Proceedings of the Iowa Academy of Science

Volume 3 | Annual Issue Article 36

1895

The Anatomy of Sphaerium sulcatum Lam.

Gilman A. Drew

West Okoboji, fifteen to twenty feet below surface	*Daphnella brachyura.* *Daphnia kal.*, variety *retrocurva.* *Simocephalus serrulatus.* *Ceriodaphnia consors.* *Eurycercus lamellatus.* *Dunhevedia setiger.* *Chydorus sphaericus.* *Chydorus globosus.* *Camptocercus rectirostris.*
East Okoboji, surface	*Sida crystallina.* *Ceriodaphnia reticulata.* *Ceriodaphnia consors.* *Daphnia kal.*, variety *retrocurva.* *Daphnia hyalina* *Macrothrix laticornis.* *Eurycercus lamellatus.* *Chydorus sphaericus.* *Leydigia quadrangularis.*
Spirit Lake, ten to fifteen feet below surface	*Daphnella brachyura.* *Daphnia kal.*, variety *retrocurva.* *Chydorus sphaericus.*
Raccoon River, Adel, Iowa	*Ceriodaphnia reticulata.* *Scapholeberis mucronata.* *Iliocryptus sordidus.* *Pleuroxus denticulata.*
Raccoon River at Sac City	*Scapholeberis mucronata.* *Simocephalus serrulatus.* *Chydorus sphaericus.* *Pleuroxus denticulatus.* *Alona sp?*

THE ANATOMY OF SPHÆRIUM SULCATUM LAM.

BY GILMAN A DREW.

For a number of years the embryology of the Cyrenidæ has been attracting considerable attention, but little has been added to our knowledge of the general anatomy since Dr. Franz Leydig's publication in 1855 (No. 5), who recorded such anatomy as could be made out from young and rather trans parent specimens.*

It is my present intention to continue the work here begun on Sphærium to a comparative anatomy of the Cyrenidæ, but in

*I find a reference to a paper by Temple Prime, entitled: Notes on the Anatomy of the Corbiculidæ and Translation from the Danish of an article on the Anatomy of Cyclas by Jacobson. Bul. Museum Comp. Zool., Cambridge, Vol. V. This volume unfortunately is not to be found in the reference libraries of Baltimore.

the meantime it seems to me that the anatomy of a single genus and a single species of that genus may not be wholly without interest, especially to those who are working in the interior, where the Unionidæ and Cyrenidæ are the only available Lamellibranchs.

Regarding the systematic position of Sphærium, suffice it to say that the old genus Cyclas includes the present genera Sphærium and Pisidium, and that these, with four or more other generally accepted genera, go to form the family which has been variously known as Cycladæ, Corbiculidæ and Cyrenidæ.

SHELL.

(Fig. 2.) The shell of this species is comparatively thick, of a dark horn color, frequently lighter near the margins of the valves, and is composed of a rather thick bluish-white nacre, covered exteriorly by epidermis. The lines of growth are well marked. The teeth are thin lamellæ, 2–2 on the right valve and 1–1 on the left valve. The adductor scars, *a s* and *p s*, are quite distinct and are joined dorsally by the retractor pedis scars. The pallial line is rather obscure. A large specimen measures 15x12x9 mm.

MANTLE.

The mantle consists of two thin lobes of connective tissue covered by epithelium, free at their anterior and ventral margins, united to form the siphons posteriorly, and continuous over the back. The lobes lie closely applied to the shell nacre, which is secreted by them, and are attached to the nacre at the pallial line by the pallial muscles, and to the epidermis through the epidermal gland, which lies in a groove in the mantle margin. A ridge, Fig. 3, *r*, extending from the ventral end of the anterior adductor muscle to the branchial siphon, runs along the inside of each mantle lobe near its ventral margin and serves, by meeting its fellow on the opposite lobe, or sides of the foot in case that organ is protruded, to close the open side of the branchial chamber and force currents of water to enter through the branchial siphon, which is protruded above the mud or sand in which the animal lives. The siphons, Figs. 1 and 3, *b s* and *c s*, are quite muscular and are capable of considerable protrusion. Neither one is fringed with tentacles.

