*Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Vie, 2023, n° 45, 23–33*

***e-ISSN : 2458-7184***

# The tactile antennae with an olfactive apex of *Adelostoma sulcatum* Duponchel, 1827 (Coleoptera: Tenebrionidae: Pimeliinae: Adelostomini): characteristics in liaison with the life in termite nests

## *Les antennes tactiles à apex olfactif d'Adelostoma sulcatum Duponchel, 1827 (Coleoptera: Tenebrionidae: Pimeliinae: Adelostomini): caractéristiques en liaison avec la vie dans des termitières*

**Michel J. Faucheux**

*Laboratoire d'Endocrinologie des Insectes Sociaux, Faculté des Sciences et des Techniques, 2 rue de la Houssinière, B.P. 92208, 44322 NANTES Cedex 3, France (faucheux.michel@free.fr)*

**Abstract**. *Adelostoma sulcatum* is a little filiform darkling beetle which is commonly found everywhere in Morocco. Its antennae are cylindrical, composed of 10 antennomeres including a scape, a pedicel, and a flagellum with 8 flagellomeres. The type, structure and distribution of antennal sensilla in the adult of *A. sulcatum* (Coleoptera: Tenebrionidae: Pimeliinae: Adelostomini) were examined by scanning electron microscopy. Six types or subypes of sensilla were observed, i.e., large aporous fusiform sensilla chaetica, small aporous fusiform sensilla chaetica, slender aporous sensilla chaetica, multiporous sensilla trichodea, and multiporous sensilla basiconica of types 1 and 2, based on their external morphology. The terminal antennomere has 83% of antennal sensilla; all of the olfactive sensilla are concentrated in a distal transversal and circular cupule. The original distribution of all the sensilla on the antennae was discussed from a double point of view: in relation to the taxonomic position of Adelostomini among the subfamily Pimeliinae, and with the discovery of *A. sulcatum* in the vicinity of a termite nest of *Microhodotermes maroccanu*.

**Keywords:** Coleoptera Tenebrionidae, darkling beetles, Adelostomini, antenna, sensilla, distribution, olfaction, termites.

**Résumé**. *Adelostoma sulcatum* est un petit ténébrion filiforme qui est commun dans tout le Maroc. Ses antennes sont cylindriques, constituées de 10 antennomères dont un scape, un pédicelle, et un flagelle avec 8 flagellomères. Les types, la structure et la distribution des sensilles antennaires chez l'adulte d' *A. sulcatum* (Coleoptera: Tenebrionidae: Pimeliinae: Adelostomini) ont été examinés en microscopie électronique à balayage. Six types ou sous-types de sensilles ont été observés, basés sur leur morphologie externe: sensilles chétiformes apores grandes et fusiformes, sensilles chétiformes apores petites et fusiformes, sensilles chétiformes apores élancées, sensilles trichoïdes multipores, sensilles basiconiques multipores des types 1 et 2. L'antennomère terminal porte 83% des sensilles antennaires, dont toutes les sensilles olfactives qui sont concentrées dans une cupule distale, transversale et circulaire. La distribution originale des sensilles sur les antennes a été discutée d'un double point de vue: en rapport avec la position taxonomique des Adelostomini au sein de la sous-famille des Pimeliinae, et avec la découverte d'*A. sulcatum* dans le voisinage d'une termitière de *Microhodotermes maroccanus*.

**Mots-clés**: Coleoptera Tenebrionidae, ténébrions, Adelostomini, antenne, sensilles, distribution, olfaction, termites.

## INTRODUCTION

At eleven o'clock, while driving from Essaouira to Agadir on 27/09/2003, we stopped for about a quarter of an hour some 50 kilometers beyond Smimou in South western Morocco, beside a forest of Barbary thuja, *Tetraclinis articulata* (Vahl) Mast, 1892 (Cupressaceae) accompanied by asphodels *Asphodelus* sp. (Liliaceae) (Fig. 1a). Large numbers of calcareous flat stones covered the sandy soil (Fig. 1b). While looking for darkling beetles, we discovered under the stones that two thirds of them housed colonies of termites whose surface rooms were swarming with workers and soldiers fleeing daylight (Fig. 1c, d). Under most of the stones (7 out of 11), on the edge of the site, we also noticed a group of 2 or 3 motionless and cylindrical beetles 6 mm long. Unfortunately, we took no photos of the beetles. Just before we left, one of us, intrigued by this association of termites and beetles, decided to capture three of the latter.

Subsequently, while studying moroccan termites, we sought to identify those and the beetles of Smimou. The species of termites is *Microhodotermes maroccanus* Sjöstedt, 1926 (Blattodea: Hodotermitidae). *M. maroccanus* is cited from Morocco as well as 5 other species: *Kalotermes flavicollis* (Fabricius, 1793) (Kalotermitidae), *Reticulitermes lucifugus lucifugus* (Rossi, 1792) (Rhinotermitidae), *Anacanthotermes ochraceus* (Burmeister, 1839) (Hodotermitidae) and *Microcerotermes palaearcticus* (Termitidae) (Ricart *et al.* 2015), and recently the invasive drywood termite, *Cryptotermes brevis* (Walker, 1853) (Kalotermitidae) (Najjari *et al.* 2023). All these species except *C. brevis* are native of Morocco.

*M. maroccanus* is a species whose nest is not at the very heart of the food mass, wood or humus. Its food harvesting is an activity imposed by hunger. It is an exclusive grass-carrying termite occupying the southern extremity of Africa as well as the South of Morocco in two ones where the vegetation is composed of sparse bushes. It seeks its fodder on cloudy days and at nightfall from grass and leaves which it cuts into small pieces (Grassé 1985). Like most harvester termites, *M. maroccanus* possesses mandibles with serrated edges; all castes have functional compound eyes (Scholtz & Holm 1985). The nest is made up of irregular chambers with a horizontal base, hollowed out at diffferent levels and connected by galleries. The chambers on the upper floors can be discovered at ground level; they serve as hay loft with straws of grasses or storehouse of fecal pellets (Fig. 1c).

