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ULTRASTRUCTURE OF THE LABIAL GLAND IN THE ANT *PACHYCONDYLA OBSCURICORNIS* (HYMENOPTERA, FORMICIDAE)

by

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ABSTRACT

The labial gland of workers of the ant *Pachycondyla obscuricornis* is made up of many acini, each consisting of one central cell surrounded by approximately ten parietal cells. The central cell shows a large amount of secretory vesicles and a well developed granular endoplasmic reticulum. In the parietal cells the amount of secretion appears to be very limited. Both cell types are associated with canaliculi that remove the secretion to the ductule. Invaginated into the central cell is a canaliculus that nearly forms a circular channel with ramifications into each parietal cell.

KEY WORDS: Formicidae, labial gland, morphology, *Pachycondyla obscuricornis*, ultrastructure.

INTRODUCTION

Although functionally diverse, exocrine glands can typically be divided in two groups based on their structural organisation. The first group consists of epithelial gland cells. These are described as type 1 gland cells by NOIROT & QUENNEDEY (1974). The other group is formed by bicellular units, each containing a duct cell and a secretory cell, known as type 3 gland cells in the classification of NOIROT & QUENNEDEY (1974).

The labial gland of some Hymenoptera, however, shows a very different structure that apparently does not correspond to either of the two groups. These labial glands contain many acini, each comprising a central cell surrounded by parietal cells. Between both cell types, canaliculi are found that carry the secretion to the ductuli. The structure is found in the social wasps (LANDOLT & AKRE, 1979), in some Anthophorinae bees (CRUZ-LANDIM, 1973; CAVASIN-OLIVERA & CRUZ-LANDIM, 1998) and in some ponerine ants (GAMA & CRUZ-LANDIM, 1982).

The present paper deals with the morphological structure of the labial gland in *Pachycondyla obscuricornis*, a ponerine ant that shows the structure with a central cell surrounded by parietal cells. The main objective is to describe the detailed ultrastructure of the gland involved, this forming the first ultrastructural study of the labial gland of this type in Formicidae. This approach should allow us to get more insight into a functional-morphological context.

MATERIALS AND METHODS

Colonies of the ponerine ant *Pachycondyla obscuricornis* Emery, 1890 were collected at La Selva (Costa Rica) and kept in plaster nests. Labial glands of workers were dissected and fixed in 2% glutaraldehyde, buffered in 0.05 M sodium cacodylate with 0.15 M saccharose. After postfixation in 2% osmium tetroxide, tissues were dehydrated in a graded acetone series and embedded in araldite. Semithin sections (1 μm) were made with a Reichert OmU2 microtome, coloured with methylene blue-thionine and observed in a Zeiss Axioskop light microscope. Ultrathin sections of 70 nm were made with a Reichert Ultracut E microtome, double stained with lead citrate and uranyl acetate and examined in a Zeiss EM900 transmission electron microscope.

Material for scanning microscopy was, after fixation in glutaraldehyde, dehydrated in ethanol and critical point dried. Observation took place in a Philips XL 30 ESEM scanning microscope.

RESULTS

As in most insect species, *Pachycondyla obscuricornis* workers have paired labial glands. The left and right ducts fuse in a common unpaired duct which in turn opens in the labium. In the thorax, the paired ducts are widened to form the reservoirs of the labial gland (fig. 1). Posteriorly to the reservoirs, the ducts ramify into many ductuli with an outer diameter

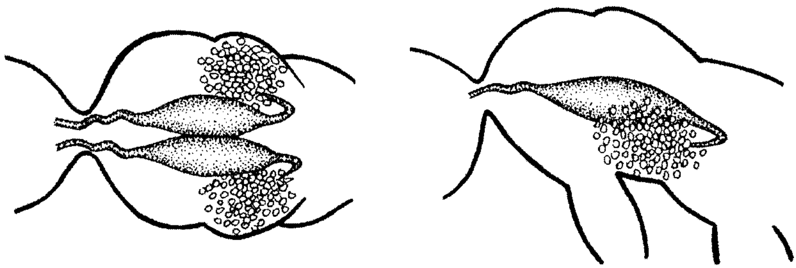


Fig. 1. Top (left) and lateral view (right) of the anterior part of the thorax of *Pachycondyla obscuricornis* showing the position of the labial gland (anterior side to the left).

of 5 μm and an inner diameter of 2 μm. They consist of a cuticular canal surrounded by epithelial cells, with a taenidial appearance of the cuticle. Each ductule ends in an acinus (figs 2, 3). The two groups of acini, forming the secretory part of the labial gland, are situated laterally of the gland reservoir (fig. 1).

