioning. The sections were cut from 3–6 μ in thickness, in frontal, transverse and sagittal planes, and were stained in Heidenhain's iron-hæmatoxylin, with a counterstain of acid-fuchsin or eosin. These sections were very helpful in determining the internal structure of the eye.

Gross Structure of the Eye.

The eye of *Salmincola edwardsii* is located in the cephalothorax, occupying a central position, directly below the loop of the attachment filament. Text figure *A*, which is a dorsal view of the larval free-swimming stage, shows the location of the eye (*e*). When viewed from the dorsal or the ventral surface of the free-swimming larva, the eye appears as a more or less x-shaped, reddish-brown pigment blotch in which three ocelli



Text Figure *A*. Dorsal view of free-swimming larva of *Salmincola edwardsii* (*Lernæopoda edwardsii*), showing the position of the eye. × 86.8 *a.f.* = attachment filament. *ant.*1 = first antennæ. *e.* = tripartite eye. *y.* = yolk.

can be distinguished. Two of these are situated dorso-laterally, while the third is placed immediately beneath them, occupying a median position. This is shown in Figs. 1 and 2, which are enlarged drawings of the eye, as seen respectively from the ventral and dorsal sides of the animal.

When favorable preparations of the eye, from which the pigment has been extracted, are studied under the high power objectives, the external structure of the ocelli becomes more apparent. In such preparations, each ocellus is seen to be embedded in a semi-lunar cup (Figs. 1 and 2, *c*), and is covered by a cuticular outer surface, which is divided up into narrow bands by means of transverse striations. These bands are

further crossed by vertical lines breaking them up into small squares. The surface of each ocellus thus appears to be made up of numerous facets, very similar to the facets of ommatidia. Figs. 1 and 2 show this appearance. Fig. 1, which is a drawing of a ventral view of the eye, shows the facet-like surfaces and the semi-lunar cups particularly well.

Internal Structure of the Eye.

The true structure of the eye is revealed when sections of the organ are studied under the microscope. In Fig. 3, which is a transverse section of the larval organism, the tripartite eye (*e*) is seen to occupy the middle space between the brain (*b*), and the dorsal wall of the body (*w*). The details of the eye can best be seen in Figs. 4 and 5. Fig. 4 is an enlarged camera-lucida drawing of the eye seen in Fig. 3, while Fig. 5 is a drawing of a frontal section of the eye. In size, the two lateral ocelli (Fig. 4, *l. o*) are equal, while the median ocellus (Fig. 4, *m. o*) measures about two thirds the dimensions of either of the aforementioned ones. Furthermore, as already stated, these ocelli are imbedded in semi-lunar cups (Figs. 4 and 5, *c*) which touch each other closely. The inner surface of each cup is thickened into a basal plate (Figs. 4 and 5, *r*) which stains a heavy black with Heidenhain's iron-hæmatoxylin. This plate comes in contact with the ocellus and, in all probability, is its most sensitive portion. Esterly ('08) found that in *Eucalanus elongatus* the lateral ocelli possessed two basal plates, while the median ocellus contained only one. In *Salmincola edwardsii* this difference was not observed. Here each ocellus bears a single plate. Between the open spaces of the semi-lunar cups the pigment granules of the eye are found distributed (Fig. 4, *p*).

Upon closer examination each ocellus is observed to consist of a definite number of cells, the so-called retinal cells (see Figs. 4 and 5), there being nine in either of the lateral ocelli, and five in the median one. This was determined by careful reconstructions of transverse, frontal and sagittal sections of the visual organ. In *Eucalanus elongatus*, Esterly found that the lateral ocelli also contained nine retinal cells, but that the median one possessed ten of them.