MUSCULAR SYSTEM.

The muscular system may for convenience be classed as adductors, retractors, foot muscles and mantle muscles, including those of the siphons.

The adductors, Figs. 1 and 3, are two in number, anterior, *aa*, and posterior, *pa*. They differ slightly in size and shape, and have for their only function the closing of the shell.

There are two pairs of retractors, anterior and posterior retractor pedis muscles, Figs. 1 and 3, *a r p* and *p r p*. They serve to withdraw, or retract, the foot from an extended position.

The foot is largely made up of crossing muscle fibers, extending more or less in all directions, but capable of being classed as longitudinal, vertical and horizontal. They aid in protrusion, by forcing the blood where most efficient, in retraction and in special movements of the protruded foot.

The pallial muscles, Figs. 4 and 5, are distributed to the inner end of the epidermal gland in the edge of the mantle and to the ridge already described. They serve to withdraw the edge of the mantle from between the edges of the valves when the valves are tightly closed.

BYSSAL GLAND.

A rudiment of the byssal gland, Fig. 1, *b*, persists in the adult animal as a single closed sack, often showing a slight sagittal constriction. It is supplied with a small nerve on each side, which spring from trunks that have their origin in the pedal ganglia. Most of the specimens which I have examined have the rudiment of the byssal gland nearer the pedal ganglia than is shown in Fig. 1.

GILLS.

The gills, four in number, consist of a pair, an outer and an inner gill, on each side of the body. The outer, Fig. 3, *o g*, is much smaller than the inner, *i g*, and falls short anteriorly by about a fourth of its length. Each gill is composed of two lamellæ. The outer lamella of the inner gill is attached to the inner lamella of the outer gill on the same side, the outer lamellæ of the outer gills are attached to the mantle lobes on their respective sides, and the inner lamellæ of the inner gills are attached anteriorly to the body wall and posteriorly to each other, Fig. 5. The gills function as respiratory organs, procurers of food and brood pouches. The latter function is monopolized by the inner gills, which carry the embryos until they are ready to function as adults.

Fig. 6, which represents a piece of gill cut squarely across the lamellæ and seen obliquely from the cut surface so that the

side of a lamella may be seen, may aid in understanding the structure of a gill. The descending and ascending portions of each filament, *f i l*, are fused throughout their length, thus uniting the lamellæ at very short intervals and restricting individual water-tubes, *w t*, between adjacent filaments.

The filaments are strengthened by chitinous rods, *c r*, and attached to one another laterally by inter-filamenter junctions, *i f j*, which are places where, during development, adjacent filaments have fused together. There are thus left openings, *i o*, known as inhalent ostea, which lead into the water-tubes. Beneath the epithelial covering of the filaments is a loose connective tissue, through which more or less definite blood spaces, *b l s*, may be traced. The outer surfaces of the filaments are covered with rather short cilia, besides which there is a row of longer cilia on each side of each filament near the outer surfaces, and another row of long cilia placed far in on the sides of the filaments, nearly opposite the chitinous rods. It seems that the inner rows of cilia serve largely to drive the water through the inhalent ostea and water-tubes and thus keep up a continuous supply of fresh water, while the other cilia are engaged in forming surface currents and in separating and transporting food particles.

LABIAL PALPI.

The labial palpi, Fig. 3, *l p*, are very long and slightly curved. There is a pair, consisting of an outer and an inner palp, on each side of the body. The anterior edges of the outer palps are connected in front of the mouth by a slight ridge, as are likewise the anterior edges of the inner palps behind the mouth. The adjacent sides of each pair are grooved and densely ciliated. Particles of food passed between them from the gills are transported to the mouth.

ALIMENTARY CANAL.

