ULTRASTRUCTURE OF THE DERMAL GLAND OF THE COCKROACH, *PERIPLANETA AMERICANA*

RITA G. ADIYODI
Department of Zoology, Calicut University, Calicut 673 635, India.

ABSTRACT

The dermal glands, located in the anterior abdominal tergites of adult male and female *Periplaneta americana*, produce an electron-dense homogeneous secretion. The possible role of this secretion is discussed.

INTRODUCTION

DERMAL glands underlying the cuticle were described in the abdominal terga and sterna of the cockroach, *Periplaneta americana* in 1950 by Kramer and Wigglesworth[1]. No information, however, is available on the fine structure of the dermal glands of this species. We report here the ultrastructure of the dermal glands in the anterior abdominal terga of *P. americana*.

MATERIALS AND METHODS

Small pieces of the third or fourth terga of newly emerged and adult male and female *P. americana* were fixed in 2.5% glutaraldehyde in 5% sucrose in 0.2 M cacodylate buffer at pH 7.2 for 3 hr at 4°C and postfixed in 1% OsO_4 for 1 hr in the dark. After dehydration in alcohol, they were embedded in Araldite. The sections were stained in uranyl acetate and lead citrate. Micrographs were taken on a Philips EM. Thick sections (1–2 μm) for light microscopy were stained with toluidine blue.

RESULTS

Structure of the epidermis

Four major types of cells could be distinguished in the epidermis of *P. americana*: (1) an outer layer of epidermal cells, (2) gland cells, (3) cells associated with the duct which transports the glandular products, and (4) oenocytes. Each gland pours out its products *via* a single duct which opens on the surface of the cuticle located in the middle of a pit.

The dermal glands

The dermal glands of *P. americana* are arranged towards the inner layer of the epidermis, almost bordering the haemocoel. Apart from the gland cell, a few duct cells are also associated with each gland. The gland cell is roughly pear-shaped and possesses a more or less centrally located nucleus, either spherical or of slightly irregular contour and measures 8–11 μm along the long axis. The gland cell is characterised by a roughly sausage-shaped end apparatus, approximately 16 μm long and 2 μm across (figure 1). The duct emerging from the end apparatus is intensely positive to toluidine blue, and has a width of 0.50 to 0.75 μm. The cuticular lining of the duct and end apparatus is discarded with the exuvium after each ecdysis. Dermal glands are generally identical in structure in both sexes; however, in males an increase in the number of the glands with the last moult is seen.

