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Scanning electron microscopic studies of antennal sensilla of adult worker *Apis florea* F (Hymenoptera: Apidae)

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Summary — The micromorphology of the antennae of the honey bee *Apis florea* F was studied. The number and distribution of the various types of sensilla were examined. Sensilla observed were sensilla placodea, basiconica, trichodea, ampullacea, coeloconica and campaniformia. Sensilla trichodea were found most frequently and were present on all the antennal segments. Sensilla placodea and sensilla basiconica were present on 8 distal segments. Sensilla ampullacea and sensilla coeloconica were present on 5 distal segments while sensilla campaniformia were confined to 7 distal segments. The highest density of sensillae was found on the distal antennal segment. The distribution of different types of sensilla on the antenna resembled that described for other *Apis* species.

***Apis florea* / antenna / sensilla / morphology / SEM**

INTRODUCTION

The honey bee, *Apis florea* F acts as a pollinating agent of some crops in the hot climates of the Indian sub-continent (Rahman, 1940; Rauala, 1972). This paper presents an initial study of the olfactory system of this insect.

The antennae are the main sites of olfactory receptors in most insects (Wigglesworth, 1965). Scanning electron microscopic (SEM) studies of worker honey bees, *Apis mellifera*, have been carried out earlier (Slifer and Sekhon, 1960; Slifer, 1970; Dietz and Humphreys, 1971) and also on many other Hymenopterans

(Norton and Vinson, 1974; Argen, 1977, 1978).

This study describes the types and distribution of sensilla on the antennae of *Apis florea* F workers as revealed by SEM (the first being undertaken by Gupta, 1986) and compares these results with other studies in the literature. The major objective of this work was to examine the external aspects of various sensilla and their distribution pattern. This information will be useful at a later stage in conducting physiological studies associated with behaviour to determine whether morphologically similar structures have been homologized within different taxa.

MATERIALS AND METHODS

Specimens were collected from fields located near Haryana Agricultural University during March 1981.

The antennae of *A. florea* worker bees were clipped, air-dried over silica gel and mounted on aluminium stubs with adhesive tape and silver glue. The preparations were coated under vacuum with a 35-nm layer of pure gold in a sputter coating unit. The antennae were viewed and photographed using a Phillips PSEM 501 B at an accelerating voltage of 7.2 kV.

Counts of sensilla were made directly from the SEM video monitor. The side of the antenna against the head was defined as the upper side and the side away from the head as the under side. The segments starting from the proximal to distal end of the antenna were designated as Se_1 , Se_2 and so on.

RESULTS

The antenna of worker bees of *A. florea* had 10 segments. Its length varied from 3.0–3.5 mm. The last segment had a blunt roundish end. The distribution of different types of sensilla along the antenna is illustrated in figs 1, 2 and table I.

Most of the sensory structures found on the antenna of worker bees are situated on the 8 distal segments. The remaining 2 segments of the flagellum are exclusively covered with sensilla placodea. Sensilla placodea and setae occupy distinct zones on the segments with very little overlapping. Scape and pedicel only have hairs and are completely devoid of setae and sensilla (fig 3). The surface is rough in the setae-rich zone and smooth in the sensilla placodea-rich zone.

Setae are found on all the segments of the flagellum. The first 2 segments are dominated by setae 2–33 μ m long (mean 15 μ m) 0.68–2.3 μ m width (mean 1.3 μ m). Proximally in Se_1 , they appear needle-like (fig 4) and incline close to the surface but

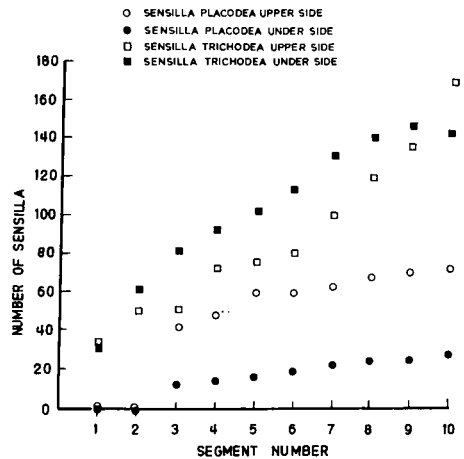


Fig 1. Mean number and distribution of sensilla placodea and sensilla trichodea on the antennae of *Apis florea* workers.