The streamlined beetles belong to the species *Adelostoma sulcatum* Duponchel, 1827 (Coleoptera: family of Tenebrionidae, subfamily of Pimeliinae, tribe of

Adelostomini). This small tenebrionid species is another example of the species that we have found on the Atlantic coast of Morocco (Faucheux 2009, 2011a, 2017). Its geographic distribution is the following: Spain, North Africa, Cyprus, Syria, Libya. It is widespread in Morocco (Labrique & Chavanon 2001). Nevertheless, its presence in the company of termites is never mentioned. This insect of crepuscular and nocturnal activity, with its laboured mobility and incapacity to fly, lives on the land and hides during the day under stones (Solier 1837) where it is found sometimes in great numbers in Morocco (Labrique & Chavanon 2001). The tenebrionids have an important role in the ecosystems in which they feed for the most part on detritus and recycle organic matter, mainly that of vegetable origin. They are also opportunistic feeders which do not disdain animal sources, sometimes even of their own congeners both dying or dead. In this respect, *A. sulcatum* is an occasional necrophagous insect (Labrique & Gomy 2010).

In the present study, we provide photographs of the insect which show antennae whose distal segment is somewhat obliquely cut off and seems to be occupied by a cupule which is unusual on insect antennae. This cupule is sometimes in the form of a light coloured circle on figures of antennae of different *Adelostoma* (Purchart 2009, 2012, 2017), but this cupule probably always exists though it has never been described as such. Mention is made of "a terminal segment abruptly and somewhat obliquely cut off" (Solier 1837), or of "an obliquely truncate apical antennomere" (Purchart 2012). Intrigued by the structure of this apical antennomere, we have observed the antennae of *A. sulcatum* by means of the scanning electron microscope (SEM) and described their sensory equipment which has helped us to better understand the presence of the tenebrionids near the nests of termites.

## MATERIAL AND METHODS

*1 - Source of insects*

Three adults of *Adelostoma sulcatum* were captured together with harvesting termites under a stone in the Smimou region of Southern Morocco). The determination of the species of termites, *Microhodotermes maroccanus,* was confirmed by Dr Frédéric Legendre (MNHN of Paris, France). The beetles *Adelostoma sulcatum* were deterrmined by Dr. Harold Labrique (Musée des Confluences, Lyon, France).

*2 - Sample preparation for SEM*

For scanning electron microscopy (SEM) study, 2 heads with antennae were cut, cleaned in acetone, dehydrated in pure alcohol, and mounted on specimen holders. After coating with gold and palladium, preparations were examined in a Jeol J.S.M. 5800 LV SEM at 12 kV. Counts of the sensilla were made by using the SEM at different magnifications. Sensillum terminology follows Zacharuk (1980), Altner & Prillinger (1980), and Faucheux (1999).

## RESULTS

*1 – Brief description of Adelostoma sulcatum*

Size: 6 mm X 1.9 mm (similar for the 3 individuals). Body narrow, subparallel (Fig. 2a, b, c).

Head a little shorter (1.1 mm) than wide (1.2 mm), widest at genae which are strongly developed (Fig. 2d, e). The vertex of the head is slightly concave in dorsal view, with a narrow neck.

The clypeus, is sharply indented anteriorly (Fig. 2e); it covers the mouthparts which are ventral and barely visible,