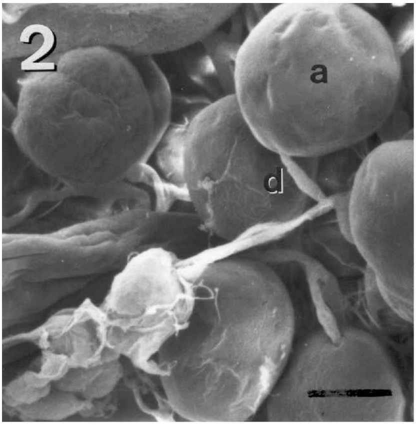
An acinus has a diameter around 100 μm and consists of a large central cell surrounded by approximately ten parietal cells (fig. 4). The latter are partly invaginated into the central cell, which results in a globular appearance of the acinus. The parietal cells in general do not touch each other. The central cell and the parietal cells are associated with canaliculi, which remove the secretion from the cells to the ductulus.

The central cell has a big central nucleus (50 μm diam.) with many nucleoli of variable size. The cytoplasm is for the greater part filled with secretory vesicles (fig. 5) with a substantial amount of granular endoplasmic reticulum between them. Peripherally some mitochondria are evident. The peripheral plasmalemma shows invaginations.

The parietal cells are much smaller than the central cells and have a nucleus of approximately 10 μm diameter with many small nucleoli. With the aid of a light microscope, there is no secretion evident, but ultrastructurally small vesicles can be seen. They also have a less developed granular endoplasmic reticulum compared to the central cells. The canaliculi in the parietal cells are surrounded by numerous mitochondria. Near the basement membrane, the cell membrane shows invaginations with many mitochondria in between them. Apically, the cell membrane of the parietal cells is in contact with the membrane of the central cell.

The canaliculi show a ramified system of small transportation canals that carry the secretory products towards the acinar ductule. In contrast with the ductule, the canaliculi show no taenidia, and have a diameter of 2 μm, which is the same as the inside of the ductule. The canaliculus forms nearly a circle around the central cell in order to reach all the parietal cells, as was confirmed by studying serial semithin sections and by dissecting canaliculi out of the acinus. Every branch of the ramifications of the canaliculus ends in one parietal cell, as illustrated in figure 8. As the circular canaliculus has a diameter smaller than that of the central cell, it is inevitably invaginated into the latter. Histologically, the canaliculi consist of a lumen, surrounded by a perforated cuticle. Around this, the membranes of the central cell and the parietal cells show microvilli (fig. 5).

