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Sternal Gland in *Coptotermes formosanus* (Isoptera: Rhinotermitidae)[1]

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ABSTRACT

The sternal gland of the Formosan termite, *Coptotermes formosanus* Shiraki, is described from serial sections stained with Delafield's haematoxylin-eosin. The gland lies ventrally in the 5th abdominal segment beneath an elongated 4th sternite, and immediately ventral to the 4th abdominal ganglion. The anterior portion of the gland is composed of a mass of globose, vacuolated cells, 2 groups of layered, flat, darkly stained nuclei with elongate cellular processes, and a large central lumen. Numerous cuticular ducts and/or campaniform structures occur in the thickened chitin between the lumen and the external environment. In sagittal section the gland exhibits a long, narrow posterior portion composed of large, ovoid, darkly staining cells. It is suggested that the secretion of the gland is produced by either or both the anterior and posterior masses of large cells, transferred by the fibrous processes of the small cells, and stored in the central lumen until released through the ventral cuticular ducts.

The most thoroughly investigated termite sternal glands are those of *Zootermopsis nevadensis* (Hagen) (Stuart 1963, 1964; Stuart and Satir 1968) and *Kalotermes flavicollis* (F.) (Noirot and Noirot-Timothée 1965a, b). Descriptions of the sternal glands in *Reticulitermes lucifugus* (Rossi) (Mosconi-Bernardini and Vecchi 1964) and *R. flavipes* (Kollar) (Smythe and Coppel 1966) have also been published, and preliminary observations of such glands in other species are available (Pasteels 1965, Noirot and Noirot-Timothée 1965c, Noirot 1969). Histological investigation of the Formosan termite, *Coptotermes formosanus* Shiraki, revealed a sternal gland in the typical location, but with several features not previously described from similar organs.

MATERIALS AND METHODS

Mature workers of *C. formosanus* were sectioned, mounted, and stained. The termites were fixed in a modified Carnoy's fixative (DeGiusti and Ezman 1955) and embedded in Paraplast®. Sections cut at 6 μ were stained with Delafield's hematoxylin-eosin. Some slides were examined on a microscope equipped with special filters and a fluorescent attachment.

Workers were the principal subjects of examination. However, a gland of essentially similar structure was present in both soldiers and dealate reproductives.

[1] Published with the approval of the Director of the Research Division, College of Agricultural and Life Sciences. This work was supported in part by the Office of Naval Research. The authors acknowledge the assistance of M. Berkowitz in preparation of the slides. Cost of expedited printing was paid by authors. Received for publication Dec. 17, 1970.
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DESCRIPTION OF THE GLAND AND DISCUSSION

The location and overall appearance of the gland have similarities to those found in *R. flavipes* (Smythe and Coppel 1966) and *R. lucifugus* (Mosconi-Bernardini and Vecchi 1964). The gland proper of a 4-mm worker has an average length of 110 μ in longitudinal section, and is an average of 30 μ thick at its thickest point. The posterior tailing portion of the gland is slightly longer, and makes the approximate overall length of the gland 245 μ. The tail is the widest portion of the gland in transverse section at ca. 170 μ, but is narrower than the gland is long. The gland lies ventrally in abdominal segment V immediately beneath the 4th abdominal ganglion. The elongate abdominal sternite IV overlaps the gland-bearing area (Fig. 1).

The gland proper consists of 2 types of cells (Fig. 2). A mass of globose, vacuolate cells ca. 5–10 μ diam comprises the anterior portion near the cuticle. Their granulate nuclei stain darkly. Beneath these cells lie several layers of flat, dark staining nuclei ca. 3–5 μ long, with no definite cell boundaries. Similarly layered flat, dark nuclei appear in the posterior portion of the gland proper at its juncture with the posterior tailing process. The middorsal part of the gland appears composed of a narrow hyaline matrix containing fibrous connectives between the 2 groups of flattened nuclei, and contains a few flat nuclei. Additional fibers appear to connect at least the anterior flat cells to a central lumen in the gland. The large, elongate-oval lumen lies in the central portion of the gland proper, and completes the structure. It is ca. 68 μ long and 16 μ high in sagittal section, and 65 μ wide in cross section.

