SOME ULTRASTRUCTURE OF THE HONEYBEE (APIS MELLIFERA L.) STING

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SOME ULTRASTRUCTURE OF THE HONEYBEE (*APIS MELLIFERA* L.) STING

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ABSTRACT

Sensory pegs, hair plates, and campaniform sensilla associated with the sting of the honeybee (*Apis mellifera* L.) are described and illustrated via scanning electron microscopy. These sensory receptors are likely external proprioceptors and their presence further elucidates the function of the honeybee sting. The topographical ultrastructure of the stings of honeybee queens and workers is compared.

INTRODUCTION

The sting of the honeybee (*Apis mellifera* L.) is a defensive organ which is structurally homologous to the ovipositor of Orthoptera, Hemiptera, and nonstinging Hymenoptera. The retracted sting apparatus lies within the sting chamber formed by the infolding of the 8th and 9th abdominal segments into the 7th abdominal segment and is covered by the sting sheath (SNODGRASS, 1956; DADE, 1962). The comparative morphology of the sting barbs in the genus *Apis* is presented by WEISS (1978). Some sensory receptors associated with the stings of certain Hymenoptera, including *A. mellifera,* have been described by various authors (HERMANN and DOUGLAS, 1976 a). However, the honeybee sting has not been fully nor accurately described. Here we illustrate and compare the external fine structure of the sting apparatus of worker and queen honeybees.

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MATERIALS AND METHODS

Queen and worker honeybees were collected from the hive, killed and preserved in 70 % ethanol. The stings were removed and dissected in 70 % ethanol. After dehydration through a graded series of ethanol (20 min each in 70, 80, 90, 100 %), the specimens were dried in a Denton Critical Point Drying Apparatus, mounted on aluminium stubs with silver conducting paint, and coated with a thin layer of gold-palladium in a Denton vacuum evaporator. The specimens were viewed in a JOEL JSM-U 3 scanning electron microscope and photographed with polaroid type 55 positive/negative film.

RESULTS AND DISCUSSION

The stings of queen and worker honeybees differ in size and shape (Fig. 1 A, B).

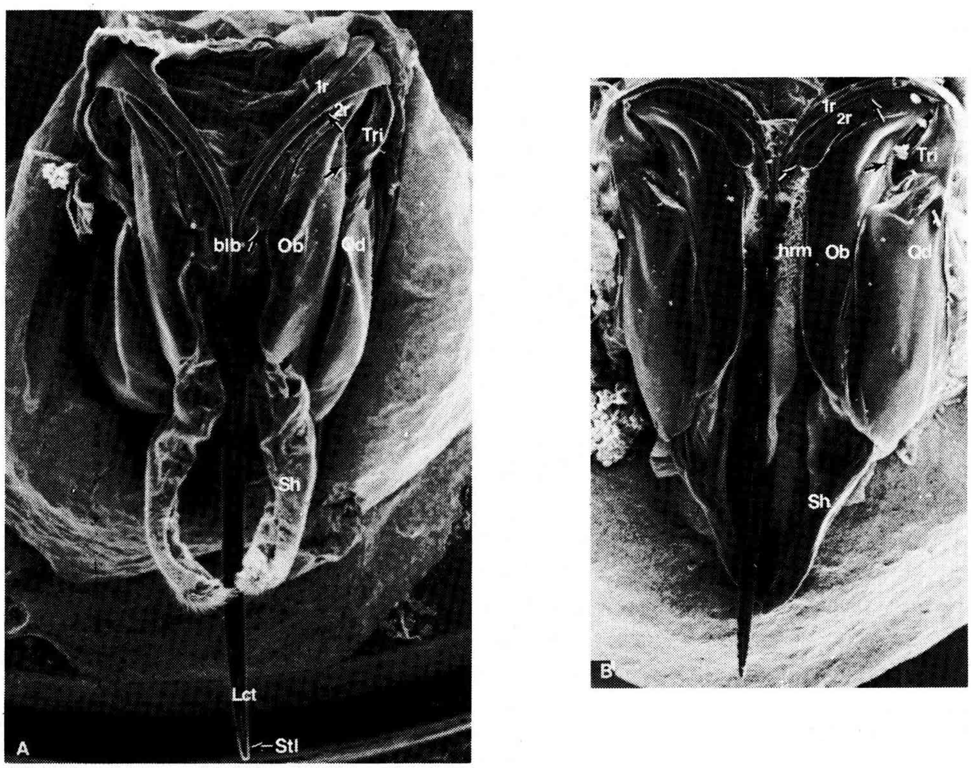

FIG. 1 A. — *The sting apparatus of a queen, ventral* (× 50).
1 B. — *The sting apparatus of a worker, ventral* (× 50) (arrows point towards proprioceptor sites).