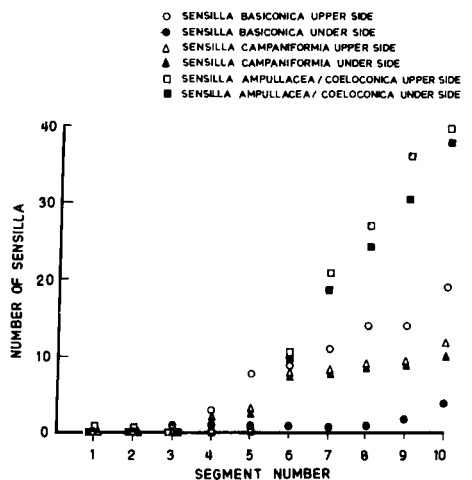


Fig 2. Mean number and distribution of sensilla basiconica, sensilla campaniformia and sensilla ampullacea/coeloconica on the antennae of *Apis florea* worker honey bees.

Table I. Counts of sensilla on the antennae of *Apis florea*.

Sensillum type	No * of sensilla	
	Upper side (dorsal side) Mean	Under side (ventral side) Mean
Sensilla placodea	482 ± 14.4 (0 – 72)	163 ± 12.4 (0 – 28)
Sensilla trichodea	887 ± 34.6 (35 – 166)	1066 ± 40.4 (34 – 146)
Sensilla basiconica	80 ± 14.1 (0 – 19)	12 ± 0.3 (0 – 4)
Sensilla campaniformia	50 ± 4.4 (0 – 12)	57 ± 4.1 (0 – 10)
Sensilla coeloconica/ ampullacea	139 ± 18.1 (0 – 40)	130 ± 16.6 (0 – 38)
Total	1638 ± 55.6 (35 – 309)	1428 ± 73.8 (34 – 326)

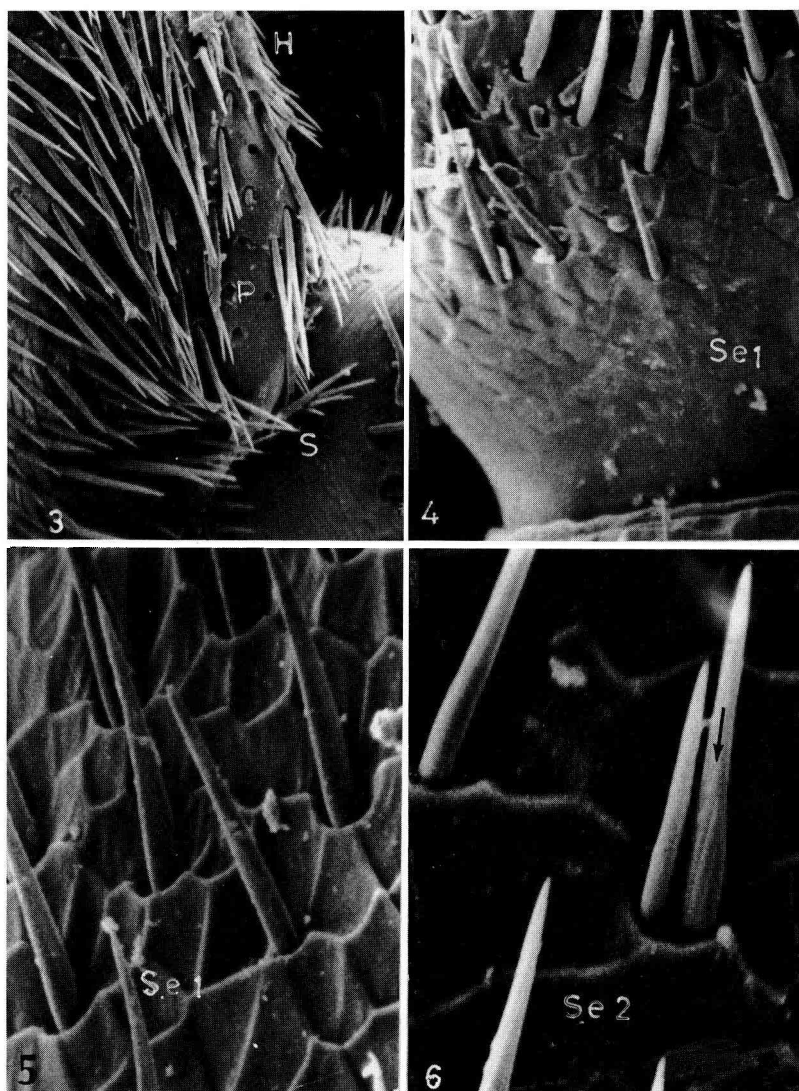
* Mean ± SD, based on all the segments of 15 antennae, values in parentheses represent ranges of sensilla per segment. Note: All means rounded to the nearest whole number.