In the central cell of some acini there is a large amount of secretion evident in between the microvilli and within the canaliculi. In figure 6, the emission of secretion from the central cell is shown very clearly. First the secretory vesicles fuse in the central cell. By exocytosis, the secretion will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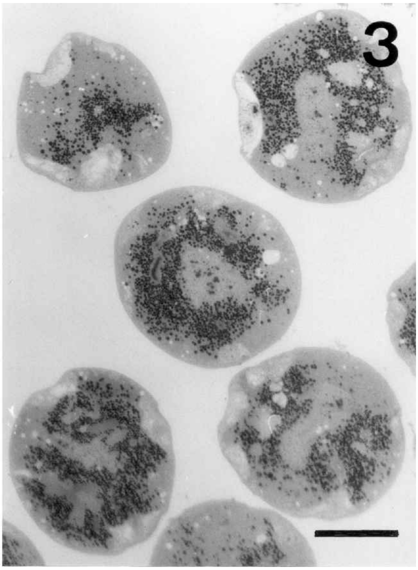
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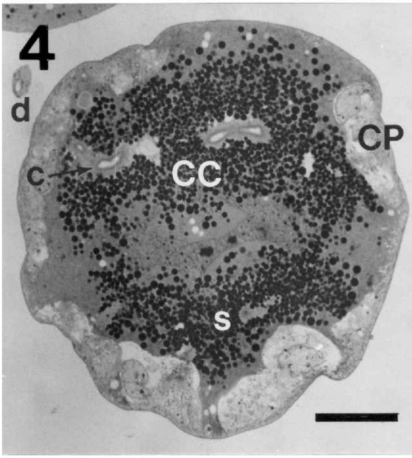
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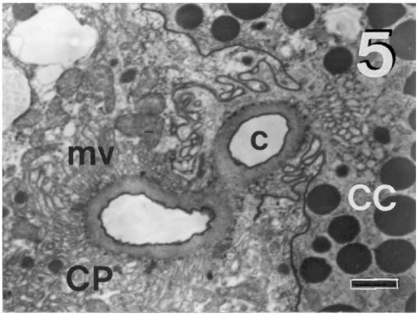
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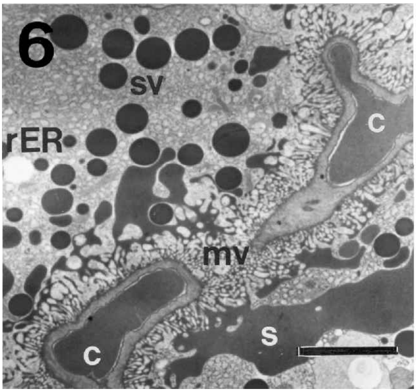
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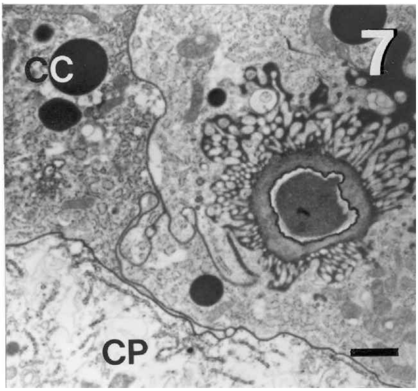
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be transported in between the microvilli and the cuticle. Then the secretion passes through the perforated cuticle that shows a granular appearance instead of different compact layers like most cuticular structures. Finally the secretion will pass the canaliculi and will leave the acinus via the ductulus.

Where both central and parietal cells adhere, the structure of the membranes is complex. In the region near the canaliculi, the membranes of the central cell and the parietal cells are in close contact with each other through septate junctions (fig. 8). Because of the smaller diameter of the canaliculus compared to that of the central cell, the canaliculus is surrounded by an invagination of the cell membrane of the central cell (fig. 7). The membranes in this structure are tightened with septate junctions. The membrane of the parietal cell invaginates and as a consequence envelopes the blind ending part of the canaliculus in the parietal cell (fig. 8).

DISCUSSION

The structure of the labial gland with a central cell surrounded by parietal cells, as described here for the ant *Pachycondyla obscuricornis*, also occurs in a number of other ponerine ants such as *Pachycondyla striata*, *Neoponera villosa* and *Odontomachus chelifer* (GAMA & CRUZ-LANDIM, 1982), as well as in social wasps (CRUZ-LANDIM & SAENZ, 1972). In contrast with the organisation in these ants, the parietal cells in wasps occupy most of the acinar surface (LANDOLT & AKRE, 1979), while their canaliculi are usually situated in between the central cell and the parietal cells, and not invaginated into the central cell as described here for *Pachycondyla obscuricornis*. Also in wasps, each parietal cell is

Fig. 2. Scanning micrograph of some acini of the labial gland of *P. obscuricornis*. a = acinus, d = ductulus. Scale bar: 50 μm.
Fig. 3. Semithin section through a few acini. Scale bar: 50 μm.
Fig. 4. Semithin section of an acinus of *P. obscuricornis*. c = canaliculus, CC = central cell, CP = parietal cell, d = ductulus, s = secretion. Scale bar: 25 μm.
Fig. 5. Ultrastructure of the canaliculus in the region between the central cell and a parietal cell. c = canaliculus, CC = central cell, CP = parietal cell, mv = microvilli. Scale bar: 1 μm.
Fig. 6. Ultrastructure of a canaliculus in the central cell which discharges secretion. c = canaliculus, rER = granular endoplasmic reticulum, mv = microvilli with secretion in between, s = secretion that is fused before emission, sv = secretory vesicle. Scale bar: 5 μm.
Fig. 7. Ultrastructure of a canaliculus which is invaginated into the central cell. c = canaliculus, CC = central cell, CP = parietal cell. Scale bar: 1 μm.

