

## On the Anal-gland found in *Squilla oratoria*<sup>1)</sup>

Tohru B. Oka (岡 徹)

Laboratory of Genetics, Faculty of Science,  
Ochanomizu University, Tokyo

### Introduction

In the course of studies on the ovarian part of the testis of *Gebia major* (Oka, 1941) in the spring of 1927, there was found a white, foam-like, massive gland, enclosing the rectum and the anal-split, lying under the dorsal carapace of the telson<sup>2)</sup>. The gland is found to be similar in both sexes, and the posterior end of the testis or ovary is found embedded in the gland.

Thereupon, several crustaceans were examined to determine whether such an anal gland might be found in other species, such as *Squilla*, or *Eupagurus*.

In *Squilla oratoria* the anal gland is present, and its histological studies are noted in the present paper. On the survey of the literature concerning the anal gland of Crustacea, there are found only two short notes which seem to be descriptions of the anal gland of *Squilla*. One of these notes is found in the paper of C. Claus (1883) entitled "Die Kreislaufs-organe und Blutbewegung der Stomatopoden", issued in the fifth volume of the Arb. Zool. Inst. d. Univ. Wien:..."Ein solches Organ findet sich nun in der Tat da, wo man es nach Analogie der Amphipoden suchen würde, als Anhang des Afterdarmes, und zwar am äussersten Ende desselben unmittelbar vor der Ausmündung neben der Afterspalte finden sich zwei Drüsensäckchen, deren Zellen stark in das Lumen verspringen und ein Secret ausscheiden, welches sich als körniges Sediment niederschlägt" (Pl. 12, Fig. 1, Dr.). The figures presented in his paper might be drawn from the gland in the larva of *Squilla*. Claus's figure is reproduced (Fig. 1) in comparison with my case. The above cited descriptions of Claus seem to be of the larval gland, and there is nothing about the gland in adult *Squilla*.

The second note is found in the paper of W.N.F. Woodland (1914) entitled "On the maxillary glands and some other features in the internal anatomy of *Squilla*", issued in the fifty ninth volume of the Quaterly Journ. of Micros. Sci.:..."rectal glands are found in both sexes underlying the ramifications of the 'liver' in the telson. They are two

1) The substance of this paper was reported before the 'weekly conference' of the Zoological Institute, Faculty of Science, Tokyo Imp. Univ., held in 1929.

2) The substance of this studies was read before the monthly meeting of the Zoological Society of Japan on Jan. 22, 1938.

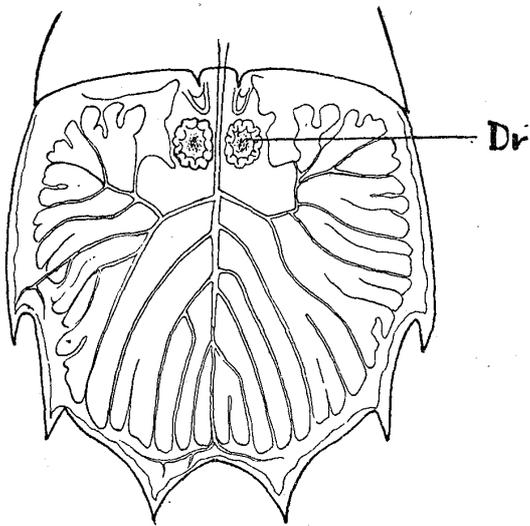


Fig. 1. "Drüsensäckchen" (Dr) in a larva of *Squilla*, reproduced from Claus (1893).

