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Sensilla on the ovipositor of the carpet moth, *Trichophaga tapetzella* L. (Lepidoptera : Tineidae)

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Summary

Sensilla on the ovipositor of the carpet moth, *Trichophaga tapetzella* L. (Tineidae) have been examined by scanning electron microscopy. Three rings of different sensilla encircle the lobes of ovipositor (3 types of aporous sensilla trichodea, aporous sensilla basiconica and dome-shaped sensilla. The distribution of sensilla is specific to *T. tapetzella* and has been observed neither in other keratophagous moths, or other phytophagous moths and butterflies. Dome-shaped sensilla are described for the first time on the ovipositor of Lepidoptera. All the sensilla are probably capable of monitoring both cuticular stress and mechanical contact of the ovipositor from the initial through the final steps of penetration in the substrate, egg-laying and copulation.

Résumé

Les sensilles sur l'ovipositeur de la mite tapissière, *Trichophaga tapetzella* L. (Tineidae) sont examinées au microscope électronique à balayage. Trois anneaux de sensilles différentes encerclent les lobes de l'ovipositeur (3 types de sensilles trichoïdes sans pore, des sensilles basiconiques sans pore et des sensilles en forme de dôme). La distribution des sensilles est spécifique de *T. tapetzella* et n'a été observée, ni chez les autres papillons kératophages, ni chez les phytophages. Les sensilles en forme de dôme sont décrites pour la première fois sur l'ovipositeur des lépidoptères. Toutes les sensilles sont probablement capables d'informer l'insecte sur les déformations cuticulaires et les contacts de l'ovipositeur depuis le stade initial jusqu'au stade final de la pénétration dans le substrat, ainsi que lors du dépôt des oeufs et de la copulation.

Introduction

The carpet moth, *Trichophaga tapetzella* L. (Tineidae), is a widespread and destructive pest of fabrics, wool, hair, and all other keratinaceous materials (Zagulajev, 1960), which inhabits temperate regions. Native to the Old World, it has been introduced through trade into the New World and the Australasian Region. In natural conditions, the larvae are often found in association with bird nests. As the choice of a suitable substrate for oviposition is of critical importance for females, we studied the ovipositor sensilla which are involved in this behaviour.

In most lepidopterans, the ovipositor bear tactile mechanoreceptive and contact chemoreceptive sensilla (Chadha & Roome, 1980 ; Valencia & Rice, 1982 ; Anderson & Hallberg, 1990 ; Faucheux, 1991). Multiporous sensilla with a putative olfactive function have been discovered in two keratinophagous Tineidae (Faucheux, 1982, 1988) and a phytophagous moth (Reymonet & Faucheux, 1991).