Within every retinal cell, there is a prominent nucleus, more or less spherical in appearance (Figs. 4 and 5, *n*), which is made up of a network, consisting of fine chromatic strands with thickened clumps of chromatin. At the base of the cell, that portion nearest the basal plate of the ocellus, there is a rod-like, heavily staining structure surrounded by a clear space. This is the phaosome (Figs. 4 and 5, *f*), and in all probability it functions in the transmission of visual stimuli to the nerves of the retinal cells. Esterly found numbers of these bodies distributed randomly through the retinal cells of *Eucalanus elongatus*. In *Salmincola edwardsii*, however, this was not found to be the case. Here there is but one phaosome to each retinal cell and this occupies a definite position between the nucleus and the basal plate of the ocellus. No definite lenses are present in the ocelli of *Salmincola edwardsii*.

The nerves of the retinal cells make their way posteriorly, from the surfaces of the semi-lunar cups. These nerves are very thin, fine strands which cannot be counted with even the highest powers of the microscope. But assuming that each retinal cell is connected with one nerve, there must be nine retinal nerves to each lateral ocellus, and five of them to the median ocellus, making altogether twenty-three nerves. Slightly back of the ocelli, these nerves combine into an optic nerve (Fig. 5, *o. n*) and this then enters the brain of the larval organism.

Summary.

1. The eye of *Salmincola edwardsii* Olsson is located medianally, in the space between the brain and the dorsal wall of the body.

2. Unlike the eye of *Achtheres ambloplitis* Kellicott another one of the Lernæopodidæ, described by Wilson, the visual organ of *Salmincola edwardsii* is normally developed and functions during the first copepodid or the free-swimming larval stage of the parasitic organism.

3. The eye is more or less of a reddish-brown, x-shaped pigment blotch, consisting of three ocelli. Two ocelli are located laterally, while the third is below these, occupying a median position.

4. In size, the median ocellus is about two thirds the dimensions of either of the lateral ones.

5. Each ocellus is constructed somewhat similarly. It is embedded in a semi-lunar cup whose internal surface is thickened into a basal plate. Covering the external face of the ocellus is a cuticle which is divided up into squares that appear like the facets of ommatidia.

6. Interiorly every ocellus contains numerous retinal cells. There are nine of these cells in each lateral ocellus and five of them in the median ocellus.

7. The retinal cell possesses a large, rounded nucleus and a single rod-like, heavily staining phaosome, which is located between the nucleus and the basal plate.

8. The optic nerve which makes its way from the ocelli to the brain consists, in all probability, of twenty-three nerves corresponding to the number of retinal cells found in the eye.

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EXPLANATION OF PLATES.

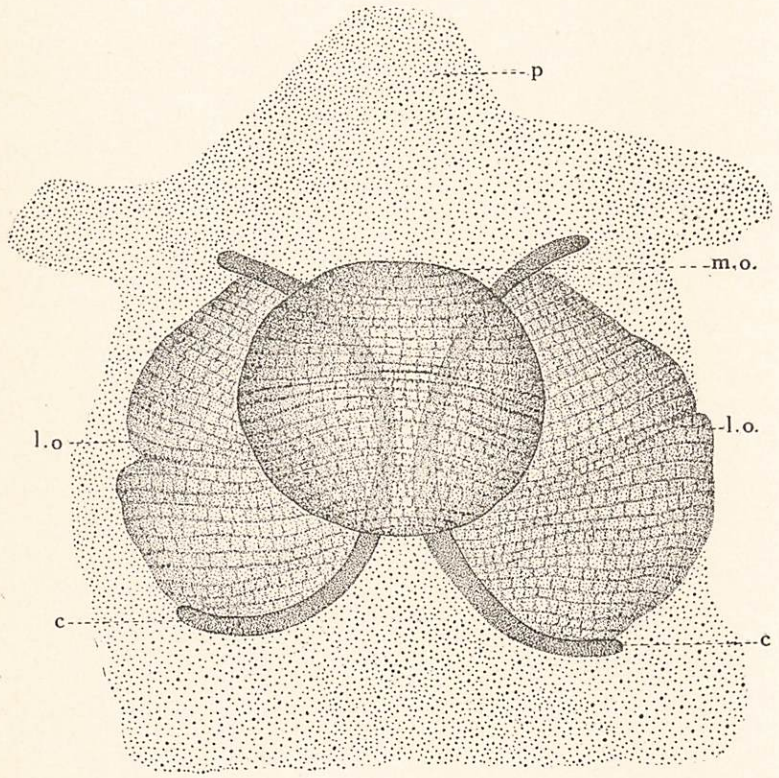
[All drawings were made with the aid of the camera lucida. The magnification of each figure is given after its description.