The mouth, situated behind the anterior adductor muscle leads into a rather long and slender œsophagus, Fig. 1, *o e*, which communicates with a somewhat spacious horn-shaped stomach, sacculated at its upper end, which curves downward and forward and gradually tapers into the intestine which at this point forms a coil. The relative positions of the loops of this coil to one another, may be made out by comparing Fig. 1, with Fig. 4, which latter represents an obliquely transverse section through the coil. The stomach 1, situated on the left

side of the body, communicates anteriorly with 2, which, near the plane of the section turns to form 3, and so on. It is of interest to note that in the young animals no such coil exists. As the alimentary canal lengthens the loops are formed and gradually lengthen. Fig. 1 is reconstructed from a smaller and apparently younger individual than the one represented in section by Fig. 4, and it will be observed that the loop *4 5*, Fig. 4, must be longer than the corresponding loop of Fig. 1, else the arms could not be separate at a point where the loop *2 3*, is turning. From the point *6*, the intestine follows back along the convex border of the stomach, then rather abruptly turns nearly at right angles to its former course, passes through the ventricle of the heart, then passes over the posterior adductor muscle dorsally and posteriorly to open in the cloacal chamber. The typhlosole is not strongly developed but is present as a small ridge as shown in Fig. 5.

The alimentary canal throughout its length is lined by elongated ciliated epithelial cells. Fig. 9 represents these cells as they appear in a section through the lower end of the stomach.

LIVER.

The liver, Fig. 1, *l*, is a paired organ, consisting of two large racemose glands, one on each side of the body. Each gland communicates with the stomach through anterior lateral pouches. The liver cells are often densely crowded with granules that stain deeply, but not infrequently part of the cells of some follicles will be full while adjacent cells will be empty. This condition is indicated by Fig. 10.

It is not unlikely that, as the animal probably feeds most of the time, digestion is a continuous process and that the liver cells are continually filling up and discharging.

NERVOUS SYSTEM.

The regular three pairs of Lamellibranch ganglia are present. The cerebral ganglia, Fig. 1, *c. g.* lie on opposite sides of the œsophagus, on a level with the dorsal end of the anterior adductor muscle. They are somewhat oblong in shape and are connected with each other by an œsophageal commissure which runs between the œsophagus and the anterior adductor muscle. The parieto-splanchnic ganglia Fig. 1, *p s g*, also oblong in shape, lie anterior to the ventral portion of the posterior adductor muscle and are fused together by their adjacent sides. The pedal ganglia, Fig. 1, *p g*, are more nearly circular than

either of the other ganglia, when viewed from the side. They lie beneath and a little posterior to the intestinal coil at the line where the muscles of the foot come in contact with the connective tissues of the body proper, Fig. 4. The pedal ganglia are likewise fused together by their adjacent sides.

The cerebral ganglia are connected, Fig. 1, with the parieto-splanchnic ganglia by the cerebro-visceral commissures and with the pedal ganglia by the cerebro-pedal commissures. Beside these commissural connections each cerebral ganglion gives rise to a small nerve which supplies the anterior adductor muscle and a larger nerve which passes down behind the anterior adductor muscle into the mantle and supplies the pallial muscles of its anterior portion.

Each parieto-splanchnic ganglion besides its commissural connection, gives rise to a small nerve which supplies the posterior adductor muscle, a larger branchial nerve which runs forward a short distance, passes over into the junction of the outer lamella of the inner gill with the inner lamella of the outer gill, where it turns abruptly backward and apparently ends at the posterior ends of the gills not greatly reduced in size, and a large nerve that runs around the ventral surface of the posterior adductor muscle and branches. The smaller branch is probably distributed to the muscles of the siphons, but I have been unable to follow it far. The larger branch runs along the mantle near the inner ends of the pallial muscles, giving off a branch near the upper border of the branchial siphon and numerous small branches to the pallial muscles.

Each pedal ganglion, besides its commissural connection, gives rise to at least five more or less distinct nerves which branch among the muscles of the foot.

OTOCYSTS.

A pair of otocysts, Fig. 1, *o t*, lie directly in front of the pedal ganglia, almost, if not quite in contact with the cerebro-pedal commissures. They are nearly spherical in shape, and consist of a wall of cells with a nearly spherical otolith inside (Nos. 4 and 5). Thus far I have been unable to find cilia in the otocysts, but this may be the fault of preservation. The otocysts of most Lamellibranches are described as being enervated by fibres from the cerebro-pedal commissures. With Sphærium a small branch is given off from the nerve which passes immediately below each otocyst that passes up, and may

often be traced into contact with the otocyst, but I have been unable to demonstrate actual connection with this or with fibres from the cerebro-pedal commissure. Regarding the function of otocysts see Dr. Brooks' article (No. 1).