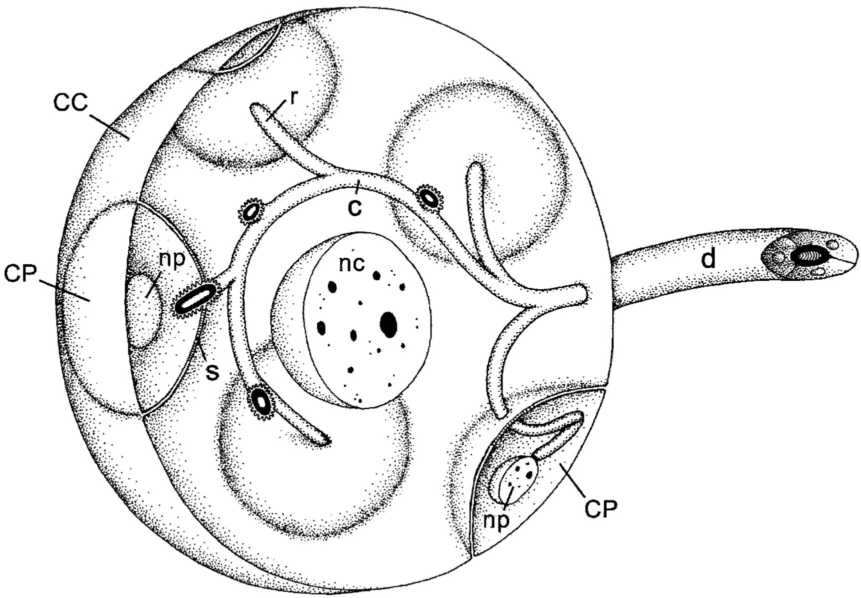

Fig. 8. Schematic representation of an acinus. c = canaliculus, CC = central cell, CP = parietal cell, d = ductulus, nc = nucleus of central cell, np = nucleus of parietal cell, r = ramification of canaliculus, s = septate junctions.

associated with one branch of the canaliculus. Furthermore the structural organisation of the cells is the same in wasps and in these ponerine ants.

This structure may possibly represent a novel type of exocrine glands, besides the epithelial glands and the secretory units described by NOIROT & QUENNEDEY (1974). However, to clarify this further ontogenetic research of the gland is needed.

The labial gland of some other insects also shows an acinar structure, although this structure differs considerably with the presence of various types of epithelial cells surrounding a central lumen. Among these are zymogenic cells and peripheral cells, that are sometimes also called central resp. parietal cells. This structure is described in the cockroaches *Periplaneta americana* (KESSEL & BEAMS, 1963) and *Nauphoeta cinerea* (BLAND & HOUSE, 1971), in the tettigoniid *Homorochoryphus nitidulus* (ANSTEE, 1975), and in the termites *Macrotermes bellicosus* (BILLEN *et al.*, 1989) and *Serritermes serrifer* (COSTA-LEONARDO, 1997).

In *Pachycondyla obscuricornis*, the central cell shows a lot of granular endoplasmic reticulum while the secretion has a granular appearance, which suggests the synthesis of a proteinaceous secretion. This is also the case in the zymogenic cells of the labial gland of *Nauphoeta*, where these cells produce amylase and probably other enzymes, corresponding to their function in producing saliva (BLAND & HOUSE, 1971). DAY (1951) has found amylase and a mucoid substance in the zymogenic cells of the cockroach *Periplaneta americana*.

There is hardly any production of proteinaceous secretion in the parietal cells, as shown by the scarce occurrence of secretory vesicles and granular endoplasmic reticulum. The numerous mitochondria that occur peripherally in the parietal cells most likely play a role in the active transportation of nutrients through the cell membrane. In the heterometabolous species mentioned, the peripheral cells have a pyramidal shape. They have an intracellular ductule lined by microvilli and their basal cell membrane is considerably infolded and accompanied by numerous mitochondria. In the cockroach *Nauphoeta cinerea*, these cells are probably responsible for the primary transport of water and ions into the gland (BLAND & HOUSE, 1971).

The secretion of the labial gland of *Pachycondyla obscuricornis* is proteinaceous, but the precise composition of its secretion and the function are still unknown, and will require further research.

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