Ultrastructural studies show that the end apparatus

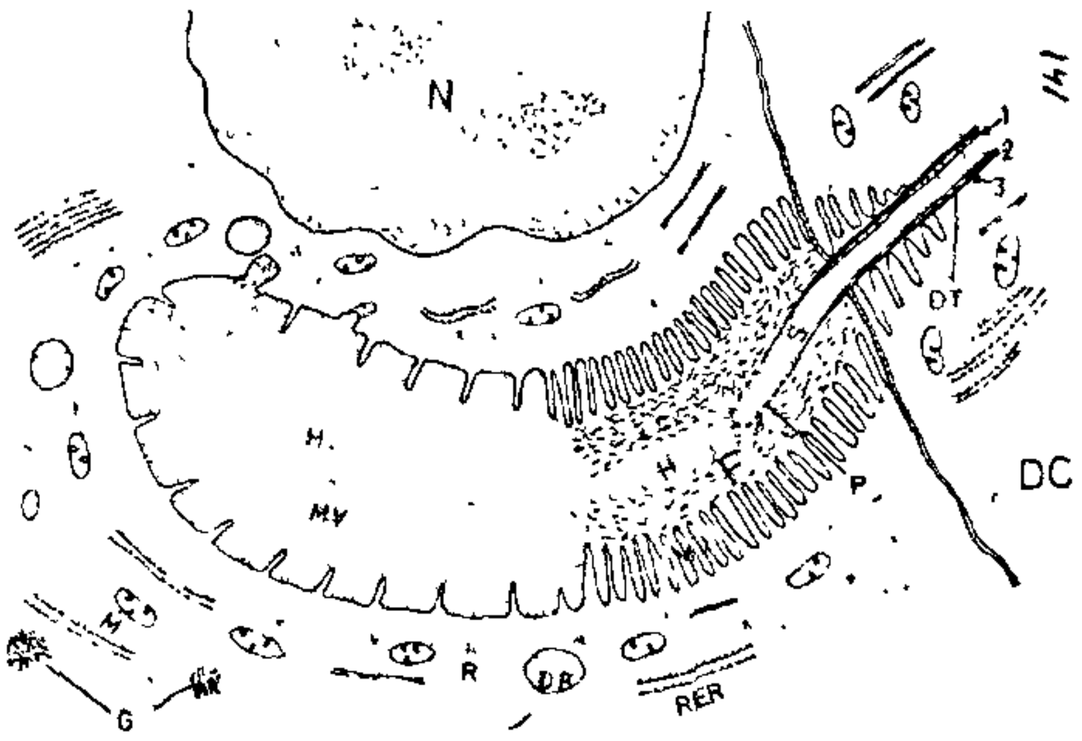

Figure 1. Diagram showing a section through the end apparatus of the gland cell and a part of the first duct cell of the dermal gland of the cockroach, *Periplaneta americana*. DC-first duct cell; DT-duct; F-fibrous luminal contents; G-glycogen deposits; H-homogeneous secretion; M-mitochondria; N-nucleus; P-perforated region of the duct; R-ribosomes; RER-rough endoplasmic reticulum; S-the homogeneous secretory product passing through the duct; VB-electron-dense vesicular bodies.

of *P. americana* is a large extra-cellular reservoir bordered by cylindrical microvilli, which are modified regions of the plasmalemma. The microvilli are relatively sparse proximally, but become more compact and stacked distally. Proximally, the contents of the end apparatus appear electron dense and homogeneous (figure 2), while distally they seemingly lose their homogeneous nature and assume a rather coarse and approximately fibrous consistency. In more distal regions, nearer the duct cell, the luminal contents appear homogeneous in the middle of the lumen, but fibrous towards the periphery close to the region occupied by the microvilli (figure 3). Notwithstanding this, secretion carried away by the emerging duct is always homogeneous. The gland cell cytoplasm contains large numbers of mitochondria. Rough endoplasmic reticulum (RER) is moderately developed. Areas possessing smooth endoplasmic reticulum, in the form of small vesicles, are scarce. Golgi complex is not very prominent in dermal gland cells of adult *P. americana*. Free ribosomes and polysomes were frequently observed in the cytoplasm. Electron-dense vesicular bodies having a consistency comparable to that of the contents of the proximal region of the end apparatus, were occasionally observed in the cytoplasm in the vicinity of the end apparatus. Areas, rich in glycogen deposits, were common in cytoplasm of the secretory cells. Septate desmosomes occur where the gland cells meet the first duct cell (figure 3). Microtubules were only sparingly observed in the cytoplasm of the gland cell. Myeloid bodies with electron-dense inclusions were occasionally noticed in the gland cells of adult female cockroaches.