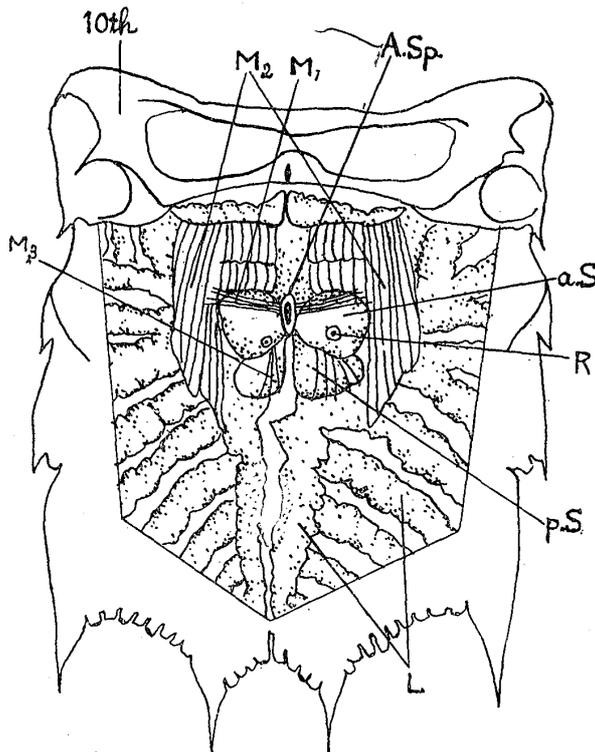


Fig. 2. Ventral view of the anal gland (a.S. and p.S.) of *Squilla oratoria*. Four sacs of the anal gland are arranged on both sides of the anal-split (A.Sp.). The ventral carapace and the underlying membrane of the telson are removed.

A.Sp., anal-split; a.S., anterior sac; L., liver;  $M_1, M_2, M_3$ , muscle; R., ring or a concretion; p.S., posterior sac; 10th., tenth segment or sixth abdominal segment.  $\times 2.5$ .

in number, are large, with spacious lumina, and open in the adult as in the larva (see Claus (5)), laterally at the posterior end of the rectum. In addition to these rectal glands there are present some small accessory tubules opening into the gut in the same region, which apparently bear some resemblance in structure to the urinary tubes of Amphipods" (p. 425). Woodland, however, presented no sketches of this in his paper.

The anal gland which I found in *Squilla oratoria* is quite different from the gland described by both Woodland and Claus, and no such glands and accessory tubules as Woodland described in *Squilla* were found in my case.

#### Material and Method

The anal gland of *Squilla* was fixed *in situ* with Bouin's solution, the material being collected monthly throughout the year for the purpose of the comparative studies on the seasonal changes of the gland and its cells. Serial sections of the gland were stained with Delafield's hematoxylin and counterstained with eosin or acid fuchsin. By means of reconstruction of the serial sections of a whole gland together with the anal-split and the rectum, the opening of the gland and the relative connections of the four sacs of the gland were studied.

### Observation

*General features of the anal gland.* The anal gland, exposed by uncovering the ventral carapace of the telson and the underlying pigmented membrane, lies immediately beneath the bundles of muscle fibers (Fig. 2, M<sub>1</sub>) that are attached transversely to both sides of the anal-split (Fig. 2, A.Sp.), and the gland is surrounded by the muscles of the telson (Fig. 2, M<sub>2</sub>) which are attached to the carapace of the telson. The ramifications of the so-called liver are spread directly under the gland (Fig. 2, L).

The anal gland is composed of four sacs lying on both sides of the anal-split, looking like four wings of a butterfly; that is, one pair of anterior sacs (Fig. 2, a.S.) and another pair of posterior sacs (Fig. 2, p.S.). They are found to be similar in both sexes. They are semi-transparent in living specimens.

Viewed from the ventral aspect, each of the two sacs of both sides seems to be attached to the lateral side of the anal-split respectively.