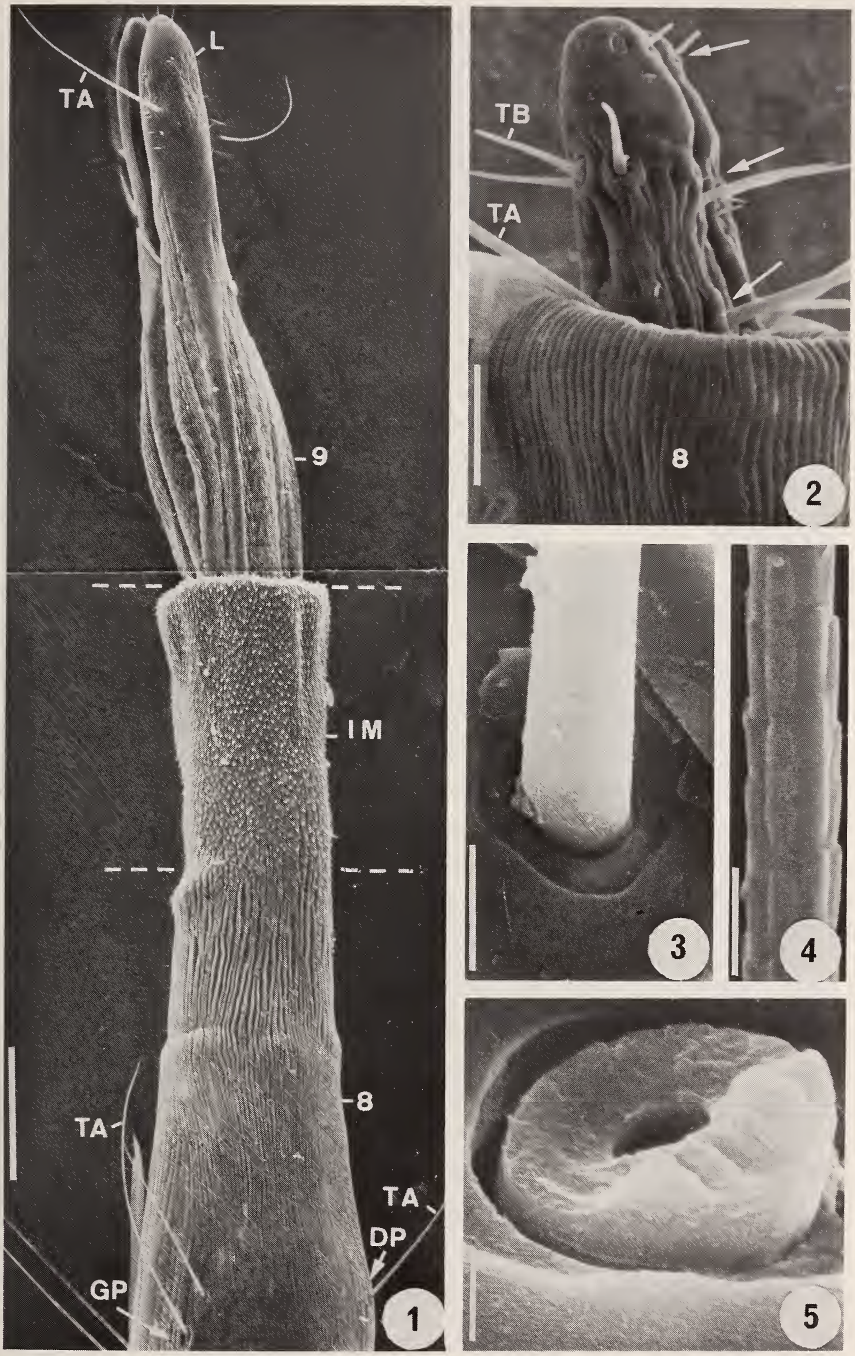
The purpose of this study was to described the types and locations of sensilla on the ovipositor of the carpet moth, utilising the scanning electron microscopy (SEM) and to compare the results with other studies in the literature.

Materials and methods

Adults of *T. tapetzella* were obtained from larvae found in the regurgitated pellets of the barn owl, *Tyto alba* L., at Limerzel and Rochefort-en-terre, in Morbihan (West of France). For SEM study, 18 ovipositors were fixed with 2.5% glutaraldehyde in sodium cacodylate buffer, post-fixed with 1% OsO_4 and dehydrated in an ethanol series. They were either dried in air or with a critical-point dryer. Specimens were coated with gold-palladium and observed with a JSM 6400 F SEM at 7 Kv. The porous areas of sensilla were determined by crystal violet (Slifer, 1960) and reduced silver techniques (Schafer & Sanchez, 1976).

Results

During the acts of oviposition and copulation, the ovipositor is protracted and appears as a relatively solid, sclerotized structure, ca. 5.3 mm long, constituted of abdominal segments 8 and 9 (Fig. 1). In cross section, the circumference of the proximal portion is round, and the distal portion is dorsoventrally flattened. When not in use, the ovipositor is kept in a retracted position within the 7th abdominal segment and is externally not visible, except for the tip of the lobes (Fig. 2). There are three more or less sclerotized sensory regions : the distal two lobes (L) or anal papillae, the dorsal plate (DP) and the genital plate (GP), both situated on the 8th segment (Fig. 1).



