Exocuticular Structures on the Sternal Gland Segments of Rhinotermitidae[1]

by

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ABSTRACT

Seven termite species, *Reticulitermes arenincola, R. flavipes, R. hageni, R. hesperus, R. tibialis, R. virginicus* and Coptotermes formosanus, all belonging to the Rhinotermitidae, were examined with both light and scanning electron microscopes for exocuticular structures on the sternal gland segments. The glands all occur anteriorly in abdominal segment V, and extend posteriorly for two-thirds of the length of the sternite. Each gland is narrowed at its middle to form an anterior and posterior portion. A depressed inverted triangular area occurs in all Rhinotermitidae observed. About 16 campaniform sensilla occur along the lateral arms of the triangular area, to form a V-shaped structure posteriorly positioned on the anterior portion of the gland. Two types of peg sensilla occur. The first type consists of one sensillum on each side, near the upper extremes of the group of campaniform sensilla. These are obtuse peg sensilla and each protrudes from an elevated socket. The second type of peg sensillum is smaller in size and has a socket flush with the cuticular surface. They occur posteriorly and laterally on the sternal gland segment and there are 8–10 sensilla on each side. Pores occur in the triangular depressed area, along the V-shaped campaniform sensilla group, and on the midline of the gland surface. Cuticular scale-like reliefs are common over both anterior and posterior parts of the gland. All cuticular structures are common to workers, soldiers and alates.

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INTRODUCTION

The trail pheromone producing glands of more than 23 species of termites have been studied by about the same number of investigators since 1893. Data are available on the location of the gland (Noirot and Noirot-Timothee 1965a, Stuart 1961, 1963, 1964, 1970, Stuart and Satir (1968), Pasteels 1972, Smythe and Coppel 1966, Mertins et al. 1971, Howard et al. 1976), its size (Stuart 1964, Sands 1965, Leuthold and Luscher 1974, Mosconi-Bernardini and Vecchi 1964, Noirot 1969, Pasteels 1965), the shape of the glands (Stuart and Satir 1968, Pasteels 1965, Smythe and Coppel 1966, Mertins et al. 1971, Noirot 1969, Quennedey 1971a;, and its role in producing trail-following pheromones (Luscher and Muller 1960, Stuart 1961, 1963, 1969, Leuthold and Luscher 1974, Pasteels 1972). Histological studies of the glands were made by Bregeon 1958, Stuart 1963, Mosconi-Bernardini and Vecchi 1964, Smythe and Coppel 1966, Mertins et al. 1971. Satir and Stuart (1965), Noirot and Noirot-Timothee (1965b), Pasteels (1965), Quennedey and Noirot (1968), Stuart and Satir (1968), and Quennedey (1969, 1971b, 1972) studied the ultrastructure of the glands with Transmission Electron Microscope (TEM). The glands have also been isolated or extracted from termites by many investigators (Verron and Barbier 1962, Moore 1966, Hummel and Karlson 1968, Karlson et al. 1968, Matsumura et al. 1968, 1969, Ritter and Coenen-Saraber 1969, Tai et al. 1971, Birch et al. 1972, Quennedey 1971a, Moore 1974). Quennedey (1971a) analyzed the gland histochemically.

The external cuticular structures, however, have been little studied except for the work of Lebrun (1971a, b, 1972), who illustrated scanning data from the outer cuticle of *Kalotermes flavicollis* Fab. and 2 species of *Reticulitermes: R. lucifugus* var. *santonensis* Feytaud and *R.* lucifugus var. *lucifugus* (Rossi). His data show many pectinate scales, digitiform expansions and some pores on the posterior area of the sternal gland. To better understand the trail-following behavior and to test the potential use of trail-following substances for termite suppression, a detailed study of the exocuticular structures of sternal glands was undertaken. An attempt was made to describe and compare the exocuticular structures of the sternal gland segments of Rhinotermitidae with both the light and the scanning electron microscope, and to relate these structures to the function of trail-laying.

MATERIALS AND METHODS

All termites used were from laboratory cultures. *R. arenincola* Goellner was obtained in 1976, from Mellen, Indiana, near the Calumet River; R. *flavipes* Kollar, in 1971, from Janesville, Wisconsin; *R. tibialis* Banks, in 1970, from Galena, Illinois; *R. hesperus* Banks, in 1974, from Butte Co., California; *R. virginicus* Banks and *R. hageni* Banks, in 1975, from

Gulfport, Mississippi; and *C. formosanus* Shiraki, in 1973, from Lake Charles, Louisiana.

The termites were fixed with 3% acetic acid for 24 h and either stained with **1%** acid fuchsin, or left unstained. The specimens, either whole or in part were mounted with Hoyer's mounting medium (Beek, 1955), for light microscope studies.

For scanning electron microscope (SEM)studies, the termite specimens were fixed in 2.5% glutaraldehyde (in 0.1 M phosphate buffer) for 1 day, then washed several times in phosphate buffer solution (7.4 pH), and dehydrated in a graded series of alcohols. The dehydrated specimens were dried in a critical point apparatus for 20 min. Before coating the specimens with a thin layer of gold-palladium in a vacuum evaporator, each specimen was examined to ensure that the anterior part of sternite V was not overlapped by sternite IV. The coated termite was viewed with a Joel U-3 SEM at 20 kV.

RESULTS

1. Light microscope observations:

A depressed inverted triangular area (staining pink with acid fuchsin) was found in all termites observed. The area was located on the midline of the anterior part of the sternite V. It was overlapped by the posterior fold of sternite IV in its natural position (Fig. 1)but was readily visible after treatment with acetic acid (Fig. 2, *R. arenincola;* Fig. 3, *R. flavipes*; Fig. 4, *R. tibialis;* Fig 5, *R. virginicus;* Fig. 6, *C. formosanus*).

About **16** pore-like structure, occurred along the lateral arms of the triangular area. The pore-like structures were arranged more or less symmetrically from both sides, forming a V. The internal gland was situated anteriorly in the midline of sternite V, and extended posteriorly for two-thirds of sternite V (Fig. 7). The gland narrowed at its middle, forming anterior and posterior portions (Fig. **7).** The anterior portion was attached firmly to the epiderm of sternite V, whereas the posterior part seemed moveable. When touched with a minuten pin, the posterior half of the gland moved freely from the epiderm, the anterior part did not. The triangular depressed area was located posteriorly on the anterior portion of the gland (Fig 5). Pores along the V-shaped structure were seen with the light microscope in *R. arenincola* (Fig. 2), *R. flavipes* (Fig. 3), *R. tibialis*

Fig. 2. *R. armincola* sternites IV and V, showing location of triangular depressed area (TD), campaniform sensilla group (CS), pores (P), and peg sensilla (PS) at the anterior part of sternite V. (375X)