SYMBOLS (1)
USED IN THE FIGURES

blb	: bulb of stylet	Qd	: quadrate plate	Vlv	: valve on lancet
hrm	: hairy membrane	Sh	: sting sheath	1 r	: first basal rami (lancet)
Lct	: lancet	Stl	: stylet	2 r	: second basal rami (stylet)
Ob	: oblong plate	Tri	: triangular plate		

(1) Abbreviations after SNODGRASS, 1956.

The sting of the queen is larger, measuring approximately 3 mm in length compared with 2.3 mm for the worker. The distal barbs on the lancets and stylet of the queen sting (Fig. 2 A, B; 3 A, B) are less pronounced than those of the worker (Fig. 2 C, D; 3 C, D). When viewed *ventrally* (Fig. 1), the left and right oblong (Ob) and quadrate (Qd) plate assemblies partially overlap the central portion of the sting shaft and are set on a more acute angle in the queen than in the worker. The entire sting apparatus of

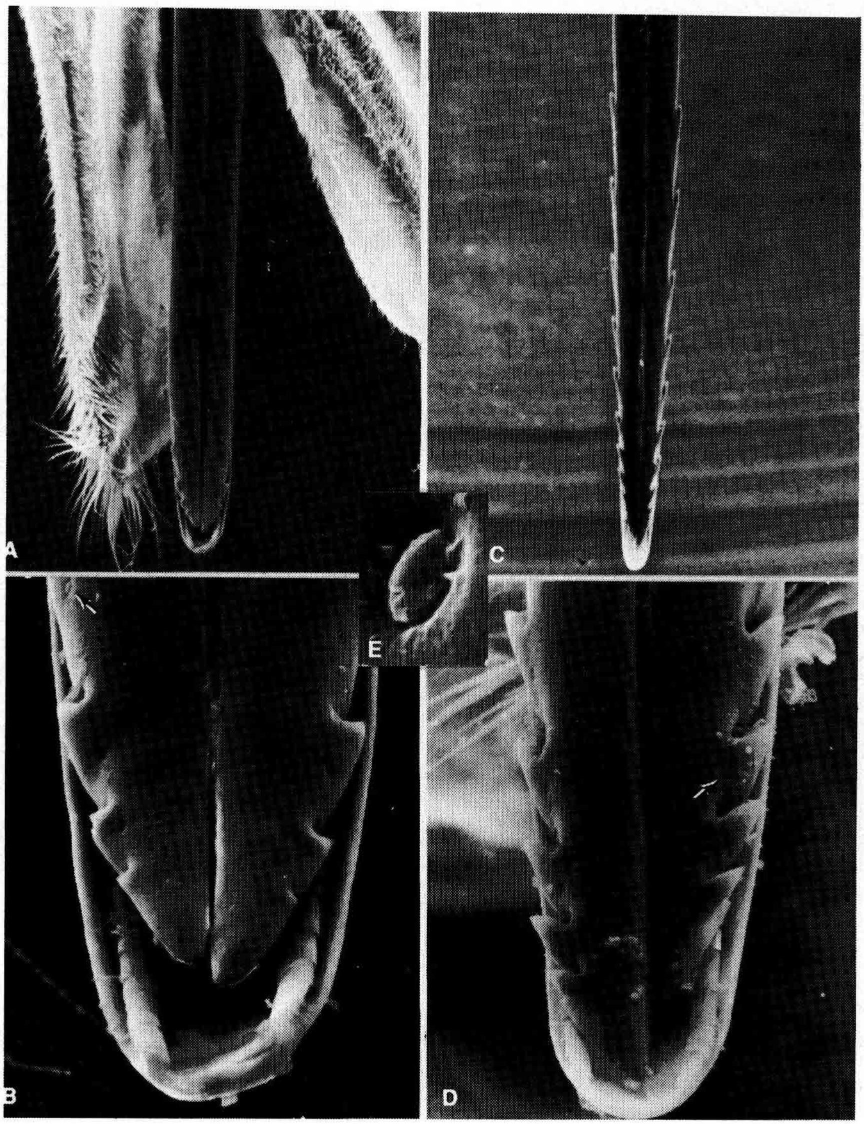

FIG. 2. — *The tip of the stylet and two barbed lancets.* Queen, A (× 150), B (× 300), Worker C (× 150), D (× 300), probably campaniform sensillum, E (× 10,0000).