gradually become knife- or sabre-like and erect on reaching the sensilla placodea field. The setae are larger on the inner side of the antenna (fig 5). The outer side of Se_{10} has smooth and curved setae. A few bifid and trifold setae are present on the flagellum. Some setae are patterned (fig 6). More sensilla trichodea were found than any other type. Other sensilla occurred with decreasing frequency: sensilla placodea > sensilla coeloconica/sensilla ampullacea > sensilla basiconica > sensilla campaniformia.

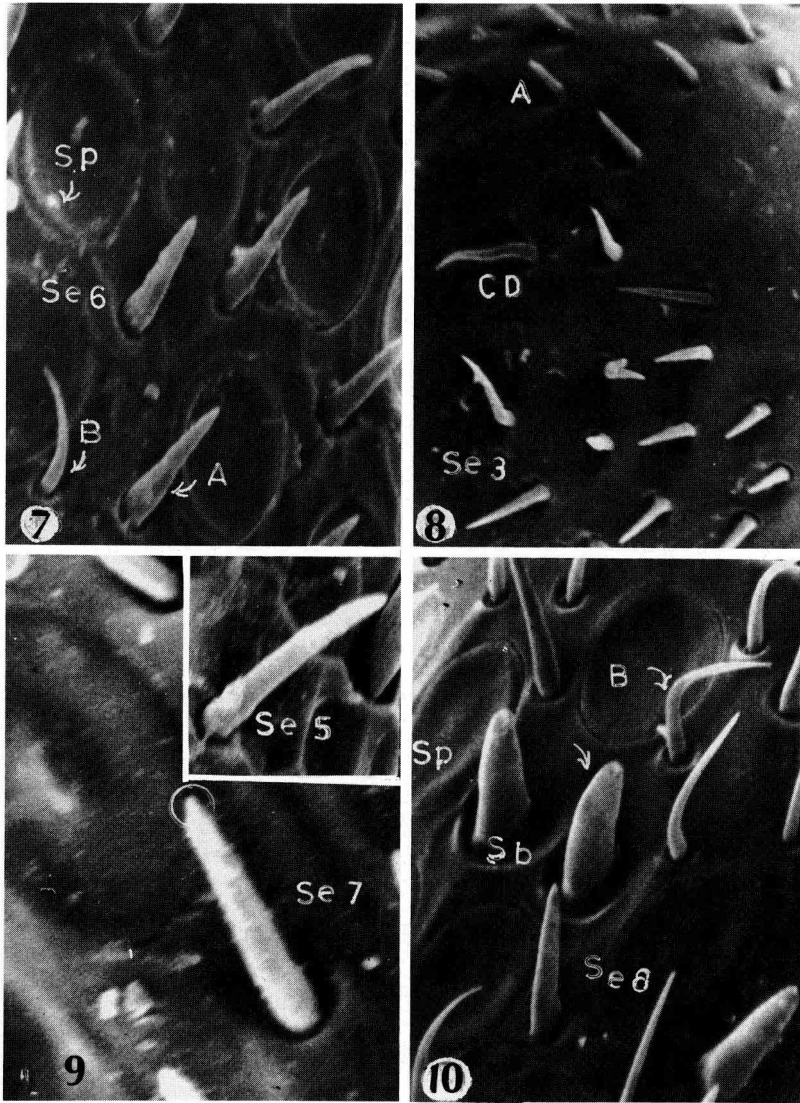
Sensilla placodea were distributed from the proximal end of Se_3 to the last segment, Se_{10} . There were 3 times as many on the upper side (dorsal side) as on the under side (ventral side). They occurred as oval pore plates with a thick, slightly raised rim and indistinct furrows all around (fig 7). Sensilla trichodea were most abundant.