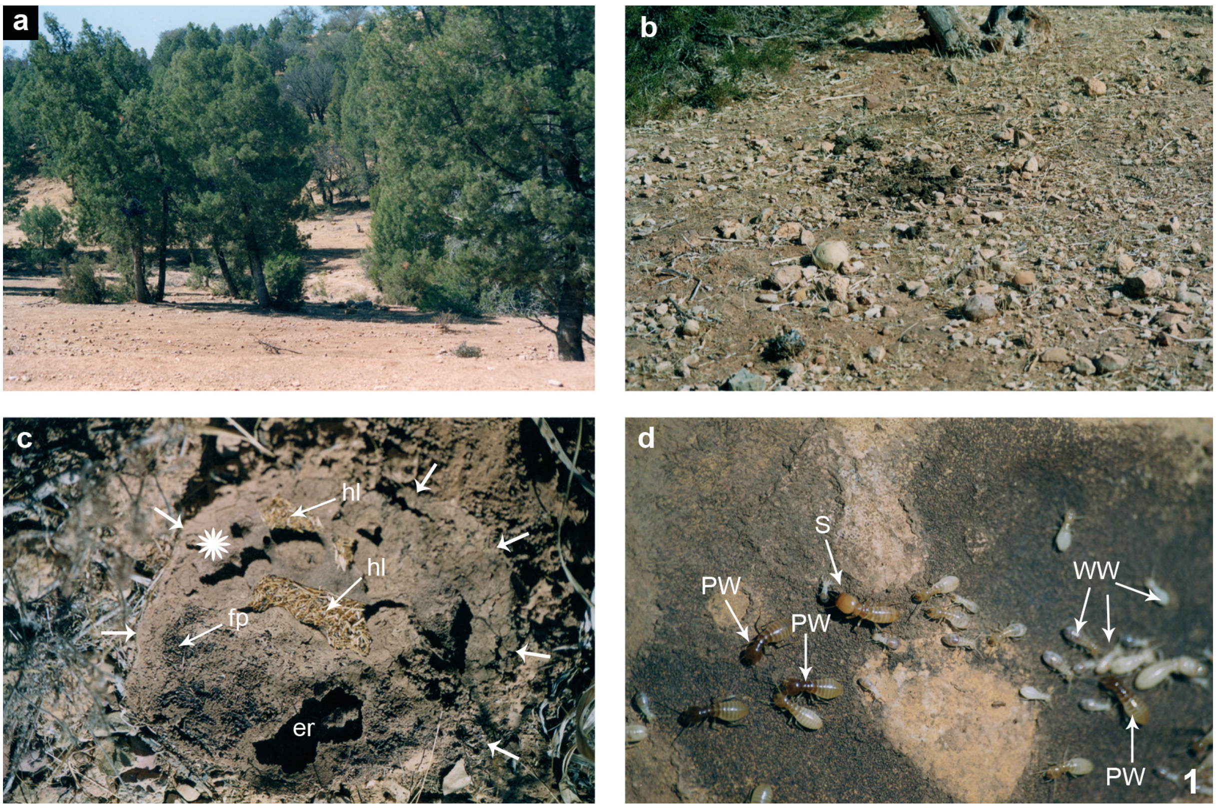


Figure 1. **a**, woodland of *Tetraclinis articulata,* Smimou region, Morocco; **b**, clearing with numerous stones; **c**, termite nest visible under stone showing hay lofts (hl), storehouses of fecal pellets (fp), empty rooms (er), possible position of *Adelostoma* individuals (asterisk), periphery of the imprint left by the stone (arrows) (x 2.2); **d**, pigmented workers (PW), white workers (WW), and soldier (S).

the palps being very small and thin mandibles: the mouth is barely visble (which explains the name of adelostoma given to the genus).

The compound eyes are very little apparent; they are concealed on the sides and located in a depression whose upper edge has the form of a crest (Fig. 3). The antennae are cylindrical and measure 1.6 mm; they are here 1.3 times longer than the width of the head.

Pronotum a little longer (1.5 mm) than wide (1.4 mm), cut off anteriorly and posteriorly, with broad lateral franges and two longitudinal high careniform ribs. Legs short and filiform; the tibiae of forelegs and midlegs are conical, the tibiae of hindlegs are cylindrical; the tarsa of 6 legs are short (Fig. 2b, c).

Elytra, subparallel, 3.4 mm long and 1.9 mm wide, with three strongly developed longitudinal and relatively high carinae on each elytron.

The body is to a large extent covered with yellow setae, both ventrally and dorsally, and conspicuous on the antennae and the legs (Fig. 2).

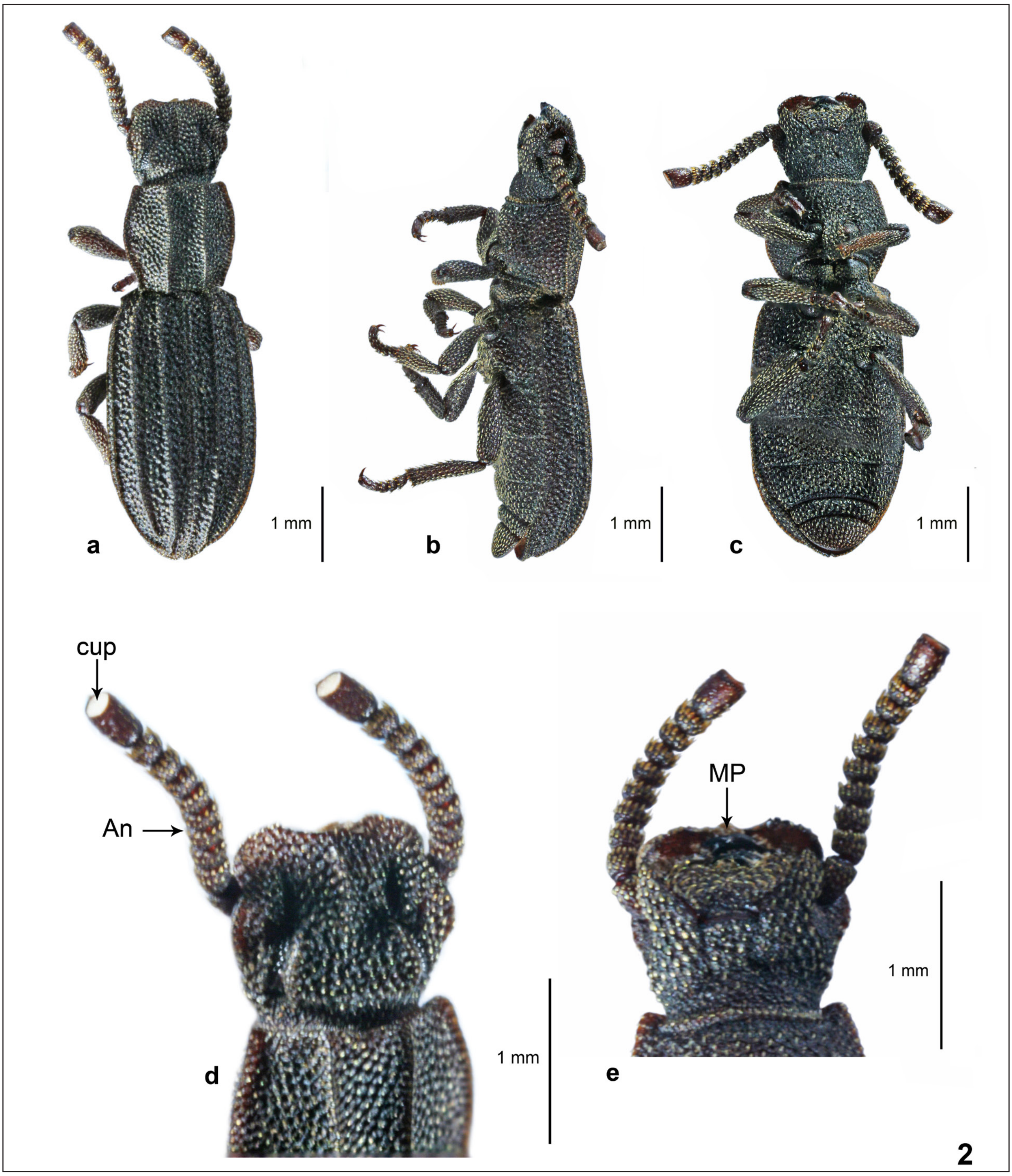


Figure 2. *Adelostoma sulcatum*, **a**, dorsal face; **b**, lateral face; **c**, ventral face; **d**, dorsal face of head and pronotum showing antennae (An) and cupule (cup) of antenna; **e**, ventral face showing the location of mouthparts (MP).