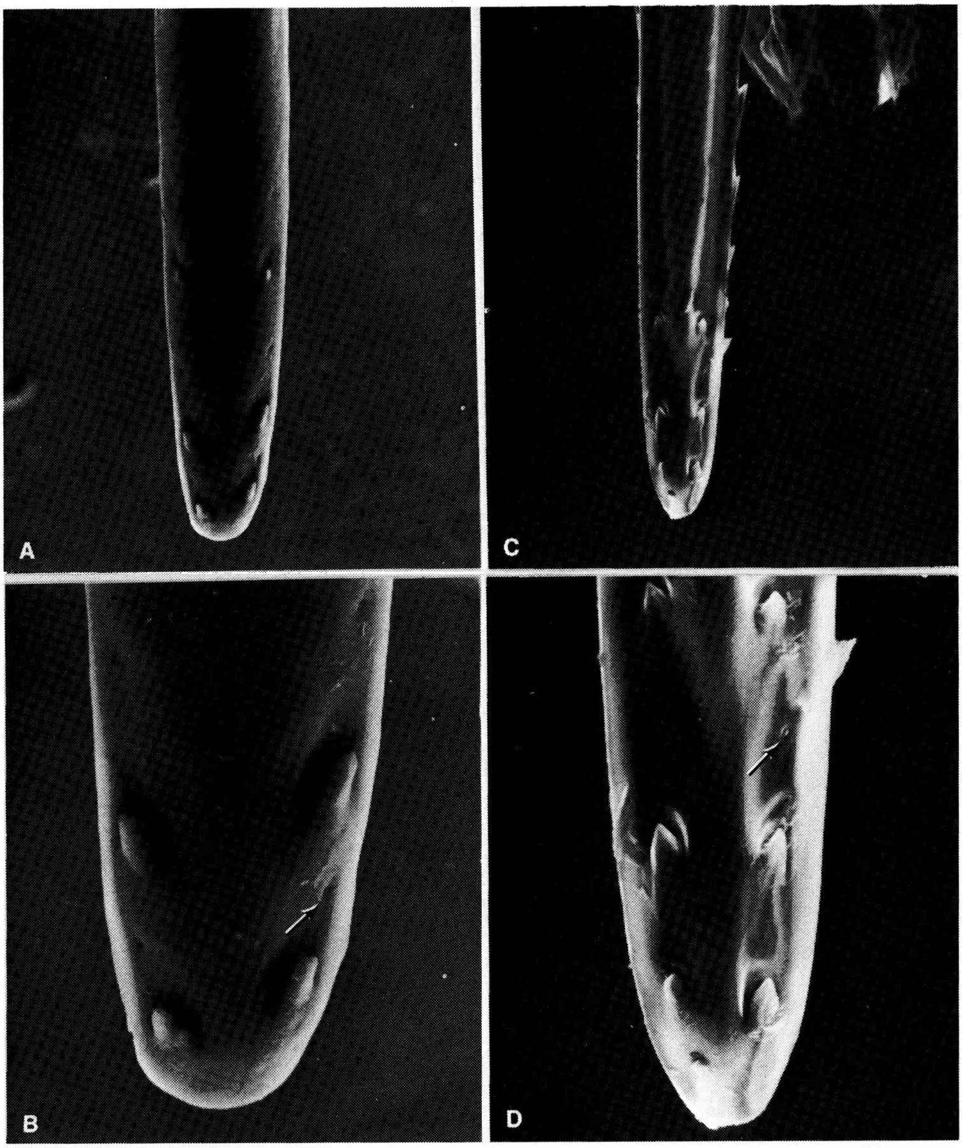

FIG. 3. — *The tip of the stylet,* Queen, A (× 150), B (× 300), Worker C (× 150), D (× 300).

the worker is shorter, broader, and more compact. A pilose (hairy) membrane (hrm) attached to the oblong plate covers the shaft dorsally (Fig. 4 A, C).