These were found on all the segments of the antenna. These were 0.83 times as many on the upper side as on the under side. This type of sensillum was ultrastructurally segregated into types A, B and CD (figs 7–9). Sensilla trichodea A had a blunt tip (fig 9, inset). Sensilla trichodea B occurred in sharply bent forms. Sensilla trichodea CD type were curved. Sensilla basiconica were less visible at the apex. They were lodged in a distinct socket and were thick with blunt depressed tips, probably indicating a pore (fig 10).

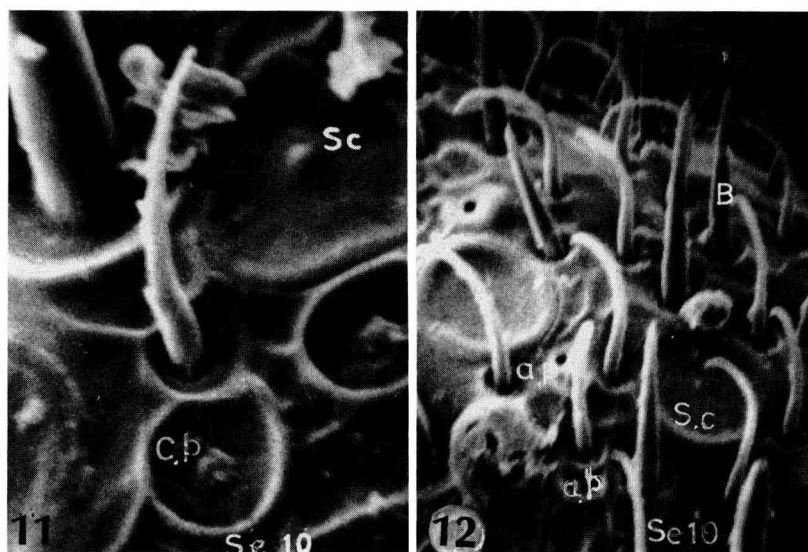
Sensilla campaniformia occurred on the 7 distal segments of the antenna. The wall around the bulb had a button-like knob (fig 11). Sensilla ampullacea and sensilla coeloconica occurred on the 5 distal segments on the antenna. Sensilla ampullacea had smaller pores whereas sensilla coeloconica showed wide pores (figs 11, 12).



Figs 3–6. 3. SEM image showing pedicel (P) of *Apis florea* possessing exclusively needle-like hair (H). S = Scape x 2625. 4. SEM image showing proximal portion of first segment (Se₁) of the flagellum of *Apis florea*. Note sabre- and needle-like setae x 1 312. 5. SEM image showing distal portion of first segment (Se₁) of the flagellum of *Apis florea*. Note sharp-tipped setae x 2 625. 6. SEM image showing a portion of second segment (Se₂) of the flagellum of *Apis florea*. Note the adjoining position of setae; one of the seta is patterned (arrow) x 5 250.



Figs 7–10. 7. SEM image of a portion of Se₆ of the antenna of *Apis florea*. Note sensilla placodea (SP) with slightly raised centres. Middle plate of SP is depressed which causes the thin membrane to hang down on the ridge, seen as an edge (arrow) x 1 312. 8. SEM image showing a portion of Se₃ of the antenna of *Apis florea*. Note sensilla trichodea types A and CD x 875. 9. SEM image showing a portion of Se₇ of the antenna of *Apis florea*. Note sensilla trichodea with papilla at the tip x 3 500. Inset: sensillum trichodeum type A with blunt tip of Se₅ x 2 625. 10. SEM image showing a portion of Se₈ of the antenna of *Apis florea*. Note the presence of sensilla basiconica (sb), sensilla trichodea types A and B and sensilla placodea (sp). Indentation on tip is a pore (arrow) x 2 625.