The anterior sacs, measuring about 4 mm in the longest diameter, are not always of the same size and are generally larger than the posterior sacs. The sacs are enclosed by several minute bundles of muscle fibres, especially at their posterior corner. It should be noted that in both of the anterior sacs is contained a small, white ring,

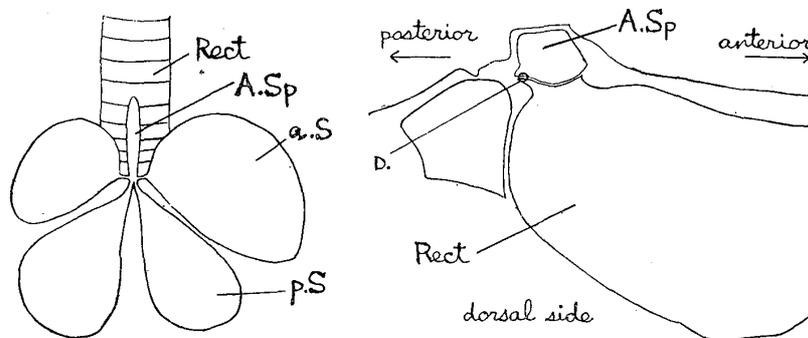


Fig. 3 (left). Diagrammatic figure of the anal gland showing the relative position of the openings of the four sacs to the anal-split.

A.Sp., anal-split; a.S., anterior sac; p.S., posterior sac; Rect., rectum.

Fig. 4 (right). Sagittal section of the anal-split and the rectum.

A.Sp., inner surface of the anal-split; Rect., rectum; D, the point where the ducts of the sacs open.

a concretion, measuring about 1 mm in diameter (Fig. 2, R. and Figs. 15-16), but sometimes either one of the sacs contains it. In living specimens, the concretion looks somewhat opaque through the semi-transparent membrane of the sacs.

The posterior sacs, measuring about 3-4 mm in the longest diameter, are not always of the same size, while they are usually smaller than the anterior sacs. The sacs are different from the anterior sacs in two

features, that is, 1) they do not contain the concretion, and 2) the sacs are more thickly enclosed by the minute bundles of muscle fibres (Fig. 2, M<sub>3</sub>) running meridionally, especially at their distal corner, and latitudinally.

*Communication of the glandular sacs to the anal-split.* As is shown in the semi-diagrammatical Figure 3, which is drawn from the reconstruction of serial transverse sections of the glandular sacs and the anal-split, each of the anterior sacs communicates, at both sides of the anal-split,