*2 - Morphological characteristics of antennae*

The antennae are thick, strong, and cylindrical and they comprise 10 segments or antennomeres (A1-A10): the scape (A1), the pedicel (A2), and the flagellum (A3-A10) comprising 8 flagellomeres F1-F8. To simplify, we shall use for the most part the term antennomere (Figs. 4, 5). The first A1 has the shape of a club and is much narrower proximally than distally; its distal median width being slightly similar to the following antennomeres (Tab. 1). Except for A10, A1 is longer than other antennomeres. A2 is longer than A3. Antennomeres A2-A9 are much shorter than A1 and more or less identical in size; they are notably transverse and encased into each other. The obliquely truncate apical antennomere A10, which is longer than broad, is approximately three times longer than the penultimate antennomere A9 (Tab. 1). The apical part of the antenna is really occupied by a circular cup which appears clearly (Figs. 6c, 7). The integument of antenna appears smooth without microtrichia but in SEM, it reveals a regular mesh network made up of very small polygons (see Figs. 6b, d, e, +f). All antennomeres bear sensilla.

*Table 1 - Morphological characteristics of antenno meres of Adelanostoma sulcatum (n = 3).*

| Antennomere | Length (µm) | Median width (µm) |
|---|---|---|
| A1 | 250.4 ± 1.7 | 210.6 ± 2.5 |
| A2 | 150.1 ± 1.4 | 198.0 ± 2.1 |
| A3 | 122.5 ± 0.8 | 209.4 ± 1.9 |
| A4 | 105.3 ± 2.3 | 207.7 ± 0.3 |
| A5 | 103.2 ± 2.9 | 202.3 ± 1.6 |
| A6 | 96.6 ± 1.4 | 191.7 ± 2.3 |
| A7 | 109.1 ± 2.2 | 175.6 ± 1.7 |
| A8 | 121.4 ± 1.8 | 194.8 ± 2.5 |
| A9 | 109.3 ± 1.3 | 196.4 ± 1.9 |
| A10 | 316.2 ± 3.1 | 214.5 ± 2.8 |

*3 - Types and distribution of sensilla*

To begin with, a noteworthy distinction needs to be made: antennomeres A1 to A9 possess an identical sensory equipment; antennomere A10 is different.

*3a* - Sensilla on A1-A9

All antennomeres A1-A9, both the scape A1 and the pedicel A2 as well as the flagellomeres A3-A9, bear the same sensillum type, the *large aporous fusiform sensilla chaetica C1* (Figs. 4, 5, 6a) on both faces (Fig. 2a, c). The tip of the sensilla on the scape is rounded and rather similar at the base (Fig. 6b) whereas it is sharper and sometimes prolonged by a filament on the sensilla of the following antennomeres. Each sensillum face possesses ten or so longitudinal ridges some of which are arranged in the shape of a V (Figs 6b, e). All sensilla possess a socket and are flexible (Fig. 6e). Compared to the length of antennomeres, the fusiform sensilla which have no pores seem enormous. They correspond to the «yellow setae» which are observed by light microscopy (Figs. 4, 5). On each antennomere, they are arranged in two or three transversal rows of 5-9 sensilla (Tab. 3). The two faces of antenna have a similar distribution of sensilla (Fig. 2d, e). The flagellomeres A3-A9 have from 22 to 36 sensilla; it is surprising to discover that is the pedicel A2 which has the largest number of sensilla, i.e 42 (Tab. 3). If all the sensilla of the same row have the same length on the same antennomere, the distal sensilla are always longer than the proximal sensilla (Tab. 2).

*3b* - Sensilla on terminal antennomere A10

Antennomere A10, which is longer than the others, shows a distinctive and unique sensory equipment. Several sensillum types are found together in the cupule.

- Wall sensilla

The wall sensilla of A10 belong to a same type: the *small aporous fusiform sensilla chaetica C2* (Figs. 6c, d, f). They resemble large aporous fusiform sensilla chaetica C1, being shorter and narrower than the latter (length: 28.5-29.7 µm; width: 3.7-3.8 µm). In about half of the sensilla, the blunt tip extends into a filament, 4 µm long (Fig. 6d). All sensilla have a narrow base, 1.8 µm wide, inserted into a socket with two cupules (Fig. 6f). About 16 longitudinal or oblique striae exist all around each sensillum. The 10$^{th}$ antennomere has a hundred sensilla, equidistant from each other, which are circular at the base and the tip, and oblique on the remain part of the segment (Fig. 6c).

- Cupular sensilla

The diameter of the cup in 3 examined beetles varies from 202.9 µm to 204.2 µm (mean = 203.7 µm). With a radius of about 102 µm, the surface of the cup is 102 µm x 102 µm x 3.1416 = 32685 µm$^2$. The wall of the cavity is thin and internally shows an irregular polygonal cuticular network (Figs. 7, 8). The sensilla, which are curved, emerge to a depth of 18 µm (Fig. 8). Four sensillum types are present:

About 67 *slender aporous sensilla chaetica C3*, regularly spaced of 9 µm, form a circle surrounding other sensilla (Fig. 8). They are sharp-pointed, 16.6-18.7 µm long, with a base of 2.3 µm wide. These sensilla are inserted into a socket and are flexible at the base. They are without pores and show fine longitudinal and transversal striae. Sensilla C3 are all curved at one third of the base towards the inside of the cupule.