ABBREVIATIONS.

b. = brain.
c. = semi-lunar cups of ocelli.
ch. = chitinous membrane of larva.
e. = tripartite eye.
f. = phaosomes.
l.o. = lateral ocellus.
m. = dorsal muscles.
m.o. = median ocellus.
mxp. g. = maxillipedal gland.
n. = nuclei of retinal cells.
oe. = oesophagus.
o.n. = optic nerve.
p. = pigment of eye.
r. = basal plates of ocelli.
w. = body wall.

EXPLANATION OF PLATE I.

FIG. 1. View of the tripartite eye as seen from the ventral surface of the larval organism. The facet-like surfaces of the lateral (*l.o.*) and median (*m.o.*) ocelli as well as the semi-lunar cups (*c*), and the pigment (*p*), can readily be observed. × 1,637.



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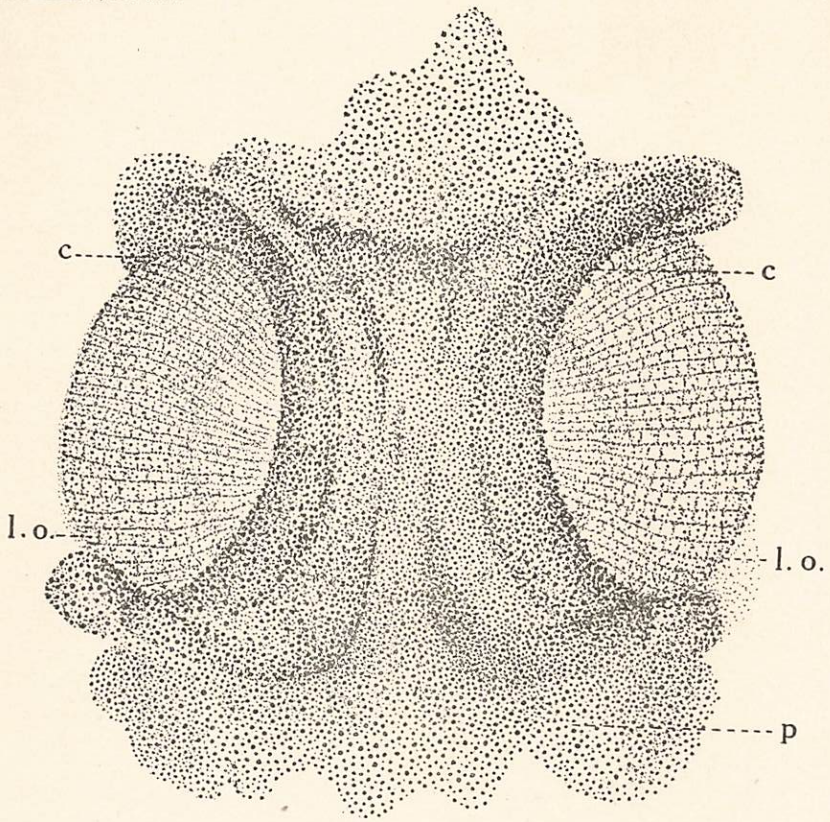
EXPLANATION OF PLATE II.

FIG. 2. View of the eye as seen from the dorsal surface of the free-swimming larva. The distribution of the pigment (*p*) is here seen to good advantage. The facet-like surface of the ocelli may also be observed. × 1,760.

FIG. 3. Cross-section of a larval organism through the region of the eye. The position of the eye (*e*) is noticed to be between the brain (*b*) and the dorsal surface of the body wall (*w*). × 460.