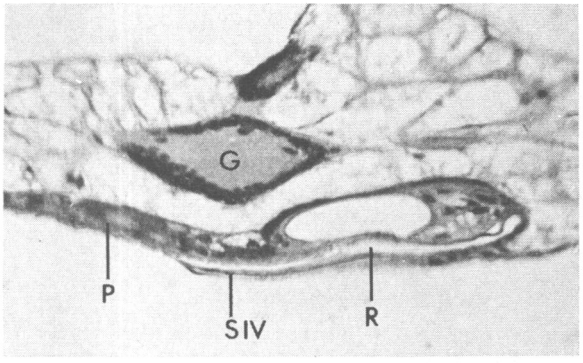

FIG. 1.—Sternal gland of *C. formosanus*, showing its relationship to the elongated abdominal sternite IV (S IV) and the 4th abdominal ganglion (G) (P, posterior portion of gland; R, possible external reservoir for gland secretions).

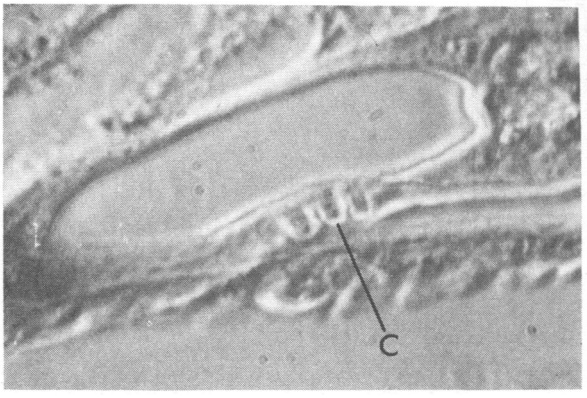

FIG. 3.—Lumen and cuticle of the sternal gland of *C. formosanus* showing the campaniform sensillalike cuticular domes (C); phase contrast.

A long, narrow process extends posteriorly beneath the cuticle toward segment VI (Fig. 1). The process is joined to the anterior gland proper by the previously mentioned group of flat, dark nuclei, and is composed of a mass of very large (ca. 11×30 μ), oval cells which gradually merge into the normal hypodermis. These cells have large, dark nuclei frequently hidden by the darkly stained granular cytoplasm.

The cuticle covering the gland varies greatly in thickness and structure. Anteriorly, over the large globose cells, it is ca. 1 μ thick, smooth-surfaced, and nonchitinized. Posteriorly, over the tailing process of the gland, the cuticle is ca. 2 μ thick, irregularly sculptured, and highly sclerotized. The cuticle in the midportion of the gland, adjoining the lumen, is greatly thickened (ca. 4.5 μ), sclerotized, and in some sections appears traversed by numerous ductules connecting the lumen to the external space between sternites IV and V. In other sections, the cuticular discontinuities in this area appear in the shape of campaniform sensilla (Fig. 3) as discussed by Stuart (1969). These discontinuities are especially prominent under fluorescent examination where they fluoresce bright yellow. The ductules appear on the midline of the gland whereas the cuticular domes are on either side of the midline.

The sternal gland of *C. formosanus* most closely resembles those of 2 other members of the Rhinotermitidae, *R. lucifugus* (Mosconi-Bernardini and Vecchi 1964) and *R. flavipes* (Smythe and Coppel 1966). The location in all 3 species is the same, and each gland consists of an anterior and posterior portion. The histology of the posterior portion is closely comparable. The histological components of the anterior portion are also similar in the 3 species, although their distribution differs somewhat. There is an anterior group of large, globose vacuolate cells, a dorsal layering of small, flat nuclei with elongate fibrous cytoplasmic processes, and a group of cuticular structures resembling campaniform sensilla.

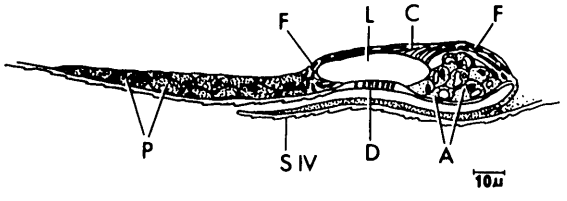

FIG. 2.—Diagrammatic representation of the sternal gland of *C. formosanus* showing cellular detail (A, anterior globose cells; C, connective fibers; D, ductules; F, flat nuclei; L, lumen; P, posterior oval cells; S IV, sternite IV).