The most numerous sensilla (897) are the *multiporous sensilla trichodea T* no-socketed, 20.5-23.6 µm long, with a blunt tip (Fig. 8). Their width varies from 2.0 µm at the base to 1.6 µm at midlength and 1.0 µm at the tip. They have fine longitudinal striae but the presumed wall pores were not observed in SEM. At the basal third of their length, they are all curved at right angles in the same direction so as to stay behind the tip of the cup. They are regularly distributed.

Sensilla basiconica are located among the sensilla trichodea. *Multiporous sensilla basiconica B1* are blunt-tipped, shorter (12.7-13.2 µm), and wider (basal width = 2.2 µm) than the sensilla trichodea (Fig. 8). They are slightly curved. Their width decreases very little along the hair that is more or less flattened and resembles sensillum auricillicum. They are rare, their number in the whole cupule was estimated at 45 sensilla. *Multiporous sensilla basiconica B2* are the smallest of the sensilla observed in the cupule; they are 6.9 µm-8.2 µm long, and 1.6 µm in basal width (Fig. 8). These blunt-tipped sensilla are enlarged at the base and the width is 1.2 µm at midlength and subsequently 1.0 µm at the tip. The cupule contains about 246 sensilla B2. The total number of sensilla in the terminal cupule can be estimated as 67 C3 + 897 T + 45 B1 +246 B2 = 1255 sensilla. So, 16.7% of total sensilla are distributed on antennomeres A1-A9, and 83.3% on distal antennomere A10 (Tab. 4).

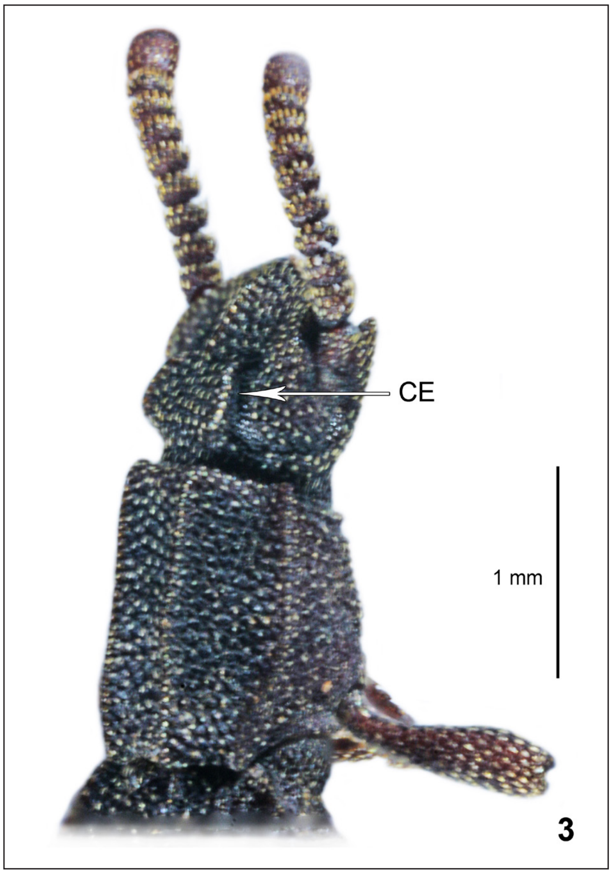


**Figure 3.** *Adelostoma sulcatum*, lateral view of head and prothorax showing the location of the compound eye (CE).

## DISCUSSION

### 1 – Comparison with other tenebrionids and presumed function of sensilla

The last antennomere A10 of *A. sulcatum* is very elongated; it probably corresponds to merged antennomeres A10 + A11. The antenna bears 6 sensillum types and subtypes: s. chaetica C1, C2, C3; s. trichodea T and s. basiconica B1, B2. In my opinion, the three subtypes of sensilla chaetica may be considered to be a single type which changes abruptly with the location of antennomeres, from the antennomeres A1-9 to terminal antennnomere A10, the sensillum becoming much thinner. No previous study has shown such a development.

The number of types and subtypes of sensilla varies among the species of tenebrionids previously studied: 6 in *Tenebrio molitor,* Tenebrioninae Tenebrionini (Harbach & Larsen 1977); 8 in *Tribolium castaneum,* Tenebrioninae Tribolini (Ali *et al.* 2016, Seada & Hamza 2018); 9 in *Scaurus gigas*, Tenebrioninae Scaurini (Faucheux 2013); 11 in *Ulomoides dermestoides*, Diaperinae Diaperini (Qian *et al.* 2018); 9 in *Pachychila impunctata*, Pimeliinae Tentyriini (Faucheux 2023). *A. sulcatum* is therefore a species with a reduced number of sensillum types.

From a morphological point of view, the sensilla of *Adelostoma* and *Pachychila* are common and present in other Tenebrionidae. Among Tenebrioninae, *Tribolium* and *Scaurus* have a similar sensillum type: «multiporous branched sensillum coeloconicum» MBSC of *Scaurus*, «sensilla basiconica I-VI» (Ali *et al.* 2016), «sensilla basiconica 3 and 4» (Seada & Hamza 2018) of *Tribolium*. Furthermore, *S. gigas* is provided with a special form of aporous sensilla chaetica named «aporous spindle-shaped sensilla chaetica C1» whose thickness gradually decreases from base to antennal apex. They are similar to the large aporous fusiform sensilla chaetica C1 in *A. sulcatum.* The Diaperinae *U. dermestoides* has «sensilla styloconica SS I and SS II» which recall the MBSC of *S. gigas*.

Judging from their morphological characteristics, aporous sensilla chaetica C1, C2, and C3 are tactile mechanoreceptors; presumed multiporous sensilla trichodea and sensilla basiconica B1 and B2 are olfactive chemoreceptors (Zacharuk 1980, 1985; Altner & Prillinger1980). In our view, it is impossible that gustatory sensilla should exist into the cupule of *A. sulcatum* because these sensilla are contact chemoreceptors which always protrude from the antennal tegument, which is not the case for any sensillum of the sensory cupule.