Fig. 3. *R. flavipes,* sternite V showing position of the triangular depressed area (TD), campaniform sensilla (CS), peg sensilla (PS) and pores (P). (375X)

Fig. 4. *R. tibialis,* sternite V (phase contrast). Showing pores (P) along sides of campaniform sensilla group (CS). (487X)

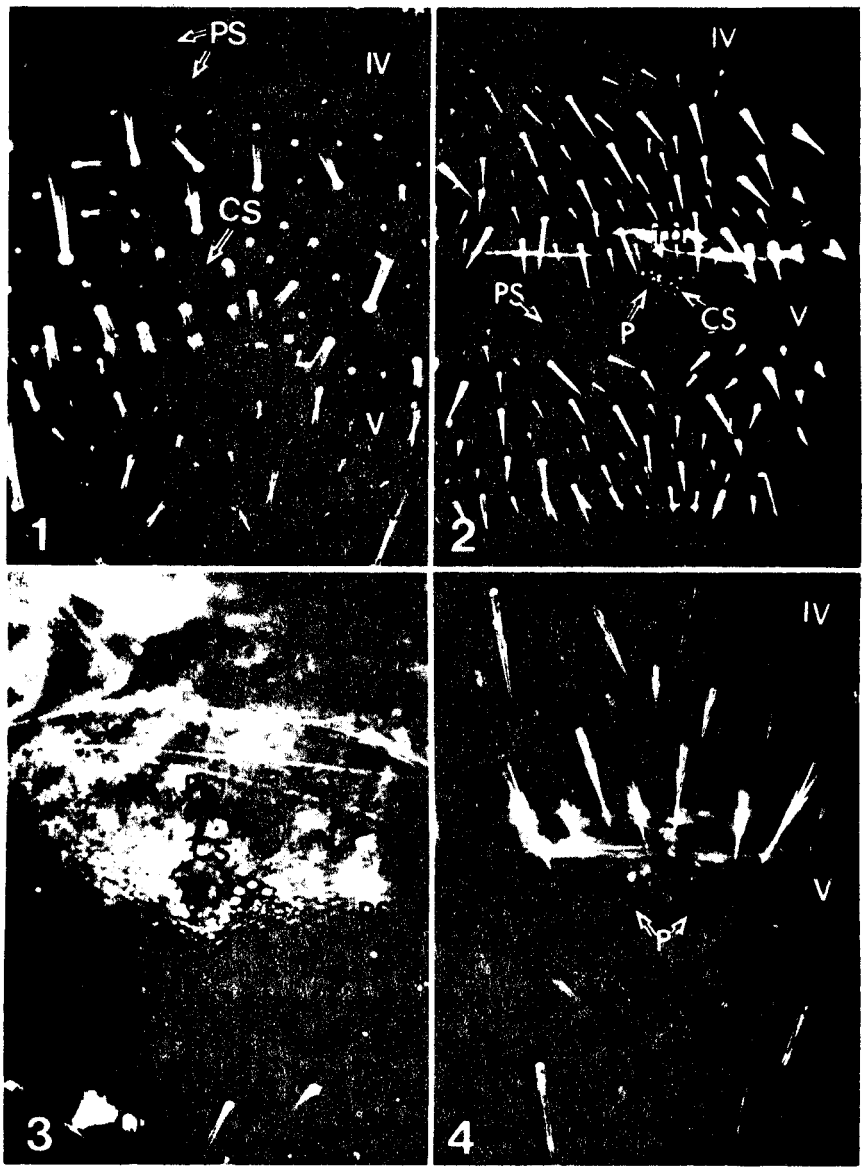

Fig. 1. Normal position of sternites IV and V of *C. formosanus.* Sternite IV overlaps V. Anterior margin of V and anterior part of sternal gland indicated by the presence of campanifom sensilla (CS) in a V-shape. Peg sensilla (PS) occur on the anterior part of sternite IV. (Phase contrast micrograph, to achieve focus of sensilla in foreground, those in background are out of focus.) (375X)

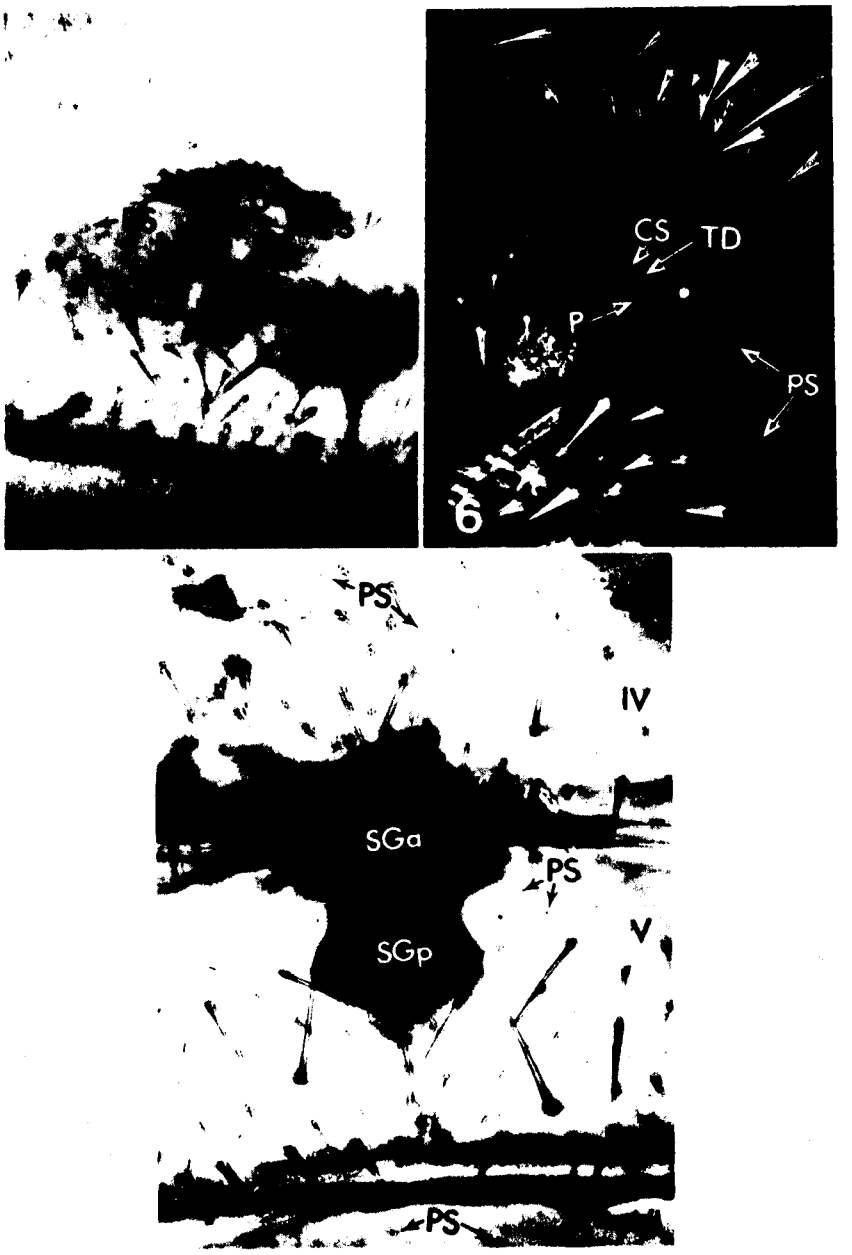

Fig. 5. *R. virginicus,* sternite V, showing position of triangular depressed area (TD), campaniform sensilla (CS) and peg sensilla (PS). (350X)

(Fig. 4) and *C. formosanus* (Fig 6).