The Sting

The shaft is composed of a stylet (Stl) and two barbed lancets (Lct) encased in a membraneous sheath (Sh) that, according to SNODGRASS (1925; 1956) is presumed to

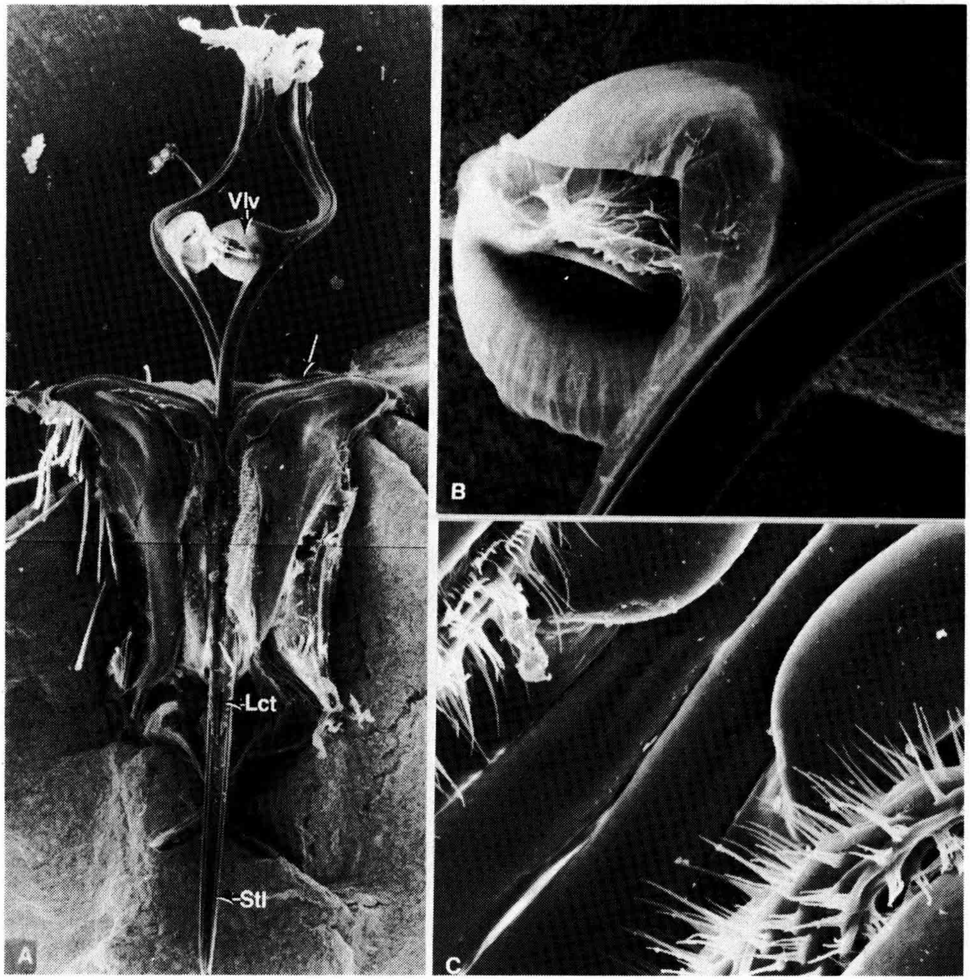

FIG. 4 A. — *Ventral view of a sting with the quadrate and triangular plates removed, the first rami and lancets were pulled forward and twisted 180° in order to show the valve and the hair plate located on the surface of the second rami, queen* (× 50).
4 B. — *The lancet valve, Queen* (× 330).
4 C. — *A ventral view of the pilote membrane covering the bulb of sting, worker* (× 500).

function in part as a proprioceptor (a sense organ that continuously registers movement, weight or other mechanical forces) for the sting (Fig. 1 and 2 A). In some Hymenoptera nerves have been seen in the lumen of the stylet (HERMANN and DOUGLAS, 1976 a). Pressure sensitive receptors, probably campaniform sensillae (Fig. 2 E) (see HERMANN and DOUGLAS, 1976 a) are present on the sting lancets and stylets of both queen and worker bees. We have determined that one such sensillum is associated with each of the barbs except those distal (Fig. 2 and 3). These do not appear to be chemoreceptors as described by KING and FORDY (1970).