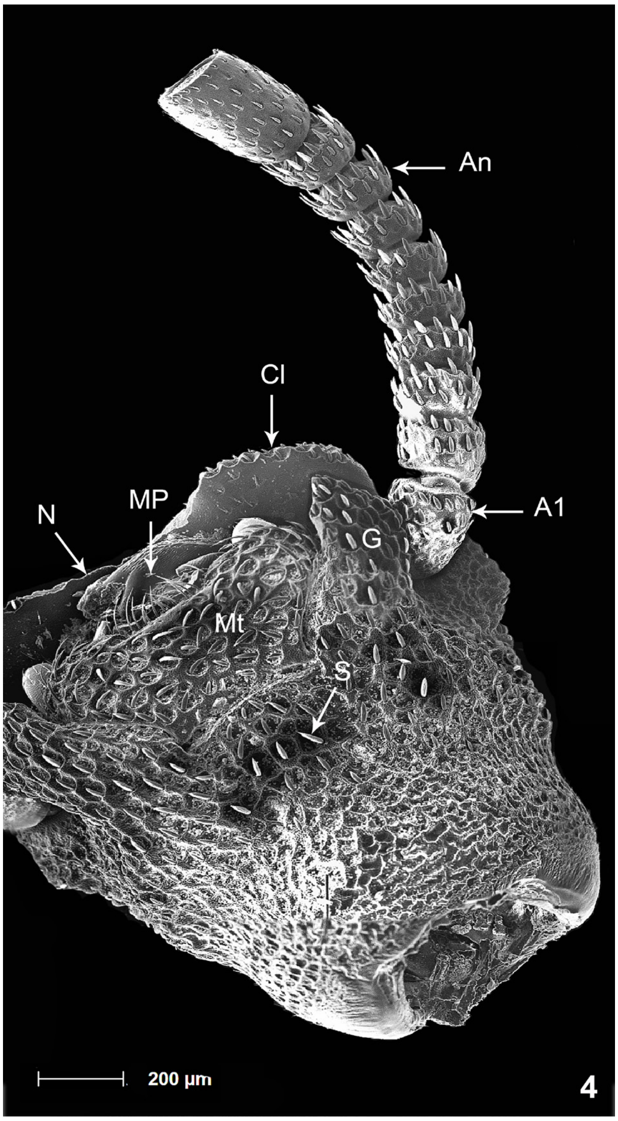


Figure 4. *Adelostoma sulcatum*,ventral view of head showing antenna (An) with first antennomere (A1), mouthparts (MP), mentum (M), gena (G), clypeus (Cl) with notch (N), and numerous yellow setae (S) (SEM).

### 2 – Identical form of antennomeres in *A. sulcatum*

In spite of the great morphological variety of insect antennae, the antennomeres of a given antenna usually show constant characteristics which are found in most orders.

Table 2**.** Morphological characteristics of large aporous fusiform sensilla chaetica C1 (for A1-A9) or C2 (for A10) on each antennomere of *Adelanostoma sulcatum* (n = 3). Ant.,A, antennomere; DS, distal sensilla; PS, proximal sensilla.

| Ant. | DS, PS | Length (µm) | Median width (µm) | Ant. | DS, PS | Length (µm) | Median width (µm) |
|---|---|---|---|---|---|---|---|
| A1 | DS | 40.0±0.2 | 11.6±0.1 | A6 | DS | 50.0±0.3 | 10.0±0.2 |
| | PS | 36.6±0.2 | 13.3±0.3 | | PS | 46.6±0.1 | 13.3±0.1 |
| A2 | DS | 36.6±0.1 | 13.3±0.2 | A7 | DS | 53.3±0.2 | 13.3±0.2 |
| | PS | 40.0±0.3 | 10.0±0.2 | | PS | 46.6±0.1 | 13.3±0.3 |
| A3 | DS | 46.6±0.2 | 16.6±0.3 | A8 | DS | 53.3±0.4 | 10.0±0.1 |
| | PS | 40.0±0.3 | 10.0±0.1 | | PS | 43.3±0.2 | 13.3±0.2 |
| A4 | DS | 46.6±0.2 | 16.6±0.3 | A9 | DS | 50.0±0.4 | 13.3±0.1 |
| | PS | 40.0±0.3 | 11.6±0.2 | | PS | 33.3±0.1 | 10.0±0.1 |
| A5 | DS | 50.0±0.2 | 16.6±0.3 | A10 | DS | 30.0±0.2 | 5.0±0.1 |
| | PS | 40.0±0.1 | 13.3±0.1 | | PS | 33.3±0.1 | 6.6±0.1 |

**Table 3 -** Numbers (n.) of large aporous fusiform sensilla chaetica C1 (for A1-A9) or C2 (for A10) on each antennomere of *Adelostoma sulcatum*.

| Antennomere | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| n. of rows | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 5 | 25 |
| n. C1 or C2 | 4,9 | 6,8,7 | 4,8,6 | 8,8 | 7,7 | 5,6 | 6,7 | 6,8 | 7,9 | 51 | 187 |
| /row/1 face | 13 | 21 | 18 | 16 | 14 | 11 | 13 | 14 | 16 | 51 | 187 |
| n. 2 faces | 26 | 42 | 36 | 32 | 28 | 22 | 26 | 28 | 32 | 102 | 374 |

Table 4. Morphological characteristics, location on antennomeres, numbers, percentages and presumed function of sensilla in *Adelostoma sulcatum*; mean ± S.E.
?, pores hypothesized but not clearly visible with studied material; n = 6.