CIRCULATORY SYSTEM.

The heart, Figs. 1 and 5, consisting of a single median ventricle, *v t*, and a pair of lateral auricles, *a u*, lies in the pericardial cavity, near the dorsal surface of the animal, and somewhat in front of the posterior adductor muscle. All the blood channels issuing from the ventricle are without very definite walls or calibre. Immediately in front of the pericardium the blood channel, Fig. 1, which leaves the heart in this direction, divides. The larger branch is continued forward along the dorsal line of the body, turns to the left and passes beneath the œsophagus, which it follows to the mouth. When opposite the dorsal end of the anterior adductor muscle, a branch is given off which passes in front of the adductor and, dividing, sends a branch to each mantle lobe. The main channel is continued down in front the cerebro-pedal commissures into the foot, where it divides into a number of small branches that apparently ultimately end in the connective tissue spaces with which the whole body is permeated. The smaller branch, which arises immediately in front of the pericardial cavity, passes downward, sends a branch to either side of the stomach, supplying that organ throughout its length with small branches, and finally ends among the loops of the intestinal coil.

Posteriorly the ventricle gives rise to a channel of considerable dimensions which surrounds the intestine, but is more spacious beneath than above it. The intestine seems to be held in the dorsal part of this channel by strands of connective tissue. Behind the posterior adductor muscle this channel widens on opposite sides of the intestine and is continued into the mantle lobes. It is not improbable that other important channels exist. Fig. 5 is a section across the body in the region of the heart showing the connection that exists between the auricles and the blood spaces of the gills.

ORGANS OF BOJANUS.

The organs of Bojanus consist of a pair of coiled and sacculated tubes, one on each side of the body, lying between the pericardium and the posterior adductor muscle. At one end

each organ opens into the pericardial cavity, and at the other end into the cloacal chamber. Fig. 1, *o B*, shows the right organ as seen from the left or inner side, and Fig. 7 is a diagram of the left organ as seen from the left or outer side. By comparing the two figures the relations of the loops will be seen. The cells lining the organ are apparently not glandular in the immediate vicinity of the pericardial opening, and are rather small near the cloacal opening, but throughout the rest of the tube the cells are large and vacuolated, as shown by Fig. 11, which represents specially large cells from the dorsal part of the organ. I have been unable to find cilia on any of the cells.

REPRODUCTIVE ORGANS.

The animal is hermaphroditic. The reproductive organs, which are paired, each consist of a racemose gland, Fig. 1, *r o*, situated beneath the pericardium and behind the stomach, varying in extent according to the age of the individual, and opening into the cloacal chamber close to the cloacal opening of the organ of Bojánus. Part of the follicles bear ova, others sperm. The ova-bearing follicles are generally among those most posterior. They are fewer in number than the sperm follicles, and, in this species, bear comparatively few ova. Fig. 8 represents a section of an ova-bearing follicle, in which are a number of nearly or quite mature and several very young ova. The sperm-bearing follicles are generally full of sperm, which lie free in their cavities. Reproduction, apparently, goes on during the greater part of the year.

LITERATURE.

1. Brooks, W. K. Sensory Clubs or Cordyi of Leodice. Jour. of Morph. Vol. X, No. 1.
2. Kellogg, James L. Contributions to our Knowledge of Lamellibranchiate Mollusks. Bul. U. S. Fish Commission, 1890.
3. Lang, Arnold. Lehrbuch der Vergleichenden Anatomie.
4. Lankester, E. Ray. Mollusca. Enc. Britt.
5. Leydig, Franz. Ueber Cyclas Cornea. Müller's Archiv., 1855.
6. Mitsukuri, K. On the Structure and Significance of some Aberrent Forms of Lamellibranchiate gills. Quart. Jour. Mic. Sci., Vol. XXI, 1881.
7. Peck, R. H. Gills of Lamellibranchiate Mollusca. Quart. Jour. Mic. Sci., Vol. XVII, 1877.
8. Pelsener, Paul. Contribution à l'étude des Lamellibranches. Arch. de Biol., Tome XI, Part 2, 1891.
9. Rankin, Walter M., Über das Bojanus' sche Organ des Teichmuschel. Jena, Zeit. Bd. XXIV, 1890.
10. Zeigler, E. Die Entwickelung von Cyclas cornea Zeit. f. wiss. Zool., Bd. XLI.