Figs 1-5. 1 — Lateral view of partly extended ovipositor, scale bar = 100 mm ; 2 — Tip of ovipositor retracted into 8th abdominal segment, showing 3 circles of sensilla (arrows), scale bar = 20 mm ; 3 — Hair base of sensillum trichodeum type A, scale bar = 4 mm ; 4 — Tiled-roof type structure of s. trichodeum type A, scale bar = 1 mm ; 5 — Transverse break of s. trichodeum type A, scale bar = 1 mm.
DP — dorsal plate ; GP — genital plate ; IM : intersegmental membrane ; L — lobes of ovipositor ; TA — sensillum trichodeum type A, TB — sensillum trichodeum type B ; 8, 9 — abdominal segments 8 and 9.

Morphology of sensilla on ovipositor lobes

The lobes of the ovipositor bear 5 types of sensilla : 3 types of sensilla trichodea, sensilla basiconica and dome-shaped sensilla. The three types of sensilla trichodea (A, B, C) can be distinguished according to their lengths and location. The proximal sensilla trichodea A are the longest hairs, 114.3 mm long (range : 82-165 mm) and possess a pointed tip (TA, Figs. 1,2). They have a basal diameter of 2.8-3.3 mm and are articulated with the ovipositor cuticle (Fig. 3). The socket tightly surrounds the base of the hair shaft which is smooth only in the basal portion (Fig. 3), but has 12 longitudinal ridges with a tiled-roof structure (Fig. 4) in the medial and distal regions. Sensilla trichodea A are thick-walled with a narrow lumen (Fig. 5). No terminal pore or wall pores are seen and the hairs did not stain with crystal violet or reduced silver nitrate. These sensilla therefore may be classified as aporous sensilla according to Zacharuk (1985).

The more distal sensilla trichodea B are shorter than the type A and measure from 20 to 38 mm long (mean : 29.3 mm) and 1.2 mm wide at the base (TB, Figs 6, 11). They have a bulbous base and are sharply tipped. Sensilla trichodea C are short sensilla, 7.6 mm long (range : 6.6 - 10.1 mm) and blunt ; the hairs are slightly inclined distally, but at varying angles (TC, Fig. 6). Like the sensilla trichodea B, the type C is inserted in a large pit (Fig. 7). The hair-shafts of both sensilla trichodea B and C are smooth, without any pore, and did not stain with crystal violet or reduced silver nitrate.

