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Structure and Development of the Frontal  
Glands of the Frogs,  
*Rhacophorus schlegelii arborea* and  
*Rhacophorus schlegelii schlegelii*\*

With 2 Text-figures

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The unique structure of the frontal glands in *Rhacophorus schlegelii arborea* and *Rh. schlegelii schlegelii* was first made known by Saguchi (1915) more than 35 years ago. He designated the unicellular glands "pear-shaped glandular cells" (birnförmige Drüsenzellen), believing that they were not homologous with the frontal glands of other amphibians.

My investigations on the morphology and development of the said glands of *Rhacophorus schlegelii arborea*, and of the morphology of the glands of *Rh. schlegelii schlegelii*, however, make it evident that the glands are derived from the neural crest cells as in other amphibians, and, therefore, are homologous with the frontal glands.

A. STRUCTURE OF THE FRONTAL GLANDS

1. *Rhacophorus schlegelii arborea*

At the time of hatching, the dorsal epidermis of the anterior half of the embryonic body contains ciliated cells, lateral line cells and frontal gland cells among ordinary epidermal cells. The epidermis proper consists of two layers of cells, i.e., the superficial and basal layers. All kinds of cells in the epidermis are devoid of pigment granules, chromatophores and Leydig cells still being absent at this stage (Fig. A, 3).

Frontal gland cells are distinguishable from other kinds of cells in the

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\* Studies on the Hatching Glands of Amphibians IX.