2. SEM observations:

The SEM findings for the termites (*R. arenincola, R. flavipes, R. hageni, R. hesperus, R. tibialis, R. virginicus* and *C. formosanus*) are described as follows:

(1) *C. formosanus*

Worker: The triangular pink stained area on the outer surface of sternite V under light microscope was also visible as a depressed area under SEM (Fig. 8, 9). Sensilla, scale-like reliefs and pores occurred on sternite V of *C. formosanus.*

A. *Sensilla:* The pore-like structures, arranged in a V were actually campaniform sensilla when viewed under SEM (Fig. 10, 11). They have a flat process and were oval, typical of campaniform sensilla (Snodgrass, **1935).** Near the upper extremes of the group of campaniform sensilla were two obtuse peg sensilla, possibly basiconica (Snodgrass, 1935). The process of the obtuse peg sensillum was prominent (Fig. 9, 10), pointed distally in some specimens (Fig. 9, 10), but somewhat blunt at the tip in others (Fig. 11, 12). However, they always protruded from elevated sockets. A second type of peg sensillum was found posteriorly and laterally on the sternal gland segment some distance from the central ridge of the sternal gland area. The sensilla were small and numbered 8–10 on each side of the gland segment. These were acuminate peg sensilla. Their sockets were flush with the cuticular surface (Fig. 13).

B. *Pores:* Small pores were scattered throughout the triangular depressed area, along the V-shaped campaniform sensilla group (Fig. 9, 10, **11, 14)** and on the central ridge (midline) of the sternal gland.

C. ***Scale-like reliefs:*** Cuticular scales were common over both anterior and posterior parts of the gland segments. The scale-like reliefs on the anterior cuticular area were finger-like (Fig. 9, 11, 15), whereas the posterior zone had digit-like cuticular expansions (Fig. 9, 11).

Soldiers: The V-shaped arrangement of campaniform sensilla of soldiers was similar to that of workers (Fig. 16, 17). Sensilla, other than the campaniform type, also occurred on the cuticular surface of the sternal gland segments of soldiers (Fig. 16). Again, as with the workers, scale-like reliefs occurred anteriorly in the region of the gland. The number of fingers on each relief varied from one (Fig. 18), to two (Fig. 17) to many (Fig. **19).** The reliefs on the posterior portion of sternite covering the gland

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Fig. 6. *C. formosanus,* sternite V showing position of triangular depressed area (TD), peg sensilla (PS), pores (P), and campaniform sensilla (CS). (Ventral view, dissected specimen, phase contrast.) (375X)

Fig. 7. *C. formosanus* sternal gland, frontal view, 1% acid fuchsin stained. The anterior portion (SG_a) is wider than the posterior portion (SG_p). Peg sensilla (PS) occur anteriorly on all sternites. (375X)

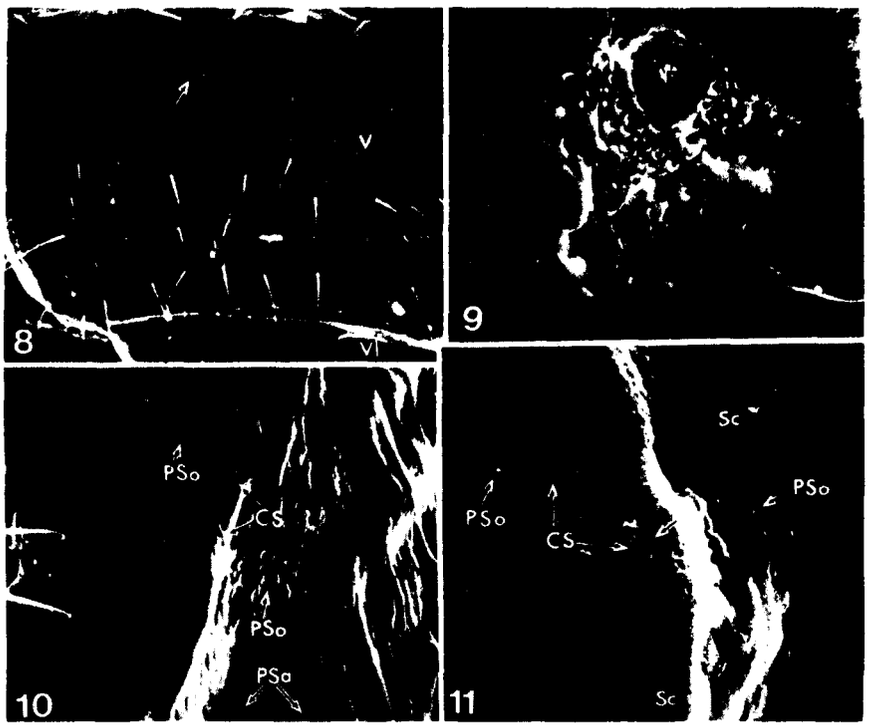

Fig. 8. *C. formosanus* worker, showing triangular depressed area (arrow) on the anterior part of sternite V. (200X)

Fig. 9. *C. formosanus* worker, 1000X magnification of the depressed area referred to in Fig. 8, showing scale-like reliefs (Sc), peg sensilla (PS), campaniform sensilla (CS) and pores (P).

Fig. 10. *C. formosanus* worker, anterior of sternite V showing campaniform sensilla (CS), acuminate peg sensilla (PS) and obtuse peg sensilla (PS). (1000X)

Fig. 11. *C. formosanus* worker, showing location of obtusely pointed peg sensilla (PS_o), one at each end of the V-arranged campaniform sensilla group (CS) on anterior of sternite V, pore (P), scale-like relief (Sc). (1300X)

were also digitiform and similar to those of workers (Fig. 16). Pores were common among the group of campaniform sensilla, in the depressed area (Fig. 16, 17), and perhaps also on the edges of some scale-like reliefs (Fig. 18).