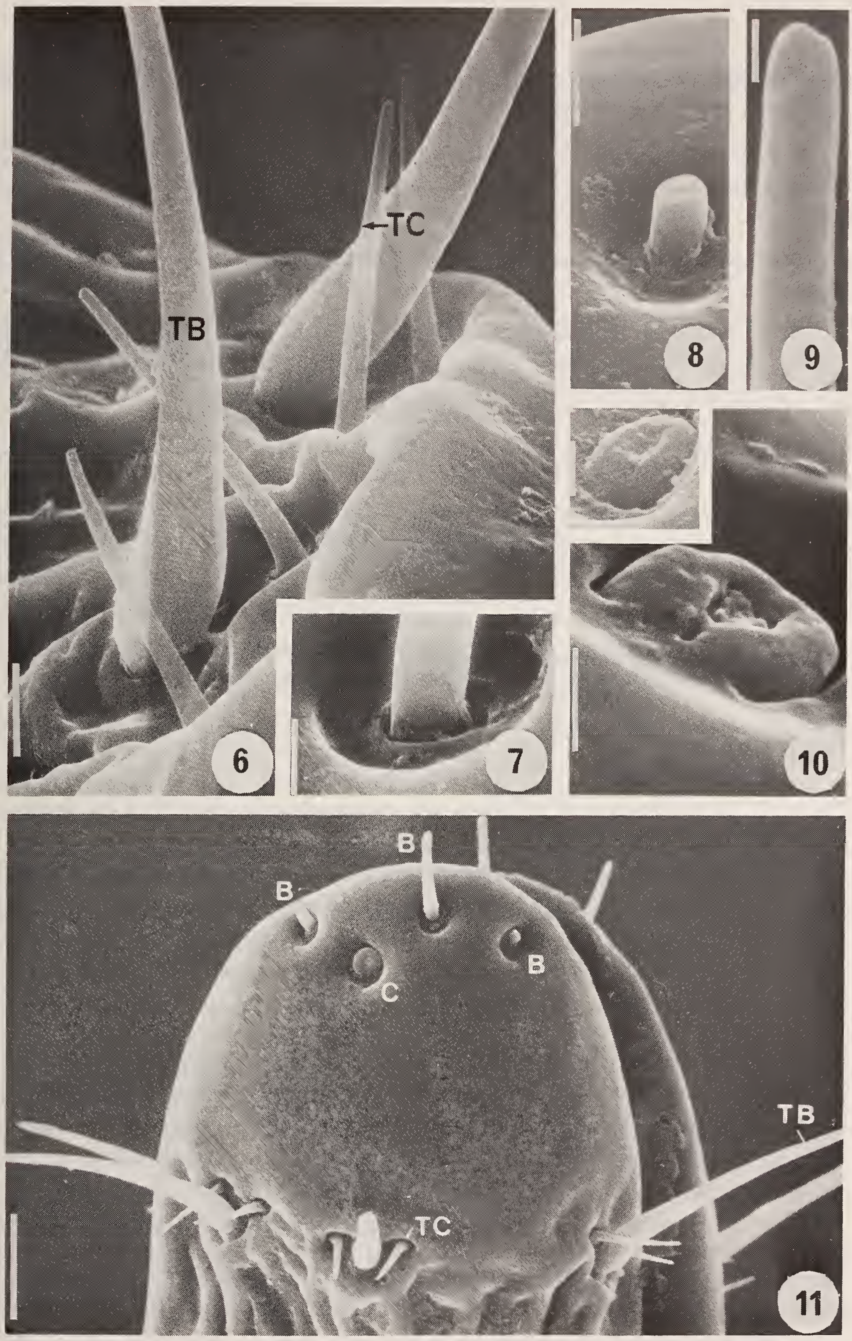
Sensilla basiconica are located at the apex of lobes (B, Fig. 11). The peg is 8.5 mm long (ranging from 5.3 to 9.8 mm) and about 1.0 mm wide at the base (Fig. 8) and is blunt tipped (Fig. 9). These sensilla are always inclined distally, no pore is visible with SEM and they did not stain when crystal violet is applied.

Dome-shaped sensilla, located distally (C, Fig. 11) possess a central pit (Fig. 10 and inset) and measure from 1.9 to 2.7 mm in diameter (mean = 2.2 mm).

Distribution of sensilla on ovipositor lobes

The distribution of sensilla on the lobes shows unusual features. We can distinguish the following from the distal region proximally :

— an apical circle of 8 sensilla (4 per lobe) comprising from distal side towards the ventral side of each lobe : one sensillum basiconicum, one



Figs 6-11. 6 — Sensilla trichodea types B and C, scale bar = 2 mm ; 7 — Base of sensillum trichodeum type C, scale bar = 1mm ; 8 — Base of sensillum basiconicum, scale bar = 2 mm ; 9 — Apex of sensillum basiconicum, scale bar = 0.5 mm ; 10 — Dome-shaped sensillum, scale bar = 1 mm ; inset. another view of dome-shaped sensillum, scale bar = 1 mm ; 11 — The two distal circles of sensilla on the lobes, scale bar = 10 mm.
B — sensillum basiconicum ; C — dome-shaped sensillum ; TB, TC — sensilla trichodea types B and C.

dome-shaped sensillum and two sensilla basiconica. The dome-shaped sensillum is slightly below the circle of sensilla basiconica (Fig. 11).

— a subapical circle of 18 sensilla (9 per lobe) regularly spaced and comprising 3 groups of sensilla. Each group possesses one central sensillum trichodeum B and 2 lateral sensilla trichodea C (Fig. 11).