The stylet has a track along each side on which the lancets slide. These are shown in Figure 4 wherein the lancets have been twisted to expose their channels, which engage the stylet tracks. Below the valves (v/v) the lancets (Fig. 4 B) close on the grooved stylet to form the venom channel (See also SNODGRASS, 1956).

At each side of the basal one half of the shaft is a series of ventral plates partially covering the shaft (Fig. 1). The oblong plate, adjacent to the shaft, is partially covered by the quadrate plate and ventrally joined to it by the triangular plate (Tri) that functions as a hinge between the two. The distal end of the oblong plate extends into the long membraneous sheath surrounding the lancets.

At their bases, the lancets each terminate in a ramus (1 r) and the stylet in a left and right ramus (2 r) (see Fig. 1). These rami interlock via the extension of the stylet track and lancet channel. In addition a groove in 2 r (adjacent to the track) accepts the curved posterior surface of 1 r. Both the lancet channel and the stylet track are finely serrated (Fig. 5 and 6) to reduce friction and are unbroken in the natural state,

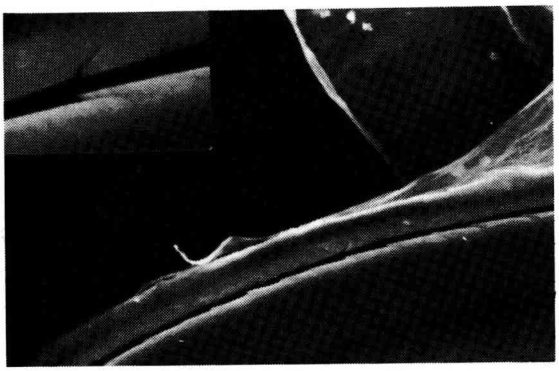

FIG. 5. — *The serrated lancet channel of the queen sting* (× 560), *inset, close-up view* (× 1,860).

not broken as noted by DADE (1962). The first ramus connects apically with the anterior corner at the triangular plate. The second ramus connects the anterior end of the oblong plate (SNODGRASS, 1956).

Sensilla Trichodea

The mechanoreceptor fields (hair plates) described probably function either (1) in the defensive positioning of the sting and/or (2) for detecting the alternating thrusts of the lancets during insertion of the sting. The first of these sensory fields is located on the second ramus at the ventral edge of the groove (Fig. 1, 6 A, B, C). This aggregation of sensilla consists of about 20 socketed setae (hairs) in both queens and workers. Figure 6 B shows the hairs engaging the first ramus; in Figure 6 C the first ramus has been removed.