| Sensilla | socket | pores | presumed function | location | numbers | % |
|---|---|---|---|---|---|---|
| Chaetica C1 | + | no pore | mechanoreceptive | A1-A9 | 272±1.9 | 16.7 |
| Chaetica C2 | + | no pore | mechanoreceptive | A10 | 102±1.5 | 6.2 |
| Chaetica C3 | + | no pore | mechanoreceptive | A10 cup | 67±0.4 | 4.1 |
| Trichodea T | – | wall pores? | olfactive | A10 cup | 897±7.1 | 55.1 |
| Basiconica B1 | – | wall pores? | olfactive | A10 cup | 45±1.6 | 2.8 |
| Basiconica B2 | – | wall pores? | olfactive | A10 cup | 246±2.3 | 15.1 |

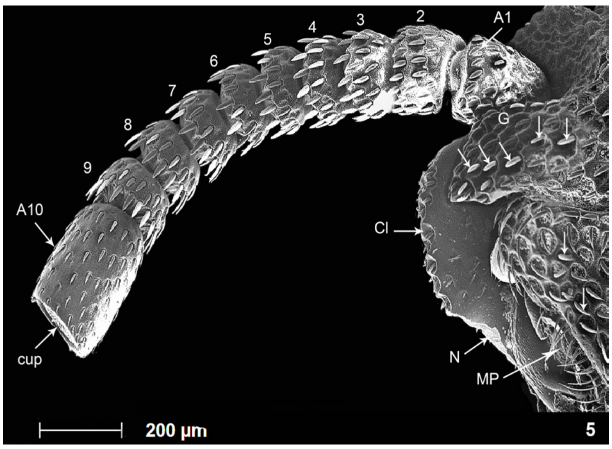


**Figure 5.** *Adelostoma sulcatum*, detail of Fig. 4 showing the antennomeres A1, 2-9, A10, and their sensilla (SEM).

According to Jeannel (1949), «The three primitive segments of the antenna are always clearly visible in coleopterans. The scape, always thick, shows a basal ball-joint which is articulated with a protrusion of the chitinous frame in which is inserted the antenna. Only the scape with a variable shape possesses its own musculature. The pedicel is usually short and always different from the following segments; it has no musculature. From 3rd segment, the antenna is constituted by the flagellum whose shape is very variable. The flagellomeres are articulated to each other through flexible membranes».

In *Adelostoma*, the antennomeres have an identical form; if the scape is larger than that of the following antennomeres, the pedicel is longer than most flagellomeres. The last antennomere, A10, is the longest but it is cylindrical and not club-shaped. The presence of a sensory cupule on the antennal apex is remarkable and does not appear to have been reported in any other insect.

### 3 - **Distribution of antennal sensilla and taxonomic importance**

The distribution of the antennal sensilla of insects is not without significance (Faucheux 1999). The first two antennomeres (scape and pedicel) usually possess tactile sensilla and Böhm sensilla which are mechanoreceptors with a proprioceptive function such as, for example, in cerambycids (Faucheux 2011b) and curculionids (Faucheux *et al*. 2019). The flagellomeres, from the first flagellomere F1 onwards, also possess olfactory and gustatory sensilla. The number of gustatory sensilla is constant from 3rd to apical antennomere but is slightly higher on the apical one. The olfactory sensilla (trichodea, basiconica, coeloconica,...) increase in number more or less regularly from the proximal to the distal flagellomere (Faucheux *et al*. 2017, 2020a, b) and the distal antennomeres frequently form a club with a maximum of olfactory sensilla (Faucheux *et al*. 2019).

The very diverse conformations of antennae in adult Coleoptera are generally related to the distribution of sensory organs and occur in both sexes (Jeannel 1949). This remark by Jeannel applies very well to the antennae of *A. sulcatum*: tactile sensilla chaetica are regularly distributed to the all flagellomeres, while grouped olfactory sensilla trichodea house the apical sensillum cupule.

In *Pachychila impunctata* (Tenebrionidae, subfamily Pimeliinae, tribu Tentyriini) (Faucheux 2023), the 3 distal antennomeres have scattered tactile sensilla chaetica and sensory fields, two lateral on A9 and A10 and one distal on A11. Each field contains olfactory sensilla – two types of s. trichodea T1 and T2, four types of s. basiconica B1-B4 –