— a proximal circle consisting of 4 sensilla trichodea A (2 per lobe) (Figs. 1 and 2).

— 20-24 sensilla trichodea C (about 10 per lobe) scattered on the proximal part of the lobes. The numbers of sensilla on the three circles are identical in the 18 ovipositors examined with SEM.

Sensilla on the dorsal and genital plates

The dorsal plate and the genital plate bear only sensilla trichodea type A, similar to those of ovipositor lobes, but longer. On the genital plate, there are two ($n = 5$ ovipositors examined), four ($n = 11$) or 5 ($n = 2$) sensilla 162 mm long (range : 127-133 mm) which are inclined distally, at varying angles (Fig. 11). The dorsal plate bears two sensilla ($n = 8$) or only one sensillum ($n = 4$), 185 mm long (range : 158-210 mm).

Discussion

Prior to and during oviposition, the ovipositor is extended by hydrostatic pressure and intrinsic muscles allow it to make orientation movements including probing the substrate. The sensilla described here are suited to play a role in this oviposition behaviour by sensing the immediate environment.

Presumed functions of sensilla

The sensilla trichodea types A, B, and C of *T. tapetzella* are morphologically similar to the 3 types of mechanoreceptors described by Valencia & Rice (1982), Faucheux (1988) and Reymonet & Faucheux (1991). Possibly, there are differences between the bristle types in the force needed for deflection. The flexibility of the cuticle around the sockets of sensilla trichodea B and C is probably an adaptation to prevent damage to these sensilla when the ovipositor penetrates the substrate. It is probable that each group consisting of one sensillum trichodeum B and two sensilla trichodea C may function as a unit. The aporous sensilla basiconica with inflexible sockets found on the antenna of *Locusta migratoria* (L.) are known to be thermo- and hygroreceptive (Altner *et al.*, 1981), but the information gathered for the sensilla basiconica in our study is not enough to ascribe a particular function.

Comparison with other Lepidoptera

The carpet moth does not possess gustative uniporous sensilla or olfactive multiporous sensilla observed in other lepidopterans. It also differs by the presence of aporous sensilla basiconica and dome-shaped sensilla. Dome-shaped sensilla on the ovipositors of Lepidoptera are described here for the first time. The reduced numbers and distribution of sensilla are one of the more striking features of the ovipositor of *T. tapetzella*. In this species, there is a total of about 60 sensilla on the whole ovipositor, compared to 110 in *Tinea pellionella* L. (Faucheux & Chauvin, 1981), 130 in *Tineola bisselliella* Humm. and 87 in *Monopis crocicapitella* Clem. (Faucheux, 1987) among the keratophagous moths.

The behavioural role of sensilla

As in other Tineidae of the subfamily of Tineinae (Faucheux, 1987), under laboratory conditions, the carpet moth prefers to oviposit in cracks or crevices (unpublished observations) and, under natural conditions, it oviposits between the woollen fibres of carpets or in regurgitated pellets. Thus, the tactile hairs may determine extent of penetration of the ovipositor. The sensilla trichodea A of the genital and dorsal plates may contact the substrate when the 9th and 10th segments are retracted into the 8th abdominal segment. To explain how the female determines the depth of the penetration hole, we suggest a mechanism analogous to that described in the dipteran insect, *Rhagoletis pomonella*. Indeed, Stoffolano & Yin (1987) believe that mechanosensilla continue to monitor pressure on the ovipositor until it can go no further and, in this case, the lack of pressure would signal the maximum depth. Furthermore, another possible method would be to have tactile sensilla located along the most distal and the most proximal portions of the ovipositor. In the carpet moth, circling the 8th segment and the terminal lobes of the telescoping ovipositor are presumed tactile sensilla trichodea A, B, and C that are believed to monitor the suitable depth of egg placement.

The mechanosensilla of the ovipositor may also serve in copulation in providing the female moth information regarding the male position during copulation.

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