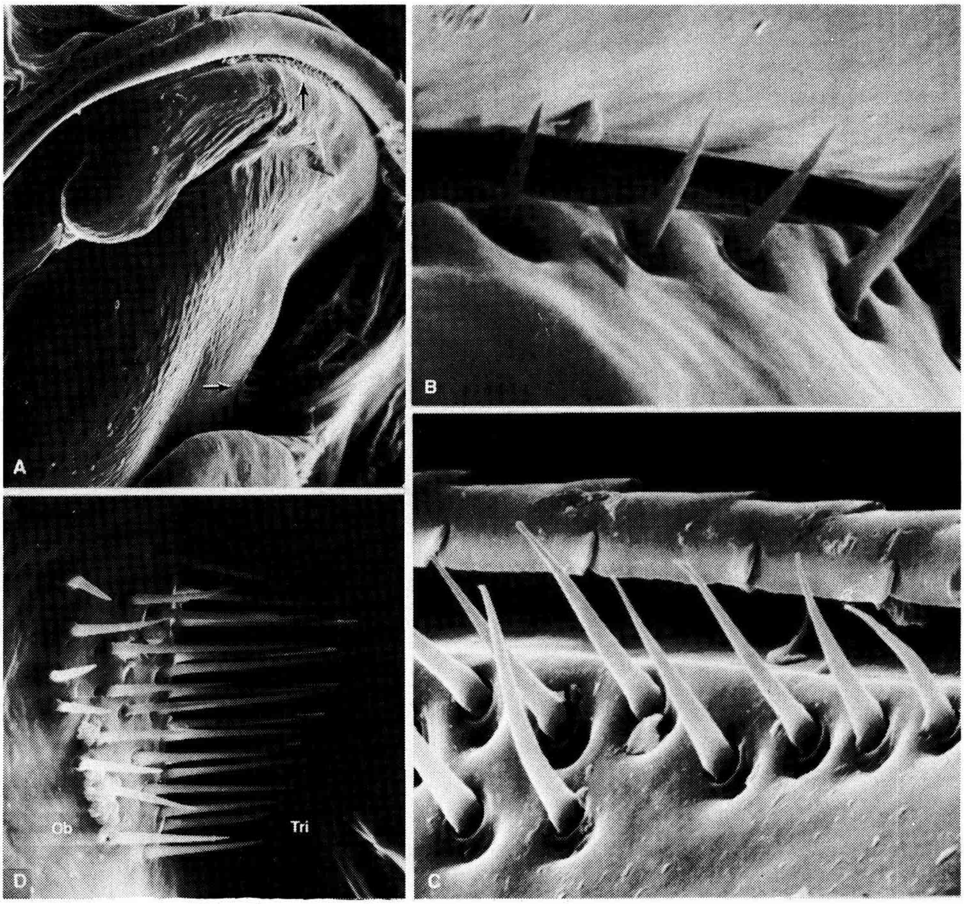

FIG. 6. — *Ventral view of the basal area of the queen sting.*
6 A. — *First and second ramus* (× 130).
6 B. — *Hair plate engaging first ramus* (× 1,800).
6 C. — *Hair plate with first ramus removed and track exposed* (× 2,790).
6 D. — *Hair plate on anteriolateral edge of the oblong plate* (× 1,000).

The second hair plate is located on the anteriolateral edge of the oblong plate directly beneath the triangular plate (Fig. 1; 6 A, D). There are 28-30 socketed setae on this receptor site in the queen (Fig. 6 D) and 21-23 in the worker (Fig. 7). Figure 7 shows this (likely) mechanoreceptor field engaging the triangular plate. A third field on which the sensilla are more peg-like is located posterior to the first plate on 2 r in the region of the sting bulb (blb) (Fig. 8).

Similar plates bearing sensory hairs or pegs have been reported from studies on other Hymenoptera (CALLAHAN *et al.*, 1959; HERMANN and BLUM, 1966, 1967 a, b, 1968; and HERMANN and DOUGLAS, 1976 a, 1976 b). However, the ones we report on the honeybee differ in setal length and number from those on other genera.

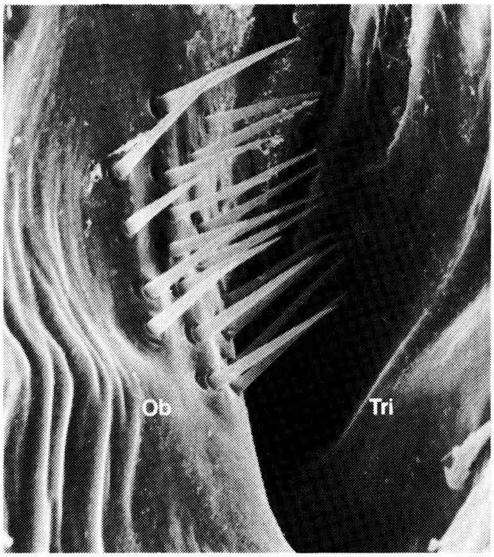

FIG. 7. — *The hair plate found on upper edge of oblong plate near the triangular plate, worker* (× 1,000).

According to SNODGRASS (1956) and DADE (1962), after an initial thrust, further penetration of the sting involves the contraction of two pairs of antagonistic muscles. The alternating contraction of these muscles on each side of the sting pulls the respective quadrate plates forward or backward relative to the position of the oblong plate. The triangular plates serve as a hinge, transmitting movement from the quadrate plate toward the first ramus and causing the corresponding lancet to retract or protract. After every thrust, each lancet holds its position by its recurved barb-like teeth ar the tip, thus effecting deeper and deeper penetration. With each contraction, venom is pumped into the wound. While making our preparative dissections we found that slight pressure applied to the beneath the arrows in Fig. 8 A, 8 C causes exsertion of the lancets (See also Fig. 1, area = lower end of 2 r).