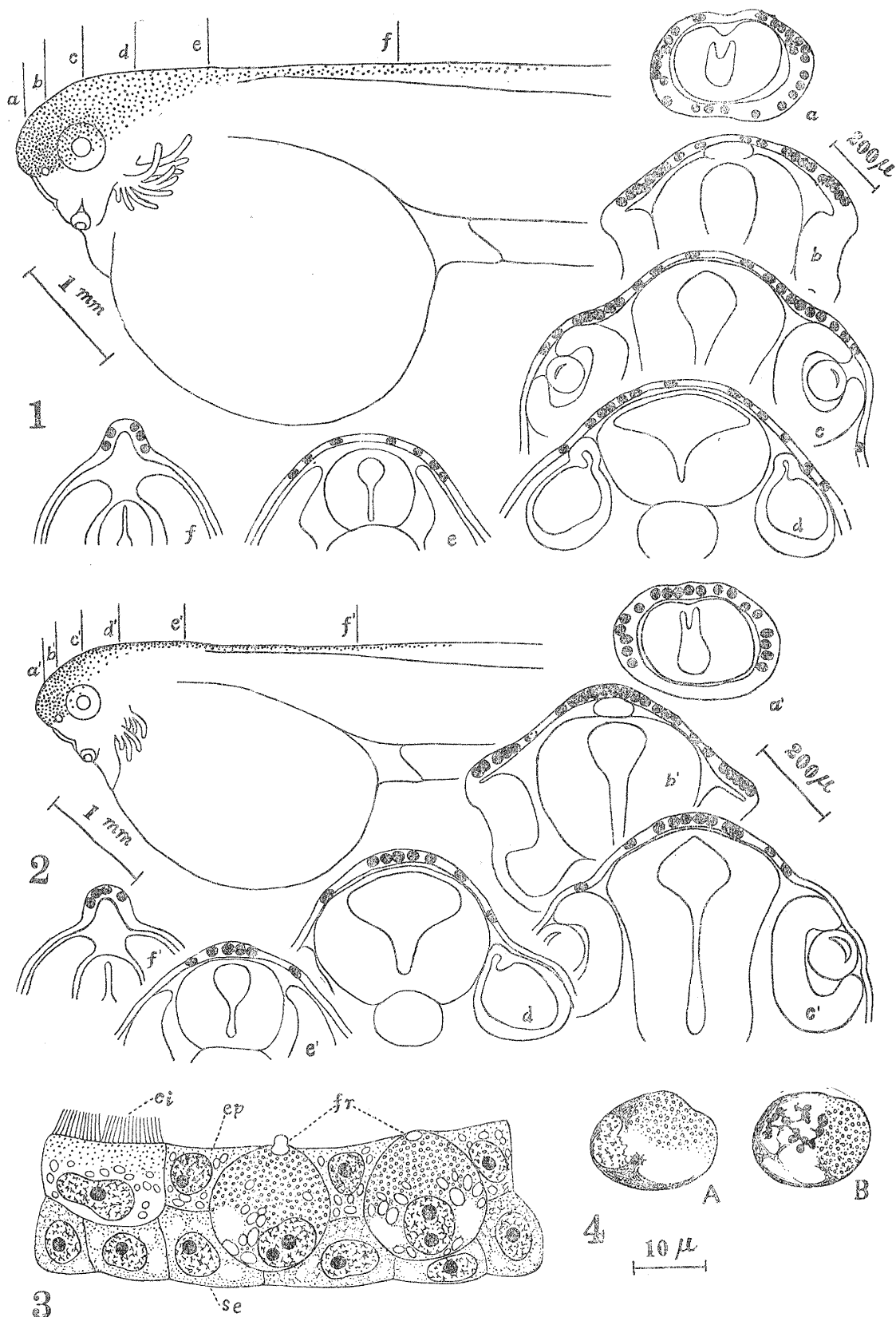


Fig. A. Distribution and morphology of frontal glands. 1. Embryo of *Rhacophorus schlegelii arborea* at hatching. 2. Embryo of *Rhacophorus schlegelii schlegelii* at hatching. Dots in side views and solid circles in sections show gland cells. 3. Transverse section of epidermis just dorsal to eye of embryo of *Rhacophorus schlegelii arborea* at hatching. ci, ciliated cell; ep, superficial layer of epidermis; fr, frontal gland cell; se, basal layer of epidermis. 4. Degenerating gland cells of young larva of *Rhacophorus schlegelii arborea*.

epidermis by their shape and stainability (*vide infra*). They are distributed on the dorsal side of the anterior half of the body, most plentifully in the frontal region, gradually decreasing in number caudally. Of approximately 1,300 gland cells per individual, about one-third to one-half are found in the frontal region (Fig. A, 1).

These findings accord well with those in other anurans (Yanai, 1950, 1951, 1952). Whereas in other frogs the gland cells are most numerous along the mid-dorsal line, however, in the present subspecies, only a few of the gland cells are found in the epidermis just above the brain and spinal cord. They are more numerous in the epidermis of the dorso-lateral part of the body. On the head, the epidermal area containing the gland cells extends to the nasal pits, eyes and ears; and on the trunk, to the upper part of the myomeres. The more ventral portion of the body is devoid of the glands (Fig. A, 1).

The gland cells are generally spherical in shape, although those encountered on the mid-dorsal portion of the head are somewhat flattened. Along with a nucleus, some yolk granules and vacuoles are found in the basal part of the cell. Two nucleoli are commonly present in each nucleus. The cytoplasm is filled with fine eosinophilic secretory granules. Sometimes a droplet of secretion is oozing from a small hole at apical end of the cell. The cuticular hem which is seen at the free end of the frontal gland cells in some other amphibians is not observable in the present subspecies (Fig. A, 3).

## 2. *Rhacophorus schlegelii schlegelii*

In this subspecies, the total number of frontal gland cells per individual is about 880 on an average (800–990). The type of distribution of the frontal gland cells of this frog is intermediate between those of *Rhacophorus schlegelii arborea* and other frogs. In the region anterior to the eyes, the range of distribution of the cells in the present subspecies is more like that in *Rh. schlegelii arborea* than in other anurans; but in the part posterior to the eyes, it resembles more that in other anurans (Fig. A, 2). The cells are almost similar in shape to those of *Rh. schlegelii arborea* except that they possess in general only one nucleolus and are always devoid of a secretory aperture.