My thanks are due to Mr. C. P. Sigerfoos for the loan of series of sections of two undetermined species of Sphærium, with which some comparisons were made.

EXPLANATION OF PLATES.

a a. Anterior adductor muscle.
a o. Anterior aorta.
a r p. Anterior retractor pedis muscle.
a s Anterior adductor muscle scar.
a u. Auricle.
b. Byssal gland rudiment.
b l s. Blood space.
b s. Branchial siphon.
c. Cloacal chamber.
c g. Cerebral ganglion.
c r. Chitinous rods.
c s. Cloacal siphon.
f. Foot.
f i l. Gill filament.
i f j. Inter-filamentar junctions.
i g. Inner gill.
i o. Inhalent ostea.
l. Liver.
l p. Labial palpus.
m. Mantle.
o B. Organ of Bojanus.
œ. Œsophagus.
o g. Outer gill.
o t. Otocyst.
o v. Ovarian follicle.
p. Pericardial cavity.
p a. Posterior adductor muscle.
p g. Pedal ganglion.
p r p. Posterior retractor pedis muscle.
p s. Posterior adductor muscle scar.
p s g. Parieto-splanchnic ganglion.
r. Mantle ridge.
r o. Reproductive organs.
t. Male follicle.
v t. Ventricle.
w t. Water-tube.

PLATE I.

Fig. 1. A reconstruction of an adult specimen from serial sections, seen from the left side. Median, and the paired organs of one side shown. The liver and reproductive organs of older specimens are more extensive.

PLATE II.

Fig. 2. Enlarged view of the outside of the right valve and the inside of the left valve of a shell.
Fig. 3. View of the animal with the right valve of the shell removed, and most of the right mantle lobe cut away.
Fig. 4. Oblique cross-section of an animal through the intestinal coil and the pedal ganglia. Seen from behind.
Fig. 5. Section through the heart in the same series as preceding.

PLATE III.

Fig. 6. Cross-section of a piece of gill seen obliquely from the side so as to show both the section and the outer surface of a lamella.
Fig. 7. Diagram of the outer, left, side of the left organ of Bojanus.
Fig. 8. Section across an ovarian follicle.
Fig. 9. Epithelial lining of the distal portion of the stomach.
Fig. 10. Liver follicle showing charged and discharged cells.
Fig. 11. Epithelial cells of the organ of Bojanus.

A STUDY OF THE GENUS CLASTOPTERA.

ELMER D. BALL.

In the development of the hind tibiae and the structure and venation of the wings, the insects under consideration represent the highest and most specialized forms of the Cercopidæ if not of the Homoptera; marking, as Uhler suggests, an important advance toward the Heteroptera in the increased freedom of the anterior coxae and the possession of a terminal membrane to the corium.

In order to correctly establish generic characters it will be necessary, first, to separate off those of family value.

FAMILY CERCOPIDÆ.

The representatives of the family in this country, at least, agree in possessing the following characters:

Front inflated, convex or compresso produced; antennae inserted in front of and between the eyes; ocelli, two, situated on the disc of the vertex; thorax large, sexangular or trapezoidal; hemelytra coriaceous; posterior coxæ and femurs short, tibiæ spatulate, armed with two spurs, the first once, the second twice as long as tibiæ are wide; tibiæ and two first joints of tarsi terminated with crescent-shaped rows of spines, third joint with a bifid claw.

The following genera are represented in the United States: *Monecphora*, *Lepyronia*, *Aphrophora*, *Philaenus* and *Clastoptera*. These may be easily separated by the character of the venation of either pair of wings by reference to plate XII.