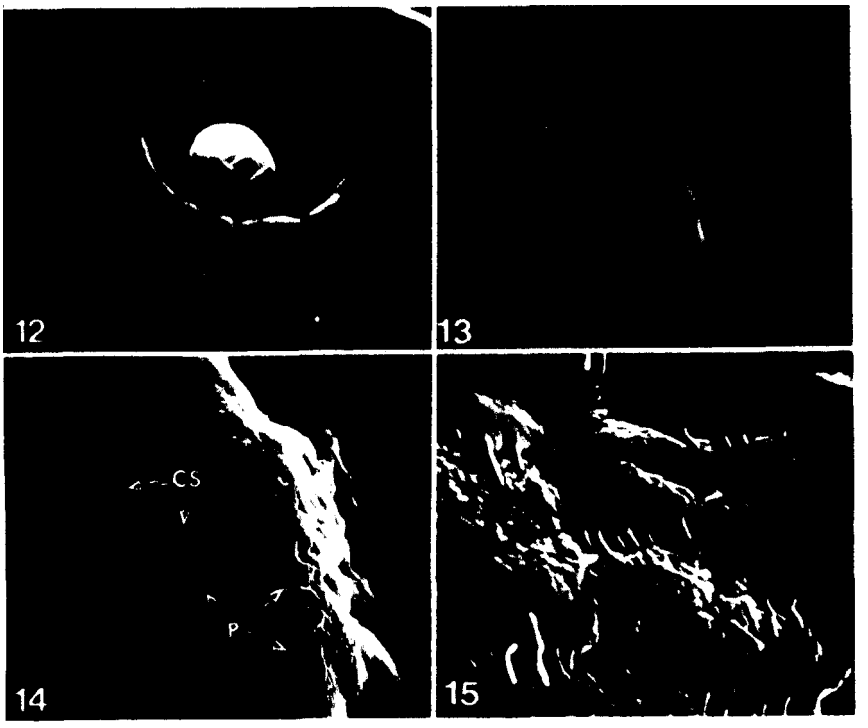

Fig. 12. *C. formosanus* worker, obtusely pointed peg sensillum with elevated socket. (20,000X)

Fig. 13. *C. formosanus* soldier, acuminate peg sensillum with socket wall flush with cuticular surface. (20,000X)

Fig. 14. *C. formosanus* worker, sternite V showing pores (P) on the mid-line of cuticular area of the gland, and posterior to the campaniform sensilla group (CS). Pores are also found along the sensilla. (3000X)

Fig. 15. *C. formosanus* worker, scale-like reliefs on the anterior part of the gland. (7000X)

2. *Reticulitermes*

R. arenincola:

Figure 20 provides a general view of sternite V of *R. arenincola.* The V-grouped campaniform sensilla, usually covered by the extension of sternite IV, were clearly visible and small circular pores were distributed along both sides of the group of campaniform sensilla (Fig. 21) and on the central ridge of the glandular cuticle (Fig. 22). The posterior area of sternite V had pectinate reliefs with single digits whereas in the anterior area,

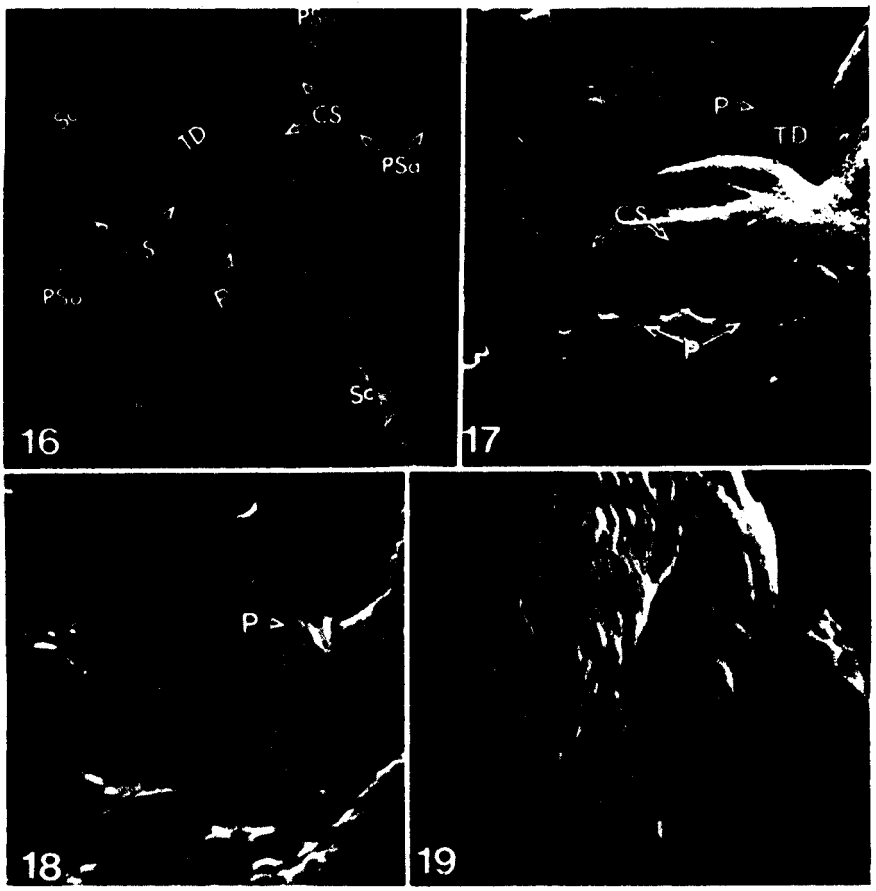

Fig. 16. *C. formosanus* soldier, center anterior sternite showing triangular depressed area (TD), anterior and posterior scale-like reliefs (Sc), V-shaped campaniform sensilla group (CS), obtuse and acuminate peg sensilla (PS_o and PS_a), and pore (P). (1500X)

Fig. 17. *C. formosanus* soldier, right side of V-shaped arrangement of campaniform sensilla (CS), with pores (P) along side of the sensilla group, and within the triangular depressed area (TD). (3900X)

Fig. 18. *C. formosanus* soldier, showing scale-like reliefs in the triangular depressed area, anteriorly on sternite V. Pores (P) on the edges of the reliefs. (13,000X)

Fig. 19. *C. formosanus* soldier, showing scale-like reliefs anteriorly on sternite V; reliefs differ greatly from those within the triangular depressed area shown in Fig. 18. (10,000X)