## B. DEVELOPMENT OF THE FRONTAL GLANDS

### 1. *Rhacophorus schlegelii arborea*

In the neurulae, at two days after fertilization, cells of the neural crest successively thrust into the epidermis at the margin of the neural groove (Fig. B, 1). The frontal gland cells are derived from these mi-

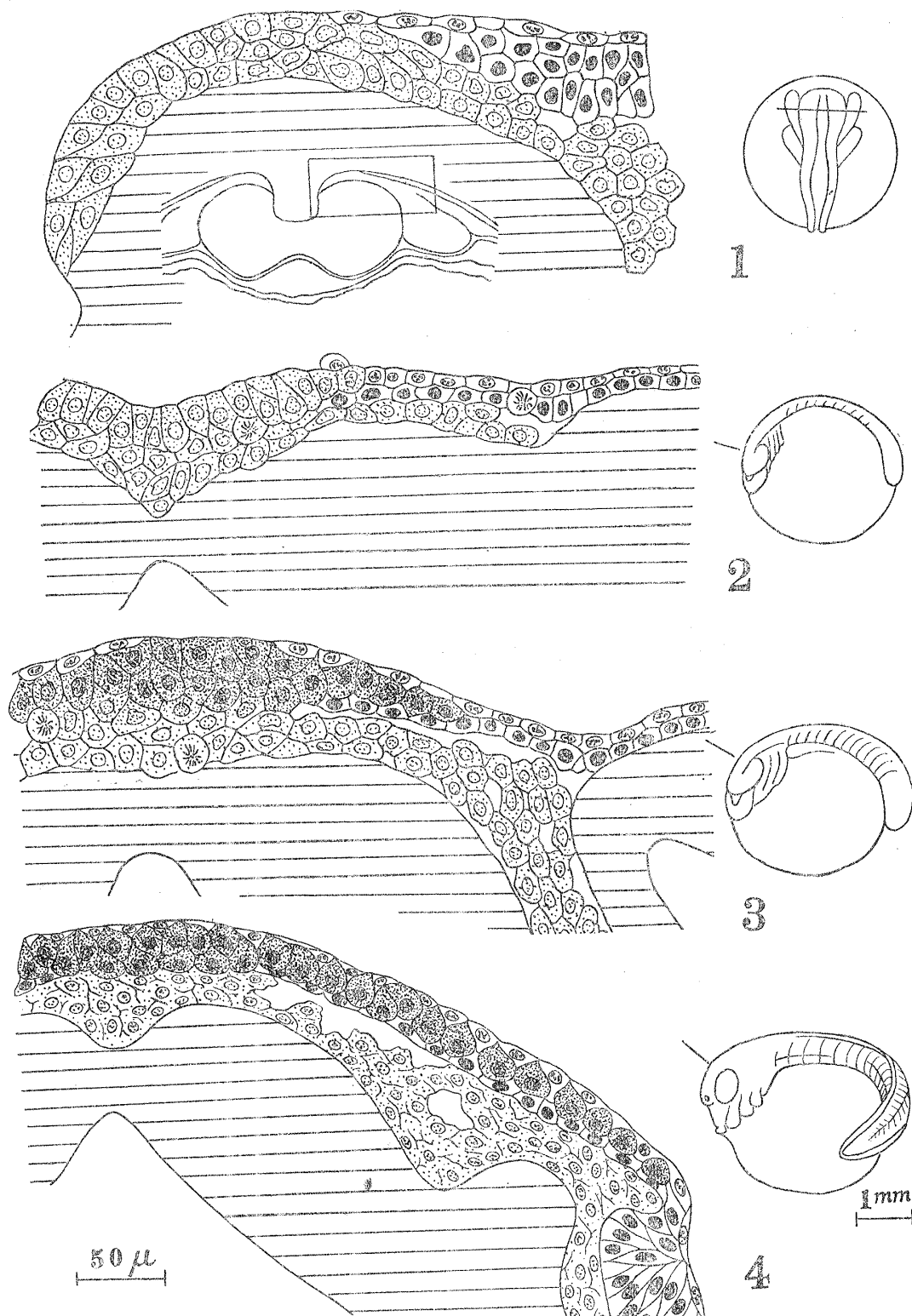


Fig. B. Development of frontal glands in *Rhacophorus schlegelii arborea*. Stages of development and levels of sections are shown on right side. A cell dropping out from epidermis is shown in Fig. B, 2.