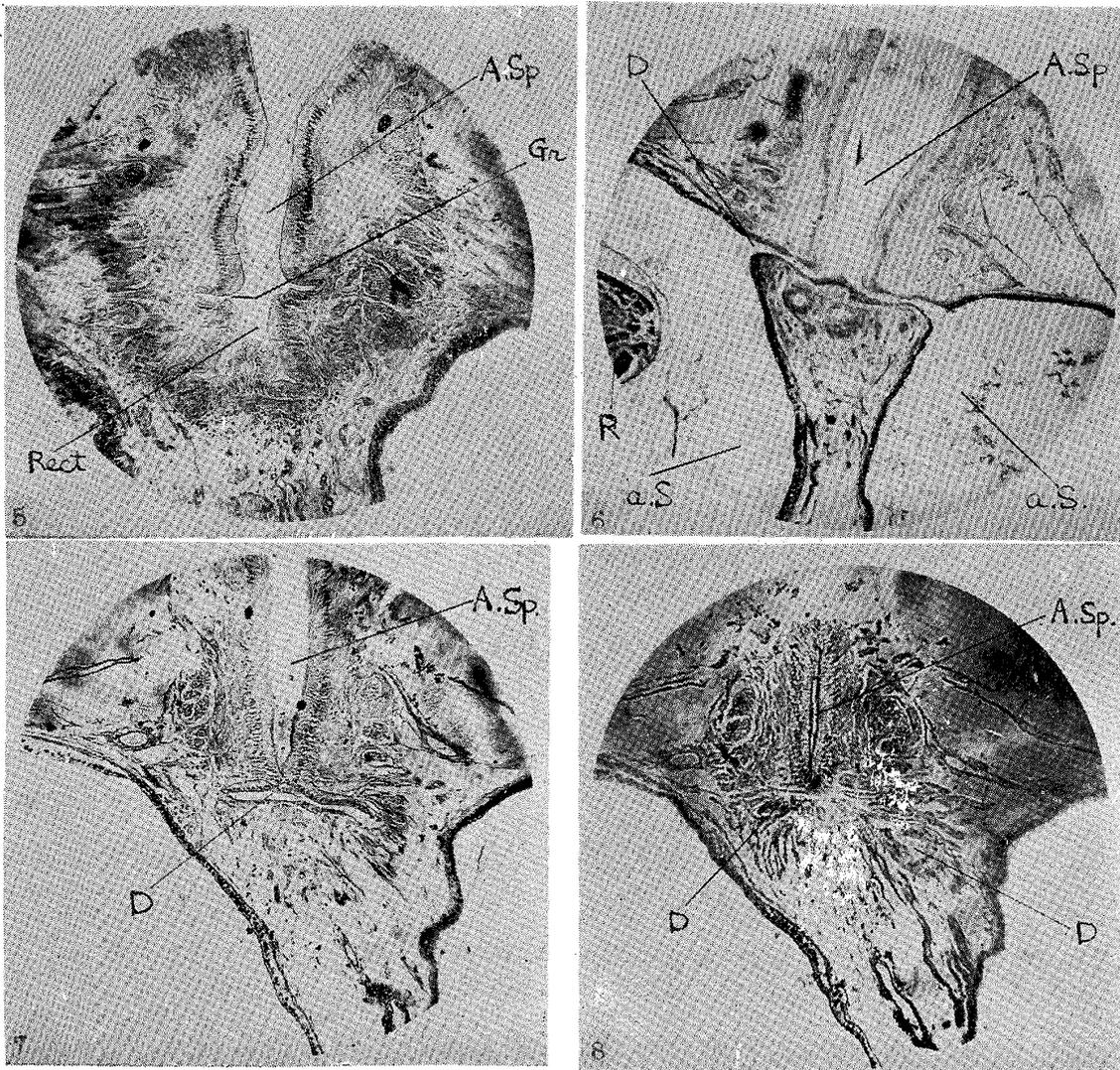


Fig. 5. A transverse section at the posterior end of the anal-split showing the anal-split (A.Sp.) and the groove (Gr.) between the rectum (Rect.) and the anal-split, into which the ducts of the anterior sacs communicate from both sides.

A.Sp., anal-split; D., duct; Gr., the groove; Rect., rectum.

Fig. 6. A section that is followed several sections from that of Figure 5 showing the communication of the ducts (D) of the anterior sacs into the anal-split.

a.S., anterior sac; R., ring or a concretion.