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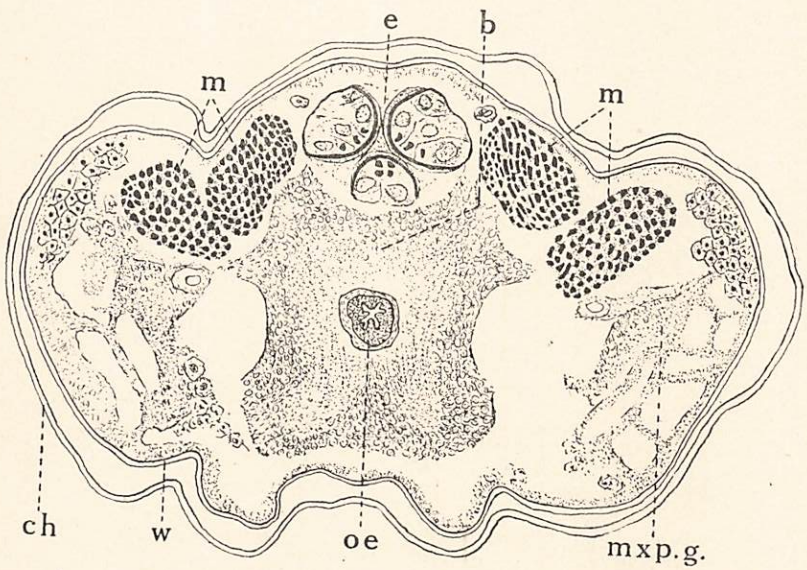

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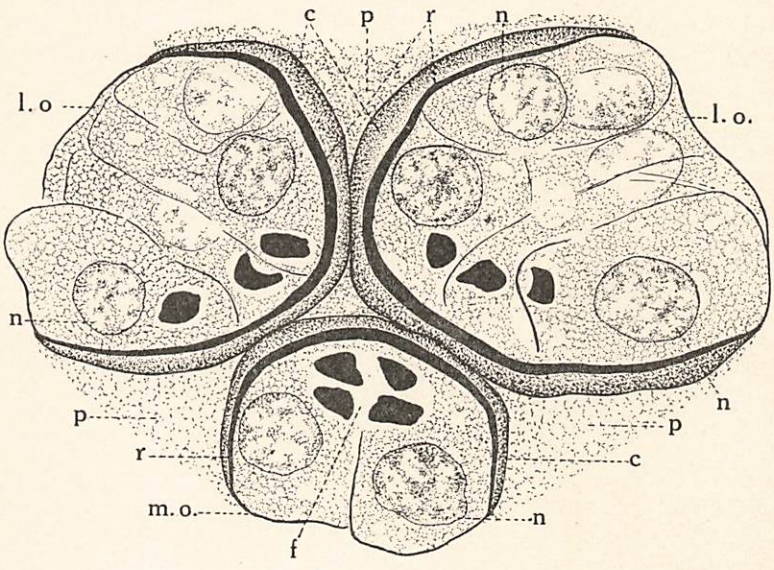
EXPLANATION OF PLATE III.

FIG. 4. Enlarged drawing of the tripartite eye observed in Fig. 3, to show the details of structure. × 1,928.

FIG. 5. Frontal section of the eye, showing details of internal structure, and also the optic nerve (*o.n.*). × 1,272.



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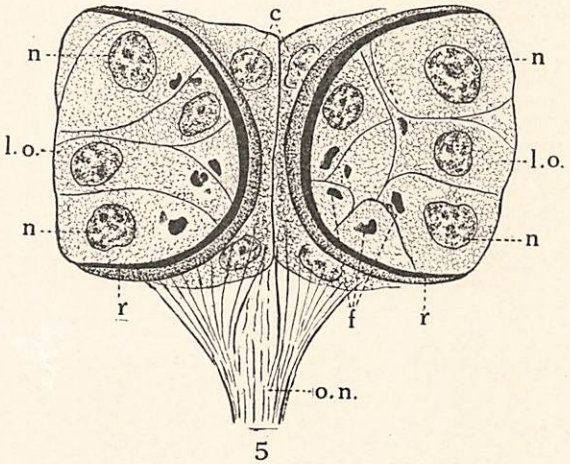

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