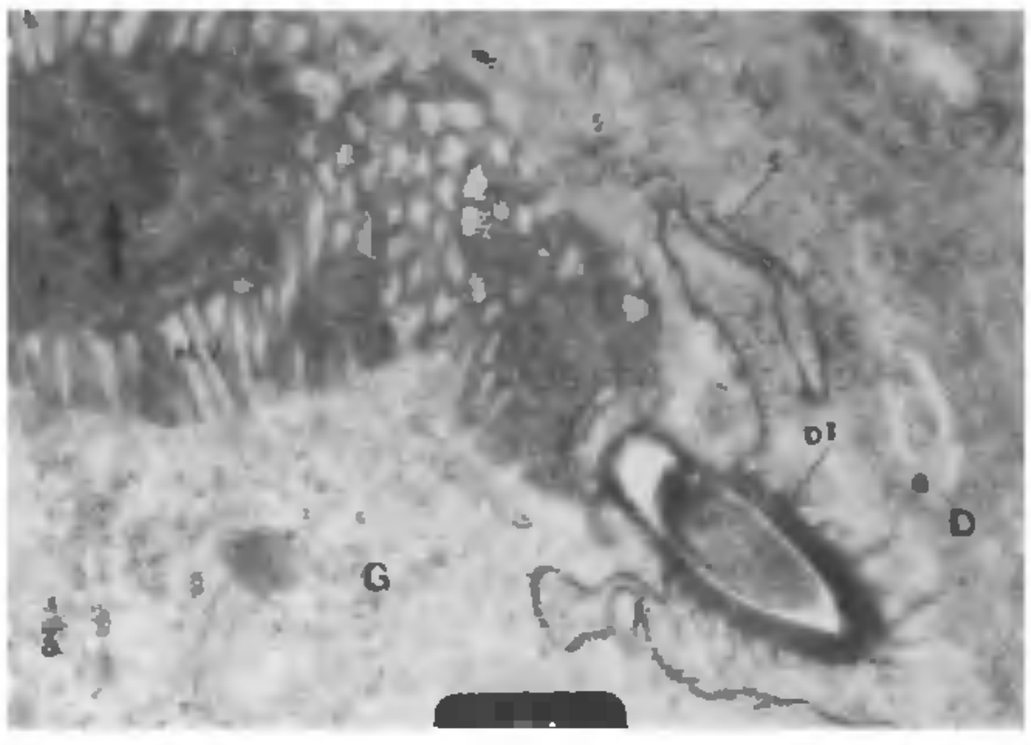

Figure 3. Junction between the gland cell (G) and duct cell (D) of the dermal gland of a newly emerged adult male *P. americana*. Septate desmosomes (S) are present connecting the gland cell and the duct cell at the point of emergence of the duct (DT) from the end apparatus. Note the presence of fibrous luminal content (F) in the distal region of the end apparatus immediately facing the layer of microvilli (MV), while in the middle of the lumen, the material appears homogeneous (arrow). × 54,000.