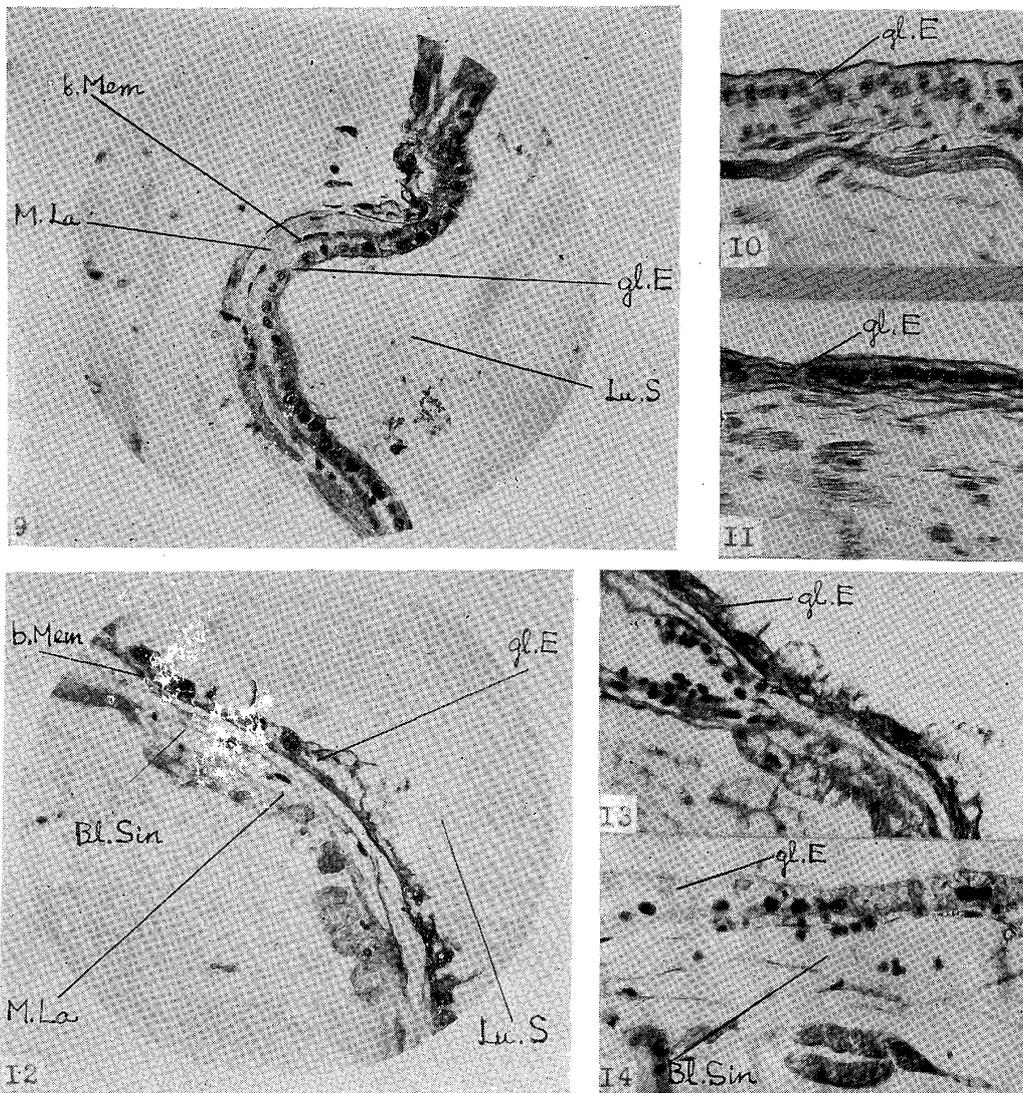
Fig. 7. A section following that of Figures 5 and 6 showing the common duct (D) of the posterior sacs.

Fig. 8. A section following that of Figure 7 showing the separated ducts (D) of the posterior sacs.

by a slender duct, with the lateral and posterior end of the anal-split, at the junction of the rectum and the anal-split (Fig. 4, marked). The anterior end of each posterior sac, on the other hand, unites with a short common duct, and this duct communicates into the posterior end of the junction of the ducts of the anterior sacs (Fig. 3).

#### Histological Features of the Anterior Sacs

The ring or concretion in the anterior sacs is stained by both eosin and Delafield's hematoxylin, and is formed of several concentric layers of the substance that seems to be accumulated (Figs. 15-16). The sacs seem to be filled with some kind of fluid, containing basophilic particles



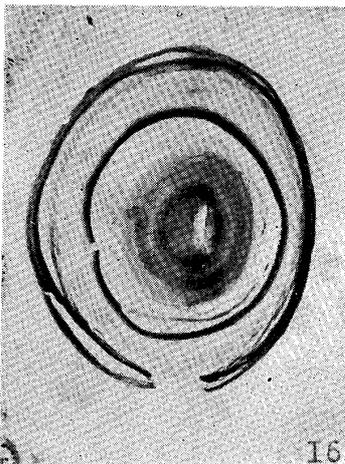
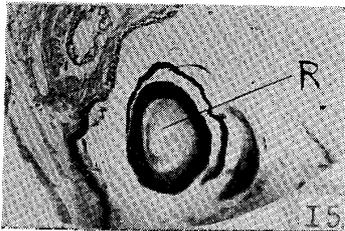
Figs. 9-11. The wall of the anterior sacs. Fig. 10. The thicker region. Fig. 11. The thinner region.

Bl.Sin, blood sinus; b.Mem, basal membrane; gl.E, glandular epithelium; Lu.S, lumen of the sac; M.La, muscle layer.