The hair plates that we found, located on the movable parts of the sting apparatus, are probably proprioceptors detecting and informing the bee of the relative positions of the triangular plate, oblong plate, and first and second rami. Thus, the hair plates on 2 r, which engage 1 r, probably detect the thrusting of the lancet while the receptors on the oblong plate and posterior lobe of 2 r may in addition to thrusting detect either the angle or extent of protaction of the sting (See also Fig. 62, p. 162, SNODGRASS, 1956). The campaniform sensilla probably detect the depth of sting insertion by assaying the increasing cuticular deformation (of the victim) that might come about with successively deeper penetrations.

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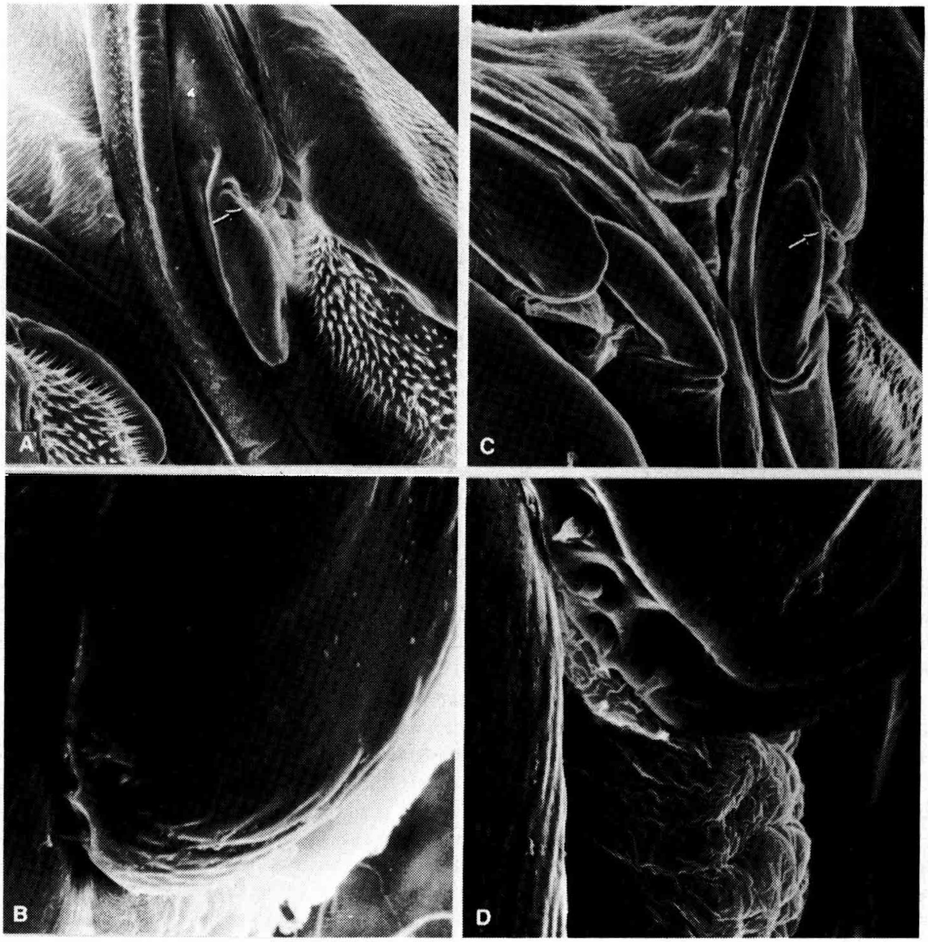

FIG. 8. — *The hair plate found on a hinged portion of the second ramus* (see also Fig. 1). Queen, A (× 150), B (× 1,800). Worker, C (× 150), D (× 1,500).

RÉSUMÉ

ULTRASTRUCTURE DE L'AIGUILLON DE L'ABEILLE (*APIS MELLIFICA* L.)

L'appareil vulnérant de l'abeille domestique (*Apis mellifica* L.), lorsqu'il est en position rétractée, est situé dans la chambre de l'aiguillon, formée par l'invagination des 8^{e} et 9^{e} segments abdominaux dans le 7^{e} segment abdominal, et recouvert par la gaine de l'aiguillon. Divers auteurs ont déjà décrit certains récepteurs sensoriels liés aux aiguillons de certains Hyménoptères, dont *Apis mellifica*, néanmoins l'aiguillon de l'abeille domestique n'a pas été décrit dans sa totalité ni avec précision.