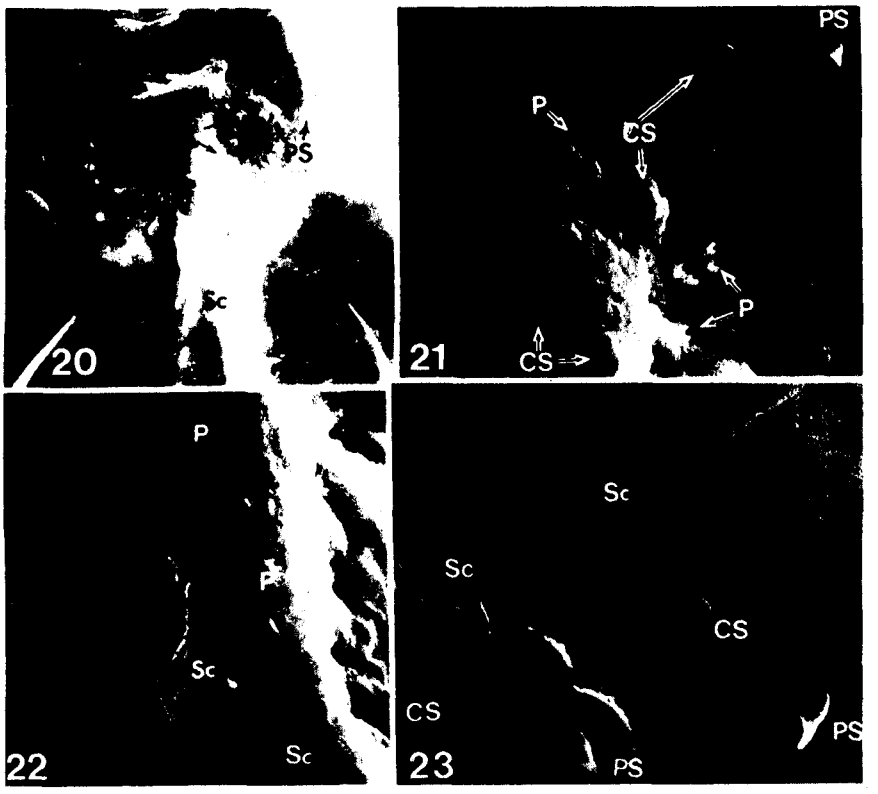

Fig. 20. *R. arenincola* worker, sternite V showing location and arrangement of campaniform sensilla (CS), peg sensilla (PS), and scale-like reliefs (Sc). (1000X)

Fig. 21. *R. arenincola,* same as Fig. 20. Detail of campaniform sensilla (CS), pores (P) along side of campaniform sensilla and peg sensillum (PS). (4000X)

Fig. 22. *R. arenincola* worker, pores (P) and scale-like reliefs (Sc) occur on the central ridge of the sternal gland. (5000X)

Fig. 23. *R. arenincola,* anterior left portion of sternal gland area, showing two obtuse peg sensilla (PS) with associated campaniform sensilla (CS) and scale-like relief patterns (Sc). (6000X)

the scales had one, two or more digits on each relief, (Fig. 23). Instead of a single prominent peg sensilla on each upper comer of the triangular area as with most species, *R. armincola* had two (Fig. 23). Acuminate peg sensilla (about 8-14 on each side) occurred on the overlapped area laterally from the midline. Such small sensilla occurred on the overlapped areas of sternites of all Rhinotermitidae observed.

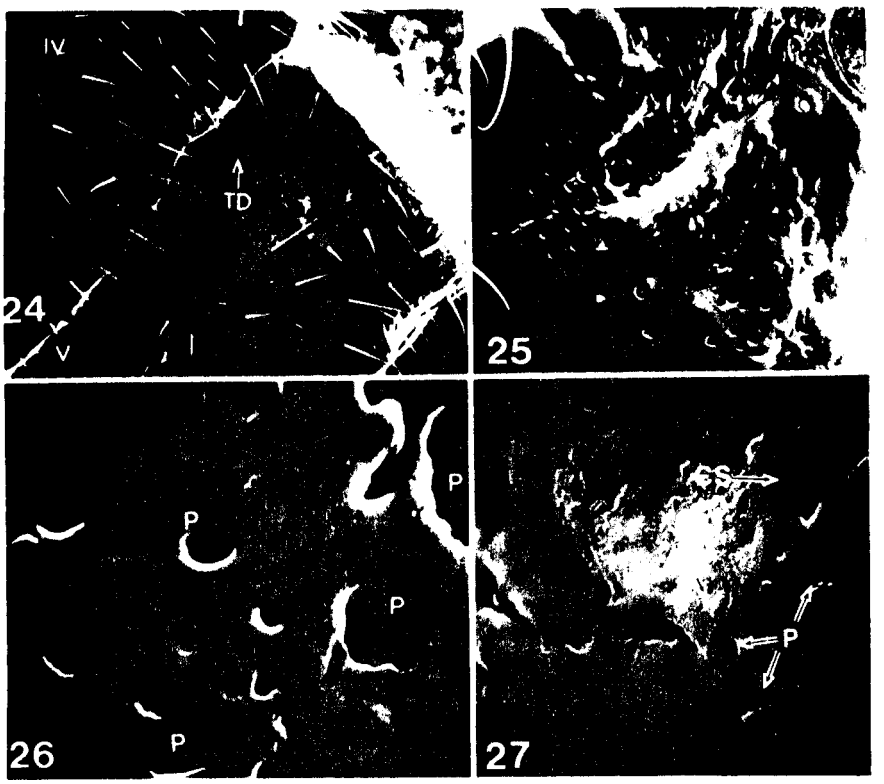

Fig. 24. *R. flavipes,* sternites IV and V in general view, showing cuticular surface and triangular depressed area (TD) of sternal gland. (234X)

Fig. 25. *R. flavipes,* detail of cuticular surface of anterior part shown in Fig. 24. Pores (P) are grouped along side of campaniform sensilla (CS) and inside the depressed triangular area, scale-like reliefs (Sc) have one to many digits. (1200X)

Fig. 26. *R. flavipes,* anterior sternal gland showing pores (P) one to many grouped inside the triangular area. (18,000X)

Fig, 27. *R. flavipes,* multiple pores (P) in depressions, and campaniform sensilla (CS) on the lower part of the triangular area. (3000X)

R. flavipes:

The triangular depressed area also occurred in *R. flavipes* (Fig. 24) with the campaniform sensilla arranged in a U-shape rather than a V-shape (Fig. 25). The two stout peg sensilla were prominent at the top of the U-grouped campaniform sensilla (Fig. 25).