Figs 11–12. 11. SEM image showing a portion of Se_{10} of the antenna of *Apis florea*. Cp = sensilla coeloconica, Sc = sensilla campaniformia $\times 2\ 625$. 12. SEM image from the tip of Se_{10} of the antenna of *Apis florea*. Sc = sensilla campaniformia; ap = sensilla ampullacea $\times 1\ 312$.

DISCUSSION

The location of different types of sensilla on antenna of *A florea* is similar to those of *A mellifera*. But the population of the types of olfactory sensilla was comparatively much less on the antenna of *A florea* (Bhardwaj, 1974; Gupta, 1982) than on *A mellifera* (Dietz *et al*, 1974). The distribution of various types of sensillae along the antenna is similar to that found in other *Apis* species.

Sensilla trichodea type A are the most common structures on the antenna. The morphology of this sensillum indicates an olfactory function (Slifer and Sekhon, 1961). The olfactory function of sensilla trichodea over the year was also hypothe-

sized by various workers (Vogel, 1921; Frisch, 1967; Schneider, 1968; Dietz and Humphreys, 1971). However, Lacher (1964) reported that sensilla trichodea type A did not respond to any chemical stimuli but sensilla trichodea type B responded to mechanical stimuli in *A mellifera*. In *Apis*, Martin and Lindauer (1966) found some of these sensilla on the distal antennal segment of *A mellifera* and suggested that they may be used to decipher wax smoothness. This type of arrangement of sensilla was neither observed in this study nor is it frequently encountered in other bees. Esslen and Kaissling (1976) suggested a gustatory function of sensilla trichodea type CD. It has also been reported that the sensilla trichodea are the sex pheromone receptors on the male spruce budworm *Cho-*

ristoneura fumigarana (Albert *et al*, 1974) and the male red banded leaf roller *Aroyrotaenia velutinana* (O'Connell, 1972, 1975).

The sensilla placodea have been shown to be odour receptors in *A mellifera* (Lacher and Schneider, 1963; Kaissling and Renner, 1968). Sensillum basiconicum has an apical pore at its tip. Although there is no evidence from the present morphological investigation to indicate the presence of a closing – opening mechanism of the apical pores, such a process is known for the terminal pores of gustatory sensilla in *Schistocerca gregaria* (Blaney and Chapman, 1969), *Locusta migratoria* (Blaney *et al*, 1971) and the blowflies *Phormia regina* and *Calliphora vicina* (Sturchow *et al*, 1973). Slifer *et al* (1959) and Schneider *et al* (1964) thought that sensilla basiconica participated in chemoreception in grasshoppers and moths, and the pores present in their walls are much suited for the perception of olfactant molecules.

In sensilla ampullacea and sensilla coelonica the surface around the pore is smooth in *A florea* (figs 11, 12) in contrast to *A mellifera* in which it was patterned (Argen, 1975). These have been shown to respond to carbon dioxide in *A mellifera* (Lacher, 1964), temperature in *Aedes aegypti* (Davis and Sokolove, 1975) and *Periplaneta americana* (Altner *et al*, 1977) and humidity in *P americana* (Yokohari and Taneda, 1976; Altner *et al*, 1977; Yokohari, 1978). Sensilla campaniformia are probably mechanoreceptors (Pringle, 1938; Esslen and Kaissling, 1976; Yokohari and Taneda, 1976; Yokohari, (1978) reported the presence of campaniform sensilla on cockroach legs which are mechanoreceptors and responded to the stresses of the cuticle. Campaniform sensilla are found to occur in association with ampullaceous and coeloconic sense organs and hence these may be considered sensitive to temperature, carbon dioxide and humidity or a

combination of these factors. This speculation is based on the electrophysiological findings of Lacher (1964) for *A mellifera*.

All *Apis* species studied so far possess similar types of sensilla on their antennae. It is the distribution of these sensilla along the antenna that differs among species. The similarities in distribution among the *Apis* species are pronounced. Less similarity occurs in distribution if one compares *A florea* with less closely related Hymenoptera.