Figs. 12-14. The wall of the posterior sacs. Fig. 13. the inactive region; Fig. 14. the active region.

here and there in the lumen of the sacs. The wall of the anterior sacs is so thin that the sacs look semi-transparent in living specimens.

Histologically, the wall of the anterior sacs is composed of three layers of different kinds of cells (Figs. 9-11); that is, 1) the inner surface of the sacs, facing the lumen (Lu.S), is lined with glandular epithelium (*gl.E.*) that is made of cells arranged in one layer, upon which the cuticular saum is attached, which is disintegrated at some places; 2) this glandular epithelium is directly covered by the thin basal membrane (*b.Mem.*), the nuclei of which are very small and stained



Figs. 15-16. A ring or concretion found in the anterior sacs.

heavily; 3) upon this basal membrane the bundles of the muscle fibres (*M.La.*), running meridionally and latitudinally, enclose the sacs. The sacs composed of these three layers are embedded in the surrounding connective tissues.

*Glandular epithelium.* The epithelium is thick at the place where the glandular cells are in an active condition (Fig. 10) and is thin where the cells are inactive (Fig. 11). The cells of this layer are large and cubic (inactive) or long and rectangular (active) in shape, and they are regularly arranged side by side, and the cell membrane of these cells is clearly seen. Generally, the cells are covered by the cuticular saum on their surface, but in some regions the cells are disintegrated and the cuticular saum is lost. The nucleus of these glandular cells is smaller than that of the posterior sacs (Fig. 12), and presents a round or oval shape, and they are regularly arranged in succession. The nucleus contains chromatin granules, but not

a nucleolus.

I was not able to find any noticeable seasonal change in the glandular epithelium and in the contents of the lumen of the sacs.

*Basal membrane.* Next to the glandular epithelium there is a thin basal membrane of one-cell layer, in which minute and heavily staining nuclei are found here and there. The membrane attaches firmly to the base of the glandular epithelium, but attaches loosely to the layer of muscles.

*Muscle layer.* The sacs covered by the thin basal membrane are enclosed by bundles of muscle fibres that are arranged meridionally and latitudinally. The meridional muscle fibres are thickly distributed over the distal hemisphere of the sacs. Over the proximal hemisphere of the sacs, on the contrary, the distribution of the muscle

fibres becomes coarse.

The muscle layer and the basal membrane of the sacs are more or less closely attached to each other all over the whole surface of the sacs, this being different from the situation in the posterior sacs. There are found, however, minute mesh-like spaces between the two layers, which contain some blood corpuscles (Figs. 9-11).

*Communication between the anterior sacs and the anal-split.* At the posterior and dorsal extremity of the anal-split, where the rectum transforms into the anal-split, there is a narrow groove on both sides of the anal-split (Fig. 5, Gr). The groove becomes deeper and finally communicates with the proximal end of each anterior sac (Fig. 6, D). This narrow groove forms the duct of the anterior sacs that opens to the posterior end of the anal-split.

### Histological Features of the Posterior Sacs

The posterior sacs contain no ring or concretion, and there are scarcely any granules staining with Delafield's hematoxylin. The wall of the sacs is thicker and less transparent, in the living specimens, than that of the anterior sacs. The sacs are covered with the bundles of muscle fibres much more thickly than in the anterior sacs.

Histologically, the wall of the sacs is composed of three layers of different kinds of cells (Figs. 12-14) as in the case of the anterior sacs; that is, 1) the glandular epithelium (gl.E.), 2) the basal membrane (b.Mem.) and 3) the muscle layer (M.La.). There are, however, some characteristic cytological features of these layers.