The basic morphological difference between the sternal glands of the 3 species lies in the presence or absence of a cavity or lumen in the anterior gland, and the relationship of the other parts to it. No lumen is present in *R. flavipes*, but Mosconi-Bernardini and Vecchi (1964) found 2 narrow cavities in *R. lucifugus*, one surrounded by cells and the other with a chitinous border. In *C. formosanus*, there is a single large lumen whose smooth margins may indicate a thin chitinous lining. Cuticular structures assumed to be campaniform sensilla are apparently present in all 3 species, but the secretory punctures described from *R. lucifugus* were not seen in *R. flavipes*. In *C. formosanus* there appear to be complete breaks or pores through the cuticle between the gland lumen and the outside in the area of the cuticular domes. It is difficult to determine the true nature of these pores, and they may be unusually cut cuticular domes, except that they do not fluoresce. In any case, this area of the cuticle shows no innervation or the direct cellular contact one would expect in sensory structures.

An interpretation of glandular function similar to that proposed for *R. lucifugus* appears reasonable for *C. formosanus* in view of the structure of the gland. The glandular secretion is probably produced in either or both the anterior and posterior masses of large cells, and conveyed via the cellular prolongations of the small flat nuclei to the lumen of the gland which functions as a reservoir until discharge through the ventral cuticular pores. Whether the space between sternites IV and V functions as an external reservoir as suggested by Stuart (1961) for *Z. nevadensis* is

not known, but the space thus formed in our sections of *C. formosanus* (Fig. 1) is not as large as those illustrated for *Zootermopsis* (Stuart 1964) or *R. flavipes* (Smythe and Coppel 1966). Mosconi-Bernardini and Vecchi (1964) found traces of secretory products in the posterior gland cavity in *R. lucifugus;* however, none was observed in *C. formosanus.*

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Dietary Requirement of the Boll Weevil[1] for Arginine and the Effect of Arginine Analogues on Growth and on the Composition of the Body Amino Acids[2,3]

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ABSTRACT

Quantitative dietary requirements of the boll weevil, *Anthonomus grandis* Boheman, for arginine were determined by feeding an amino acid diet containing different amounts of arginine. Citrulline produced good growth and development when it was substituted for arginine, but no growth occurred when ornithine was substituted. Canavanine was toxic and inhibited growth of the boll weevil. This toxic effect could be partially reversed by arginine. Homoarginine did not appear to be toxic, and, when combined with arginine, it alleviated the toxicity of canavanine.

A method is described for the qualitative analysis of the amino acids in boll weevils by thin-layer chromatography. The contents of free and protein-bound amino acids were determined in weevils fed several rearing diets and in those fed diets containing analogues. Canavanine was not found in eggs and adults of boll weevils fed larval or adult diets containing this analogue. Homoarginine was found in the free amino acids of all samples, but not the protein.

A satisfactory diet that contained amino acids as the sole source of protein was reported previously for the boll weevil, *Anthonomus grandis* Boheman (Vanderzant 1965). This diet was used to determine the amino acids indispensable for growth and to adjust the amounts of these amino acids to satisfactory levels. This course also made it possible to change the concentrations of amino acids for testing purposes and replace them with their analogues.

Arginine, an indispensable dietary amino acid for several insects and other animals, is also required for growth of the boll weevil. Since this amino acid has some unique metabolic functions in invertebrates, the effect of feeding analogues of arginine was of interest. This study was made to determine the quantitative dietary requirements for arginine and the effects on growth of citrulline, ornithine, canavanine, and homoarginine. We wanted to know also whether canavanine and homoarginine were incorporated into weevil tissue. Therefore, the amino acids of weevils fed on diets with and without these analogues were separated and identified by thin-layer chromatography (TLC).

[1] Coleoptera: Curculionidae.

[2] In cooperation with the Department of Biochemistry and Biophysics, Texas Agricultural Experiment Station, Texas A&M University, College Station, 77843. Received for publication Aug. 17, 1970.

[3] Mention of proprietary products does not constitute endorsement by the USDA.

MATERIALS AND METHODS

Diets for Weevils.—Stock boll weevil larvae were reared axenically on a casein diet (Vanderzant 1959) and adults were fed a germinated cottonseed diet (Vanderzant and Davich 1961). Tests of the effects of analogues on growth and development as reported here were performed with an amino acid diet (Vanderzant 1965). Tables 1 and 2 indicate changes made in the diet for testing certain amino acids. For feeding adults, canavanine and homoarginine were added to the diet reported earlier (Vanderzant and Davich 1961). Boll weevil samples were frozen until needed