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Résumé — Étude en microscopie électronique à balayage des sensilles de l'antenne chez l'ouvrière adulte d'*Apis florea* (Hymenoptera, Apidae). Les récepteurs sensoriels du flagelle des ouvrières d'*Apis florea* ont été étudiés en microscopie optique et en microscopie électronique à balayage (MEB). L'antenne comprend le scape, le pédicelle et le flagelle constitué de 10 segments. Le scape et le pédicelle n'ont que des poils en forme de plumes mais aucune structure semblable aux soies ou aux sensilles du flagelle. Les soies prédominent sur les 2 premiers segments du flagelle. On n'observe pas de séparation nette entre les sensilles et les zones de soies. La distribution et le nombre des divers types de sensilles (*trichodea*, *placodea*, *basiconica*, *ampullacea*, *coelonica* et *campaniformia*) ont été déterminés. Les *sensilla trichodea* sont les plus nombreuses et présentes sur tous les segments du flagelle. Les *sensilla placodea* et

basiconica sont présentes sur les 8 segments terminaux. Les *sensilla ampullacea/coelonica* sont présentes sur les 5 segments terminaux et les *sensilla campaniformia* sur les 7 derniers. Certaines *sensilla basiconica* présentent une dépression montrant un pore à l'apex. Trois types de *sensilla trichodea* sont présents; les *sensilla trichodea* A sont fines et droites, les B sont courbées. Les types C ou D sont incurvés mais difficiles à distinguer l'un de l'autre. Les *sensilla ampullacea/coelonica* et les *campaniformia* se présentent par groupes dans la même région. Les *sensilla ampullacea* sont plus petites que les *coelonica*, elles-mêmes plus petites que les *campaniformia*. Ces dernières sont les moins nombreuses.

***Apis florea* / antenne / sensille / morphologie / MEB**

Zusammenfassung — Rasterelektromikroskopisches Studium von den Fühlerssensillen der Arbeitsbiene *Apis florea* (Hym, Apidae). Die sensorischen Rezeptoren am Flagellum der Arbeiterinnen von *Apis florea* wurden mittels Licht – und REM-Mikroskopie untersucht. Die Antenne besteht aus Schaft, Pedicel (Sockel) und 10-gliedriger Geißel (Flagellum). Schaft und Sockel tragen nur gefiederte Haare und keine Strukturen ähnlich den Borsten und Sensillen der Geißel. Die ersten beiden Segmente der Geißel sind vor allem mit Borsten besetzt. Zwischen den Arealen der Sensillen und der Borsten ist keine klare Abgrenzung zu erkennen. Es wurden Verteilung und Populationen von *Sensilla trichodea*, *Sensilla placodea*, *Sensilla basiconica*, *Sensilla ampullacea*, *Sensilla coeloconica* und *Sensilla campaniformia* bestimmt. Die *Sensilla trichodea* waren am häufigsten und wurden auf allen Geißelsegmenten gefunden. *Sensilla placodea* und *S. basiconica* waren an den

acht distalen Segmenten vorhanden. *Sensilla ampullacea* und *S. coeloconica* waren auf fünf, *S. campaniformia* auf sieben distale Segmente beschränkt. Die größte Sensillendichte wurde auf dem letzten Geißel-segment gefunden. Einige *S. basiconica* waren in die Oberfläche eingesunken, so daß sie den Eindruck einer Pore erweckten. Es gab drei Typen von *S. trichodea*: *Sensilla trichodea* A waren schlank und gerade; *S. trichodea* B waren gebogen; *S. trichodea* vom Typ C oder D waren kurvenförmig, aber in der gegenwärtigen Studie sehr schwer voneinander zu unterscheiden. *S. ampullacea*, *S. coeloconica* und *S. campaniformis* traten in Gruppen in demselben Feld auf. *S. ampullacea* waren kleiner als *S. coeloconica*, die ihrerseits kleiner waren als *S. campaniformia*. In geringster Häufigkeit traten *S. campaniformia* auf.

***Apis florea* / Antenne / Sensille / Morphologie / REM**

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