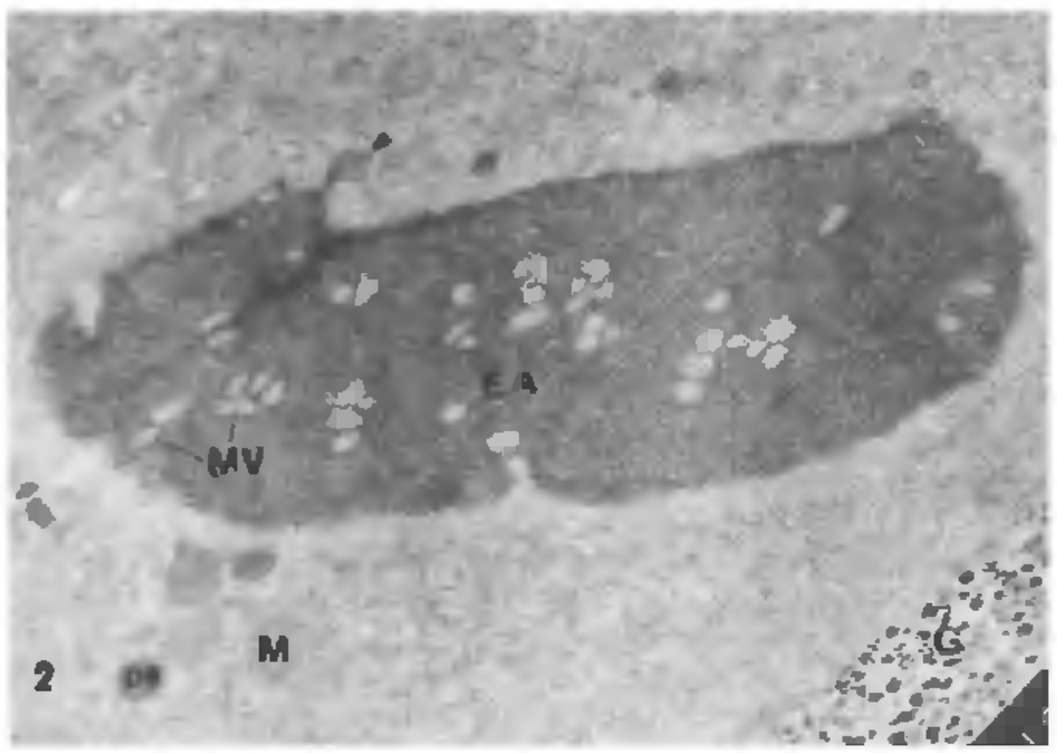

Figure 2. Electron micrograph showing the homogeneous luminal content in the proximal region of the end apparatus (EA) of the dermal gland of an adult male *P. americana*. Electron-dense bodies (DB) having a consistency comparable to that of the luminal content are seen in the cytoplasm and such bodies also appear as if they are in the process of being released into the end apparatus (arrow). G-glycogen; M-mitochondria; MV-microvilli. × 42,000.

The duct and the duct cells

The duct which passes through two types of duct cells, begins as a thin structure from the distal half of the end apparatus of the gland cell. Further down, the porous wall of the thin duct containing a homogeneous product becomes evident in the middle of the fibrous luminal contents towards the distal half of the end apparatus of the gland cell (figure 1). More distally, the duct wall seems to become a continuous and nonporous entity, but still quite thin compared to its final thickness. In the next region, the duct wall gets reinforced by a second cuticular layer. Nearer to the point of its exit from the gland cell, the three-layered nature of the duct wall becomes quite distinct and the wall also seems to have gained considerably in thickness. The inner cuticular layer is the thinnest; the outer two are almost equal in thickness, each 5–6 times as thick as the inner cuticular layer. At the point

where the duct emerges from the gland cell, the plasmalemma of the first duct cell is provided with microvilli which seem to wrap around the emerging duct (figure 3). It is possible that the first duct cell also has a role in the formation/reinforcement of the duct wall. From the region of the microvilli, the duct takes an intracellular course and frequently passes through more than one duct cell. The duct passes close to the duct cell nucleus and coils around it. From the last duct cell, the duct pierces vertically through the tergite cuticle and opens out on the surface of the tergum.

Septate desmosomes are common between the duct cell and the epidermal cell. Electron-dense bodies of varying sizes are found in the cytoplasm. A fairly well organized RER is present in the duct cell. Mitochondria are profusely scattered in the cytoplasm. Microtubules are present in large numbers. Duct cells possess a distinct Golgi complex with vesicles containing a dense core.

Throughout the course of the duct, the luminal content appears electron dense and homogeneous and resembles the contents of the proximal half of the end apparatus of the gland cell.

DISCUSSION

Insect dermal glands are believed to provide a layer of cement over the epicuticle during the few hours following exuviation[1–4]. As the gland cells appear active and the ducts remain filled with secretion, even in adult males long after final ecdysis, it becomes obvious that the role of these dermal glands does not end with the production of the cement layer alone. A comparable phenomenon was earlier reported in *Tenebrio molitor*[5].

Structurally, the dermal glands of *P. americana* are largely comparable to the type B dermal glands of *Tenebrio molitor*[5]. In both species, the dermal gland secretion is the product of a single gland cell. However, regional differences in the consistency of the contents of the end apparatus, observed in *P. americana*, are not seen in type B dermal glands of *T. molitor*.

The progressive formation of the duct, which emerges from the dermal gland in *P. americana*, can be compared to the formation of the duct in sternal dermal glands of *Tenebrio molitor*[5]. The dermal gland duct is generally assumed to be the product of the plasma membrane of one or more duct cells[3,4].

In both *T. molitor* and *P. americana*, the initial region of the duct, located in the distal half of the end apparatus of the gland cell, is perforated, conceivably to facilitate the passage of secretory products into the duct. The significance, if any, of the intimate association between the duct and the duct cell nucleus, observed in dermal glands of *P. americana*, remains unknown. A similar coiling of the duct in close proximity of the duct cell nucleus has been described earlier in dermal glands in the sterna and terga of the male desert locust, *Schistocerca gregaria*[6].

ACKNOWLEDGEMENTS

The author thanks The Rhodes Trust for the award of a Rhodes Visiting Fellowship at Somerville College, Oxford University and also Dr P. C. J. Brunet for laboratory facilities.

3 February 1984; Revised 28 May 1984

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