*Glandular epithelium.* The epithelium is one-cell layered and is thinner than that of the anterior sacs, and its component glandular cells are smaller than those of the anterior sacs. The cells are not lined by clear cell membrane, and the epithelium looks like a syncytium (Figs. 12-14). The inner surface of the epithelium lacks the cuticular saum, while that of the anterior sacs bears it. The nuclei of this syncytial epithelium stain flat and are much larger (Fig. 12) than those of the anterior sacs (Fig. 9), and they are irregularly distributed here and there. It is to be noted that the nucleus of the glandular cells contains a nucleolus, while that of the anterior sacs lacks it. In the active cells their distal surface is disintegrated (Fig. 12, gl.E), while in resting cells their distal surface is clear, bearing the cuticular saum (Fig. 16, gl.E). The glandular epithelium of the proximal region of the sacs seems to be in the resting condition, while that of the distal region is in an active condition. No noticeable seasonal changes are found in the glandular cells and in the contents of the lumen of the sacs.

*Basal membrane.* Attached firmly to the base of the glandular epithelium, there is found the basal membrane consisting of a one-cell layer.

The nuclei of its component cells are minute and heavily stained, and distributed here and there along the membrane (Fig. 12, b.Mem).

*Muscle layer.* The posterior sacs, covered with the basal membrane, are enclosed by bundles of muscle fibres or hooped with bundles of muscle fibres running meridionally, while a few of them run latitudinally (Figs. 12-14, M.La). The sacs are hooped more thickly with muscle fibres than in the case of the anterior sacs. The distal hemisphere of the sacs is more thickly hooped with muscle fibres than the proximal hemisphere of the sacs.

*Blood sinus between the basal membrane and muscle layer.* It should be noted that in the posterior sacs there are many mesh-like blood sinuses between the basal membrane and the muscle layer (Figs. 12-14, Bl. Sin.). The blood sinus is well developed at the proximal hemisphere of the sacs.

*Communication between the posterior sacs and the anterior sacs.* The proximal end of the posterior sacs becomes narrow, forming a stalk (Fig. 3), and the stalks of both sacs unit and open to the posterior end of the junction of the ducts of the anterior sacs. The ducts communicate into the posterior end of the anal-split as is shown in Figure 3.

### Summary

1. In the adult of *Squilla oratoria* there is found an anal gland composed of four semi-transparent sacs situated on both sides of the anal-split; that is, one pair of anterior sacs and one pair of posterior sacs.

2. Both of the anterior sacs contain a small white ring, a concretion, while in the posterior sacs no such concretion is found.

3. Both the anterior and the posterior sacs are hooped with bundles of muscle fibres running meridionally and latitudially, and the former is more thickly hooped with muscle fibres than the latter.

4. Each of the anterior sacs communicates into the posterior and dorsal end of the anal-split on each side with a minute duct which reaches to the groove that is formed at the junction of the rectum and the anal-split.

5. The posterior sacs of both sides unite, at their proximal ends, into a common short duct, and the duct communicates into the posterior end of the ducts of the anterior sacs.

6. The wall of the anterior and the posterior sacs is made of three layers of different kinds of cells: that is, 1) glandular epithelium, 2) basal membrane, and 3) muscle layer. The glandular epithelium of the anterior sacs is a one-celled layer of glandular cells, and the cells, containing round or oval nuclei, bear a cuticular saum on their surfaces, and are arranged regularly in succession, lined clearly by the cell membrane.

7. The anterior sac, enclosed by the basal membrane, is hooped with bundles of muscle fibres running meridionally and latitudinally, especially, on its distal hemisphere, it is hooped more thickly with muscle fibres.

8. The glandular epithelium of the posterior sacs lacks the cuticular saum and is thinner than that of the anterior sacs, and the component cells lack cell membranes. The nuclei of these cells are larger than those of the anterior sacs. It is to be noted that the nucleus contains a nucleolus, while in that of the anterior sacs no nucleolus is found.

9. The muscle layer of the posterior sacs is thicker than that of the anterior sacs.

10. In the posterior sacs, there are many mesh-like blood sinuses between the basal membrane and the muscle layer.

#### Literature

- Oka, T. B. 1941: Oocyte-like Cells in the Ovarial Part of the Testis of *Gebia major*. Journ. Fac. Sci. Imp. Univ. Tokyo, Sect. IV, 5-3: 265-289.

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