Pores occurred in the depressed area (Fig. 26), along the campaniform

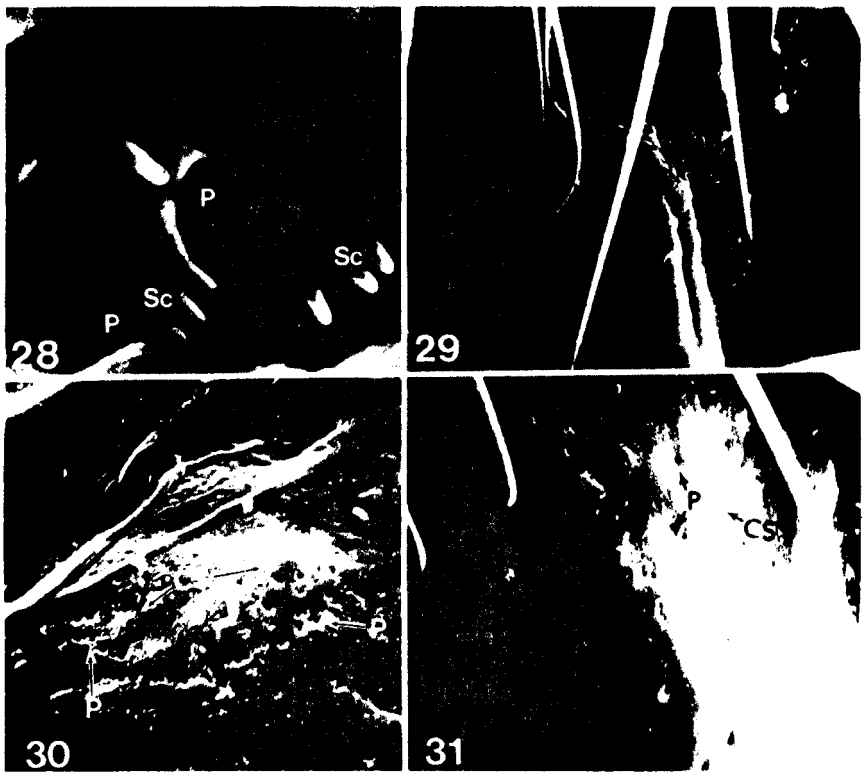

Fig. 28. *R. flavipes,* scale-like reliefs (Sc) on the anterior part of sternal gland showing pores (P) at the sides of the reliefs. (10,000X)

Fig. 29. *R. flavipes,* alate male, sternite V showing cuticular surface of sternal gland similar to that of a worker of the same species. (1000X)

Fig. 30. *R. hageni,* sternite V showing campaniform sensilla group (CS) with associated pores (P). (3000X)

Fig. 31. *R. hageni,* pores (P) inside the triangular area of sternite V. (3000X)

Fig. 35. *R. tibialis* workers, pores (P) inside the triangular depressed area (TD), along the campaniform sensilla group (CS), and also on the central ridge of the gland. (3000X)

Fig. 36. *R. virginicus* worker, showing structures on the anterior part of sternite V. Scale-like relief (Sc), peg sensilla (PS), campanifom sensilla (CS), and pres (P). (1000X)

Fig. 37. *R. virginicus,* detail of left ridge of the V-shaped area shown in Fig. 36, showing campaniform sensilla (CS), associated peg sensillum (PS), and pore (P). (3000X)

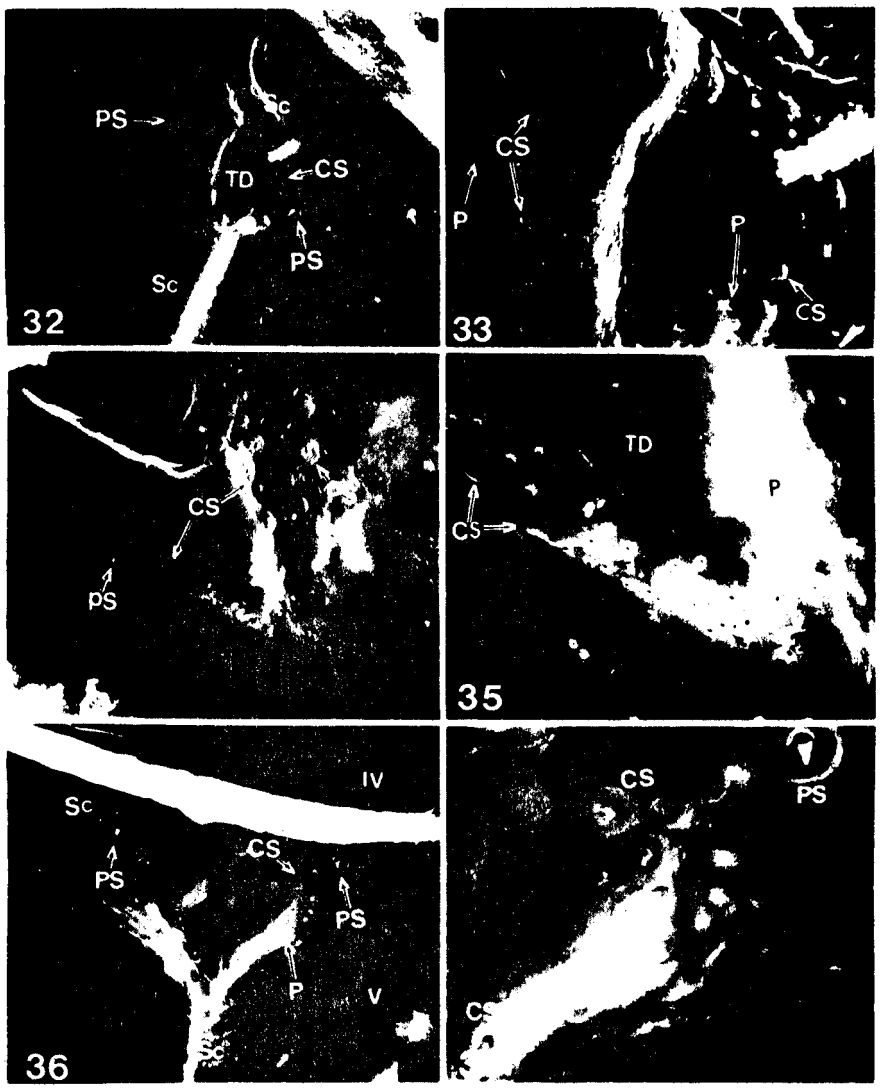

Fig. 32. *R. hesperus* worker, sternite V in general view, showing anterior and posterior scale-like reliefs (Sc), triangular depressed area (TD), campaniform sensilla (CS), peg sensilla (PS) on the cuticular surface. (1000X)

Fig. 33. *R. hesperus* worker, 3000X magnification of the triangular area shown in Fig. 32. Pores (P) occur along side of campaniform sensilla (CS).

Fig. 34. *R. tibialis* worker, cuticular surface of sternal gland segment showing V-shaped area. Peg sensilla (PS) one at each side of campaniform sensilla (CS) group. (1000X)

sensilla (fig. 27), and at the edge of the scales (Fig. 28). The pores were different from those of *C. formosanus* and the other species observed. Small pores were grouped within a shallow depressed area (Fig. 26, **27)** rather than scattered about singly. The number of small pores within the shallow areas varied from 1–10, depending on the size of the different shallow areas.

Soldiers of *R. flavipes* were not examined with the SEM however, alates were pictured. Similarity of the soldiers to the workers was confirmed with light microscope observations. The alates had sensilla, pores and scales similar to those of workers (Fig. 29).