On a extirpé et disséqué les aiguillons de reines et d'ouvrières. Après déshydratation on les a séchés, montés et enduits, puis observés au microscope électronique à balayage et photographiés.

L'aiguillon de la reine est plus gros, les barbes distales des soies barbelées et du stylet moins prononcées que chez l'ouvrière. L'appareil vulnérant total de l'ouvrière est plus petit, plus large et plus compact. Sur les soies barbelées et les stylets des reines et des ouvrières on a mis en évidence des récepteurs sensoriels de pression, probablement des sensilles campaniformes. Une sensille est associée à chacune des bardes sauf les plus distales. On a trouvé des propriocepteurs sur diverses parties mobiles de l'appareil vulnérant et leur aspect diffère selon les castes. Le stylet possède un rail denté sur chaque côté duquel glissent les soies barbelées.

Le canal de la soie barbelée et le rail du stylet sont tous deux finement dentés (pour réduire le frottement vraisemblablement) et sont continus à l'état naturel. Les champs de mécanorécepteurs (propriocepteurs) décrits servent probablement (1) à placer l'aiguillon en position défensive et/ou (2) à détecter les poussées alternatives des soies barbelées pendant l'insertion de l'aiguillon. Il semble que les sensilles campaniformes détectent la profondeur de l'insertion de l'aiguillon en testant la déformation cuticulaire croissante (de la victime) qui peut se produire suite aux pénétrations de plus en plus profondes de la victime.

ZUSAMMENFASSUNG

ZUR ULTRASTRUKTUR DES STACHELS DER HONIGBIENE (*APIS MELLIFERA* L.)

Der eingezogene Stachelapparat der Honigbiene liegt innerhalb der Stachelkammer, die durch die Einstülpung des 8. und 9. Abdominalsegments in das 7. Abdominalsegment gebildet wird; er wird von den beiden Stachelscheiden bedeckt. Von verschiedenen Autoren wurden bei einigen Hymenopteren, einschliesslich *Apis mellifera*, Sinnesrezeptoren beschrieben, die mit dem Stachel in Verbindung stehen. Der Stachel der Honigbiene wurde jedoch bisher weder vollständig noch genau untersucht.

Die Stachelapparate von Königinnen und Arbeiterinnen wurden herausgelöst und präpariert. Nach Entwässerung wurden die Präparate getrocknet, montiert und bedampft. Die Präparate wurden dann unter einem Rasterelektronenmikroskop betrachtet und photographiert.

Der Stachel der Königin ist grösser, und die distalen Widerhaken an den Lanzetten (Stechborsten) und dem Stilett (Stachelrinne nach Zander) sind weniger ausgeprägt als bei den Arbeiterinnen. Der gesamte Stachelapparat der Arbeitsbiene ist kürzer, breiter und kompakter. Druckempfindliche Rezeptoren, vermutlich kampaniforme Sensillen, sind an den Lanzetten und Stiletten sowohl der Königin wie der Arbeitsbienen vorhanden. Ein solches Sensillum ist mit jedem der Widerhaken verbunden, ausgenommen die am weitesten distalen. Haarplatten wurden an verschiedenen beweglichen Teilen des Stachelapparates gefunden, mit Unterschieden zwischen den Kasten. Das Stilett besitzt an jeder Seite eine gezahnte Schiene, an welcher die Lanzetten entlanggleiten.

Sowohl der Lanzettenkanal wie die Schiene des Stiletts sind fein gezackt (vermutlich um die Reibung zu verringern) und im natürlichen Zustand nicht unterbrochen. Felder von Mechanorezeptoren (Haarplatten), die beschrieben werden, haben wahrscheinlich eine Funktion entweder 1.) bei der Einnahme der Verteidigungsstellung des Stachels und/oder 2.) bei der Orientierung über das wechselseitige Vorschieben der Lanzetten während der Einpflanzung des Stachels.

Die kampaniforme Sensille stellt wahrscheinlich die Tiefe der Einführung des Stachels fest, indem sie die wachsende kutikulare Deformierung (des Opfers) prüft, die mit dem zunehmend tieferen Eindringen in das Opfer entstehen kann.

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