grated neural crest cells. When the neural tube becomes folded off from the surface ectoderm, the epidermis overlying the neural tube is chiefly composed of hypertrophied neural crest cells (Fig. B, 2). In this region cells which are dropping out of the epidermis are often encountered.

After the neural tube is formed, the neural crest cells on the dorsal side of the tube undergo active proliferation and give rise to two layers of cells, the outer layer consisting of mother cells of the frontal glands and the inner one comprising the neural crest cells proper (Fig. B, 3). Now the cells in the outer layer actively migrate between the superficial and basal layers of the epidermis and scatter outward. From this time on, no mitotic figures are found in the cells. By three days after fertilization, when the trunk of the embryo becomes enlarged, some of the frontal gland cells have reached the right and left sides of the neural tube (Fig. B, 4). The gland cells are readily distinguishable from the epidermal cells by having in their cytoplasm secretion granules which stain blue with "Blauschwarz".

A half day later, i.e., one day before hatching, the thrusting of neural crest cells into the epidermis comes to an end and frontal gland cells filled with secretion granules have been formed.

## 2. *Rhacophorus schlegelii schlegelii*

Since materials for embryologic studies have not yet been available to me, I have not investigated the development of the frontal glands of this subspecies. It is strongly suggested, however, by the mode of their distribution which is intermediate between *Rhacophorus schlegelii arborea* and other anurans, that a less marked outward scattering of neural crest cells from the original site of proliferation along the mid-dorsal line takes place in the present subspecies than in *Rh. schlegelii arborea*. The existence of a type of frontal glands to be regarded as an intercalated type between *Rh. schlegelii arborea* and other frogs supports the conclusion that the frontal glands of *Rh. schlegelii arborea* are homologous with similar glands in other amphibians.

## C. RETROGRESSION OF THE FRONTAL GLANDS

### 1. *Rhacophorus schlegelii arborea*

At hatching, a few gland cells are already undergoing degeneration. After this, retrogression of the gland proceeds rapidly and at three days after hatching most of the gland cells have disappeared. At this stage, the external gills have been lost, the suckers are showing signs of degeneration, and some chromatophores and Leydig cells appear in the epidermis. After two more days, when the suckers have regressed to traces, the

glands are gone completely (Table 1).

Table 1

Reduction in number of gland cells during the course of retrogression of the frontal gland.

| Body length<br>(mm) | Days after<br>fertilization | Days after<br>hatching | Mean total<br>number of<br>gland cells* | Range of<br>variation | Number of<br>individuals |
|---------------------|-----------------------------|------------------------|---|-----------------------|--------------------------|
| 6.0                 | 3.5                         |                        | 1,336                                   | 1,091-1,796           | 6                        |
| 8.0                 | 4.5                         | 0                      | 1,263                                   | 1,045-1,584           | 6                        |
| 11.4                |                             | 1                      | 801                                     | 745- 898              | 6                        |
| 13.0                |                             | 2                      | 254                                     | 152- 357              | 4                        |
| 16.0                |                             | 3                      | 45                                      | 0- 9                  | 4                        |
| 19.0                |                             | 5                      | 0                                       |                       | 4                        |

\* Degenerating cells are included.

As in other amphibians, no gland cells are transformed into other kinds of cells. It is worth mentioning that no pigments are formed in the cells throughout the life of the glands.

Before closing this paper, I wish to express my cordial thanks to Professor T. Kawamura of Hiroshima University and to Mr. K. Nakane, teacher of the attached middle school of Aichi University, who helped me in obtaining the material for this investigation.

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