R. hageni:

Sensilla, pores, and reliefs occurred on the cuticular areas of the anterior portion of sternite V of *R. hageni* (Fig. 30) as with other members of *Reticulitermes.* Small circular pores occurred along the side of the campaniform sensilla, on the central ridge of the gland (Fig. 30) and inside the triangular area (Fig. 31). *R. hageni* had pores in considerably larger numbers than did *C. fornosanus.*

R. hesperus:

Campaniform sensilla occur on both sides of the triangular depressed area (5 on each side). The peg sensilla, one each on the upper outer side of the V-grouped campaniform sensilla, and the pores scattered both inside the depressed area and along-side of the campaniform sensilla group (Fig. 32, 33) were all similar to those of other Rhinotermitidae examined. The scale-like reliefs, which occurred both anteriorly and posteriorly on the cuticular surface of the sternal gland (Fig. 32) were also similar.

R. tibialis:

Sternite V of *R. tibialis* (Fig. 34) had the same cuticular structures, triangular area, V-arrangement of campniform sensilla, pores and peg sensilla. The pores situated along with the sensilla and on the central ridge are shown in Fig. 35.

R. viginicius:

Sternite V of *R. virginicus* (Fig. 36) showed the position of the V-shaped area. At higher magnification, the left ridge of the triangular area of the gland showed both peg sensilla and campaniform sensilla with pores along the side (Fig. 37). The right ridge of the same specimen, tilted at a different angle, showed the same features as that on the left ridge of the triangular area (Fig. 38), indicating the symmetrical distribution of these structures. The anterior scales had pointed digits which varied in numbers and in size whereas the scales on the posterior part of the gland were more pectinate (Fig. 36).

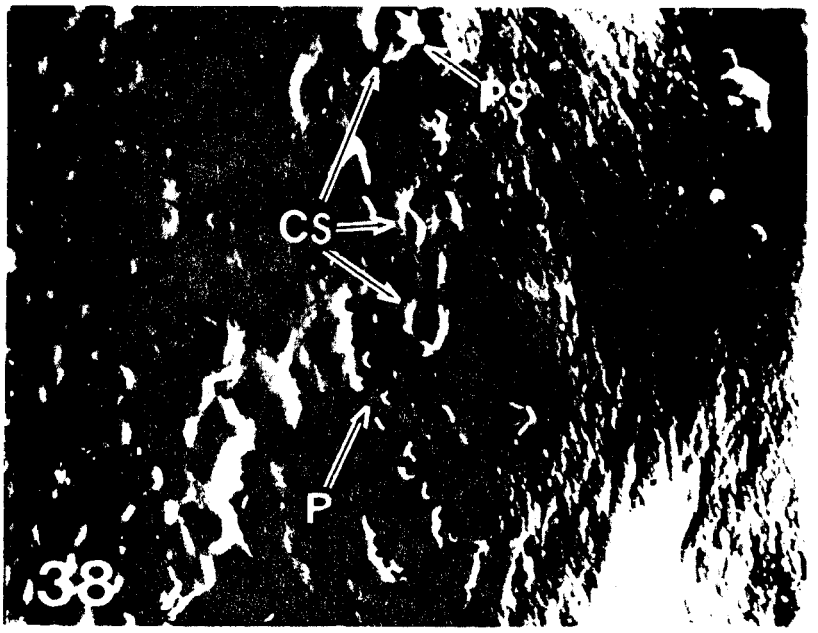

Fig. 38. *R. virginicus,* enlarged right ridge of the triangular area, showing the arrangement of peg sensilla (PS), campaniform sensilla (CS), and pores (P) somewhat symmetrical to that on left ridge shown in Fig. 37. (3000X)

DISCUSSION

1. *Location and shape of sternal gland:*

The sternal glands of R. *arenincola, R. hageni, R. hesperus, R. tibialis* and *R. viginicus* were located anteriorly in abdominal segment V and covered by the posterior extension of sternite IV. Their location is similar to that for *R. flavipes* and *C. formosanus* previously reported by Smythe and Coppel (1966) and Mertins et al. (1971) respectively.

The sternal gland consists of an anterior and a posterior part in all the termites studied. C. *formosanus* (Mertins et al., 1971), *R. flavipes* (Smythe and Coppel, 1966) and *R. lucifugus* (Mosconi-Bernardini and Vecchi, 1964) also contain a sternal gland of two parts. It may be safe to assume that all Rhinotermitidae have their sternal glands divided into anterior and posterior portions. However, the shape of the sternal gland may not be family specific. In Hodotermitidae, the shape of the sternal gland is not unique within the family, since the gland of *Z. nevadensis* is individualized (Stuart and Satir, 1968), whereas *A. ochracens* possesses a sternal gland with two parts (Noirot, 1969).

Table 1. Chronological arrangement of references to termites with campanifom sensilla on cuticle of sternal gland segments

Termite Species	Type of Study	Author	Year
Z. nevadensis	Histology	Stuart	1963
R. lucifugus	Histology	Mosconi-Bernardini & Vecchi	1964
Kalotermes	TEM*	Noirot & Noirot-Timothee	1965b
Nasutitermes	TEM	Pasteels	1965
R. flavipes	Histology	Smythe & Coppel	1966
C. flavicollis	TEM	Quennedey & Noirot	1968
Z. nevadensis	TEM	Stuart and Satir	1968
C. flavicollis	TEM	Quennedey	1969
C. formosanus	Histology	Mertins et al.	1971
K. flavicollis	TEM	Quennedey	1971a
R. santonensis	TEM	Quennedey	1971b
T. geminatus	TEM	Quennedey	1972

*Transmission Electron Microscopy

2. *Sensilla:*

More than two kinds of sensilla, namely : campaniform sensilla and 2 types of peg sensilla, previously undescribed, were found on the sternal gland segments of Rhinotermitidae. Sensilla were reported on the cuticular surface of the sternal glands of some termites, however, campaniform sensilla were the only type reported by these authors (Table 1) except for Lebrun (1971, 1972).

Mosconi-Bernardini and Vecchi (1964), Smythe and Coppel (1966) Mertins et al (1971) and Quennedey (1971b) studied *R. lucifugus, R. flavipes, C. formosanus* and *R. santonensis* respectively and suggested the presence of campaniform sensilla on the sternal gland segments of these Rhinotermitidae. Our study shows clearly the presence of sensilla on the exocuticular surface of the gland segments of the termites. The following features were common to all the Rhinotermitidae studied: **(1)** There are two kinds of sensilla on the exocuticle of the sternal gland segment, campaniform sensilla and peg sensilla; **(2)** The campaniform sensilla are

always present in a group, 10 to 18 in number, average 14 in most species examined; (3) The group of campaniform sensilla is located anteriorly at the mid-portion of the sternal gland, and the sensilla are arranged in a V- to U-shape. (4) Two types of peg sensilla occur on the cuticular surface of sternite V; an obtuse peg sensillum with an elevated socket, and an acuminate peg sensillum with socket flush with cuticular surface. (5) The number of obtuse peg sensilla is generally two, whereas the number of acuminate peg sensilla is 10 or more. (6) The two obtuse peg sensilla are always located at the upper corner of the V-group of campaniform sensilla, one on each side, whereas the acuminate peg sensilla are scattered laterally and posteriorly from the sternal gland area. (7) Both campaniform sensilla and the obtuse peg sensilla stain with acid fuchsin, the acuminate peg sensilla do not. (8) The sensilla are present in all castes and all species of Rhinotermitidae included in this study.

Campaniform Sensilla:

The campaniform sensilla-like cuticular domes that Mertins et al. (1971) assumed to be the campaniform sensilla of the sternal gland of *C. formosanus* may in fact be campaniform sensilla. They stated that the cuticular domes were on either side of the midline, posterior to the anterior portion of the gland. Their observations are corroborated in this study. The group of campaniform sensilla lies along the lateral sides of the triangular area which is located centrally and anteriorly on sternite V of *C. formosanus.*

Although Smythe and Coppel (1966) did not confirm the presence of campaniform sensilla for the sternal gland of *R. flavipes,* it is very possible that the "ill-defined cuticular structures at the apex of the anterior hump of the gland" they described is part of the V-shaped campaniform sensilla group observed in this study. The campaniform sensilla-like processes occurring on the posterior portion of the gland (Smythe and Coppel, 1966) may probably be peg sensilla. They are scattered laterally and posteriorly from the gland (Fig. 3).

The campaniform sensilla on the sternal gland were always found in close proximity to the pores, suggesting a relationship to the release of trail following pheromone. Campaniform sensilla are the innervated domes set in the cuticle, according to Wigglesworth (1974). They are stimulated by pressure or by the bending of the cuticle, and report the strains set up in the cuticle. Perhaps they also determine the amount of pheromone deposited during trail laying.

Peg sensilla:

The number of obtuse peg sensilla is generally two, as mentioned above, however, as an exception, four obtuse peg sensilla, two on each side, were found atop the campaniform sensilla group in *R. armincola.* The difference in the number of obtuse peg sensilla in *R. armincola* may be

of taxonomic importance to separate this species from other members of Reticulitermes.

The two different peg sensilla with distal processes located anteriorly on sternite V may be thick-walled or thin-walled sensilla basiconica (Snodgrass, 1935). The acuminate peg sensilla can be differentiated from the obtuse peg sensilla not only by their socket characteristics and smaller size, but also because they do not stain with acid fuchsin as do the obtuse peg sensilla. Slifer (1954) stated that thick-walled chemoreceptors of insects were penetrated by stain when a solution of acid fuchsin was applied to the external surface, whereas the thin-walled chemoreceptors remained uncolored.

The obtuse peg sensilla take up stain similar to the campaniform sensilla and may have some function in the act of pheromone release. They occur only on the sternal gland segment which suggests their involvement in trail pheromone desposition, possibly the occlusion of the overlapping sternite over the pores of the termites. Acuminate peg sensilla are also present on the overlapped area of the other sternites, but much fewer in number than those on the sternal gland segment.

3. *Exocuticular pores:*

The only other study that observed the pores directly from the outer cuticle was that of Lebrun (1972). Based on SEM data, he noticed that isolated or groups of pores occurred on the posterior zone of the sternal gland of *R. lucifugus* var. *santonensis.* In our study the pores are on the anterior zone of the sternal gland.

Pores are unquestionably present on the sternal gland sements of *R. arenincola, R. flavipes, R. hageni, R. tibialis, R. virginicus,* and *C. formosanus.* Without exception, the pores are located at the triangular area within and along the V-grouped campaniform sensilla and on the central ridge of the sternal gland. The pores associated with the campaniform sensilla group are believed to provide the orifices through which the trail pheromone is secreted from the sternal gland. Smythe and Coppel (1966) and Mertins et al. (1971) suggested that the trail substance probably escaped through the cuticle in the anterior part of the gland.

During preparation of a whole mount of the Formosan subterranean termite, it was noticed that air bubbles were escaping from the triangular depressed area, (where the pores occur) on abdominal segment V. The specimen was treated with 10% KOH for 2 days, at which time the sternal gland was visible externally from a lateral view. The air bubbles were observed under the microscope when the specimen was transferred from 75% alcohol (5 min) into Hoyer's mounting medium.

The pores that lie alongside the campaniform sensilla group are recognizable even with the light microscope although they are somewhat unclear. Pores were clearly visible under SEM. No effort was made to see

Table 2. Type of scales found on the sternal gland segments of Rhinotermitidae

Termite	*Type of scale on sternal gland segment Anteriorly	Posteriorly	Fig. #
C. formosanus worker	digitiform, palmate & pectinate	pectinate	9,11,15
C. formosanus soldier	digitiform & palmate	pectinate	16,17,18,19
R. arenincola	digitiform & palmate	digitiform	20,22,23
R. flavipes	digitiform & palmate	--	25,28
R. hesperus	digitiform & palmate	pectinate	32,33
R. tibialis	digitiform & palmate	digitiform	34
R. virginicus	digitiform, palmate & pectinate	pectinate	36

*Digitiform: Finger-like
Palmate: Resembling a hand with fingers spread
Pectinate: Having narrow parallel projections, or like teeth of a comb

how deep pores penetrated, however, Mertins et al. (1971) indicated that some of their histological sections were tranversed by numerous ductules which appeared to connect the lumen to the external space between sternites IV and V. The ductules appeared on the midline of the sternal gland, whereas the cuticular domes were on either side of the midline.

The pore arrangement for *R. flavipes* was somewhat different from the other species observed. There were small pores (1 - 10) within a depressed shallow area. The number inside the shallow area varied. Pores of other species examined were individually located. The apertures of the pores and the intervals between the pores were irregular.

4. *Scale-like reliefs on the cuticular surface of the sternal gland segments:*

Different types of scale-like reliefs are found anteriorly and posteriorly on the sternal gland segments of the Rhinotermitidae studied. These are summarized in Table 2.

Two or more types of scale-like reliefs are found anteriorly on the sternal gland segment, whereas a single type of relief is present posteriorly. The role of the scale-like relief is not known. Scales were found on the outer cuticle of *R. lucifugus* var. *santonensis* (Lebrun, 1972). Reviewing Lebrun's data on the reliefs, Quennedey (1975) indicated that they do not have a role in depositing the trail pheromone because the

previous sternite overlaps the gland surface entirely during trail laying.

A few scale-like reliefs appear to have pores (Fig. 28) somewhat similar to the glandular epithelium on the posterior abdominal tergites of Blatta *orientalis* (Plattner et al., 1972). These authors indicated that the pores were connected to inner secretion cells. Whether the pores shown as part of the scale-reliefs of *R. flavipes* are connected to inner secretion cells remains unanswered.

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