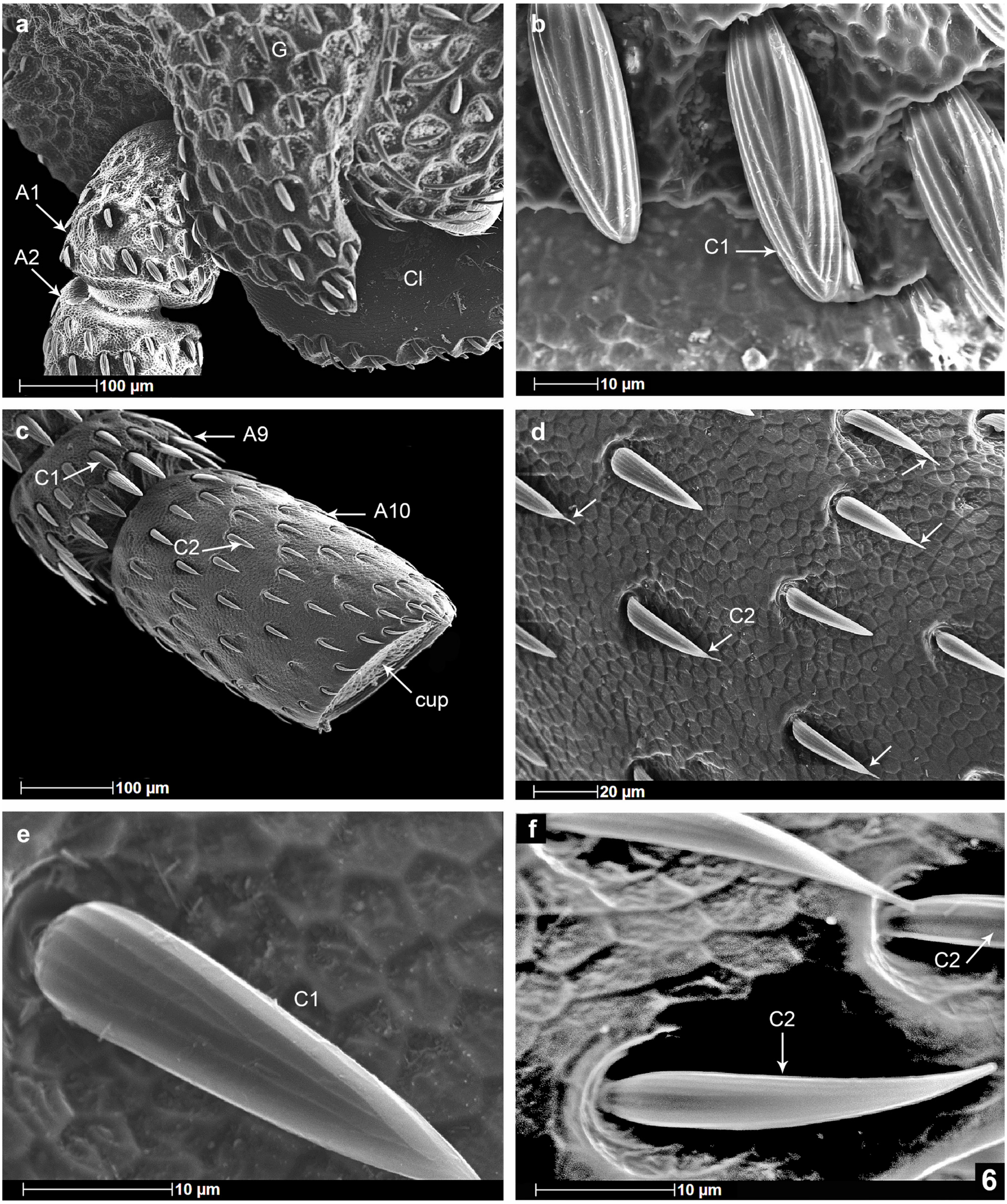


Figure 6. *Adelostoma sulcatum*, **a**, ventral view of antennomeres A1 and A2; **b**, detail of sensilla C1 on scape; **c**, distribution of sensilla C1 and C2 on antennomeres A9 and A10, with cupule; **d**, sensilla C2 on antennomere A10, the arrows show the terminal filament of certain sensilla; **e**, detail of base of C1; **f**, detail of base of C2 (SEM).

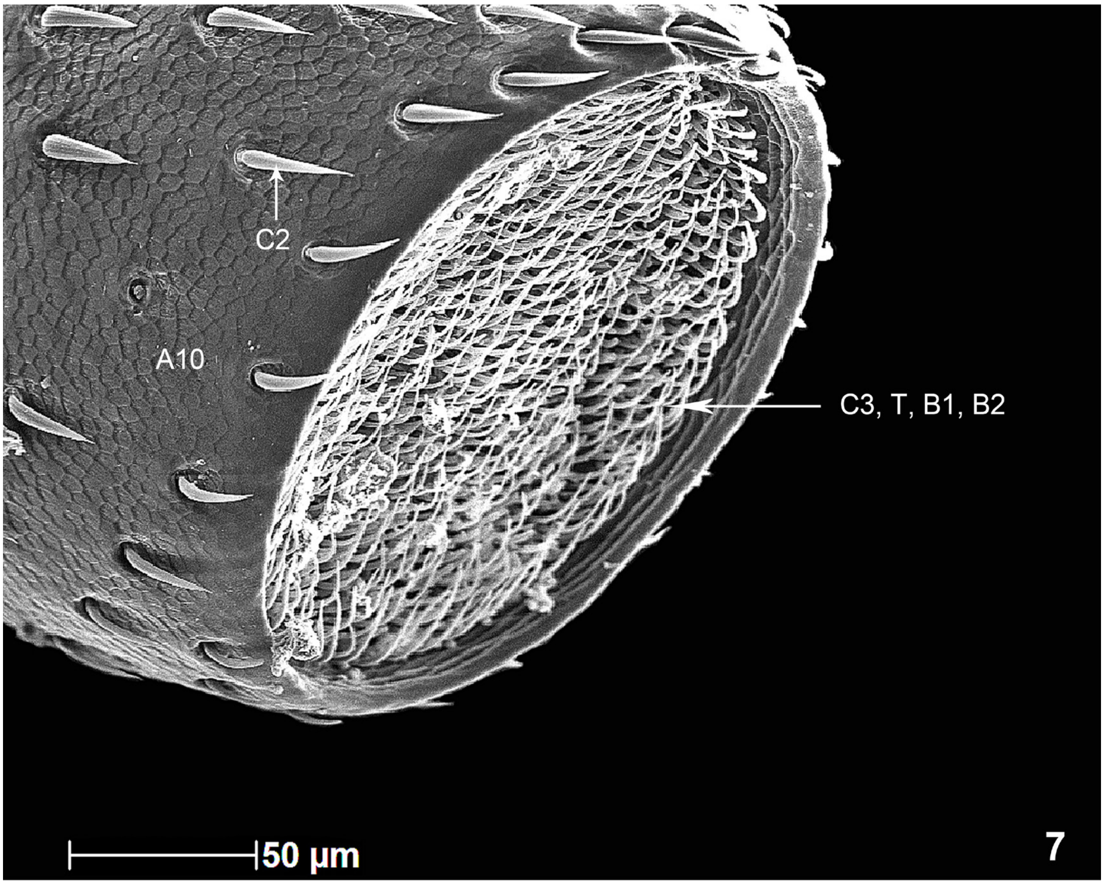


**Figure 7.** *Adelostoma sulcatum*, cupule of A10 showing set of sensilla chaetica C3, trichodea T, basiconica B1 and B2 (SEM).

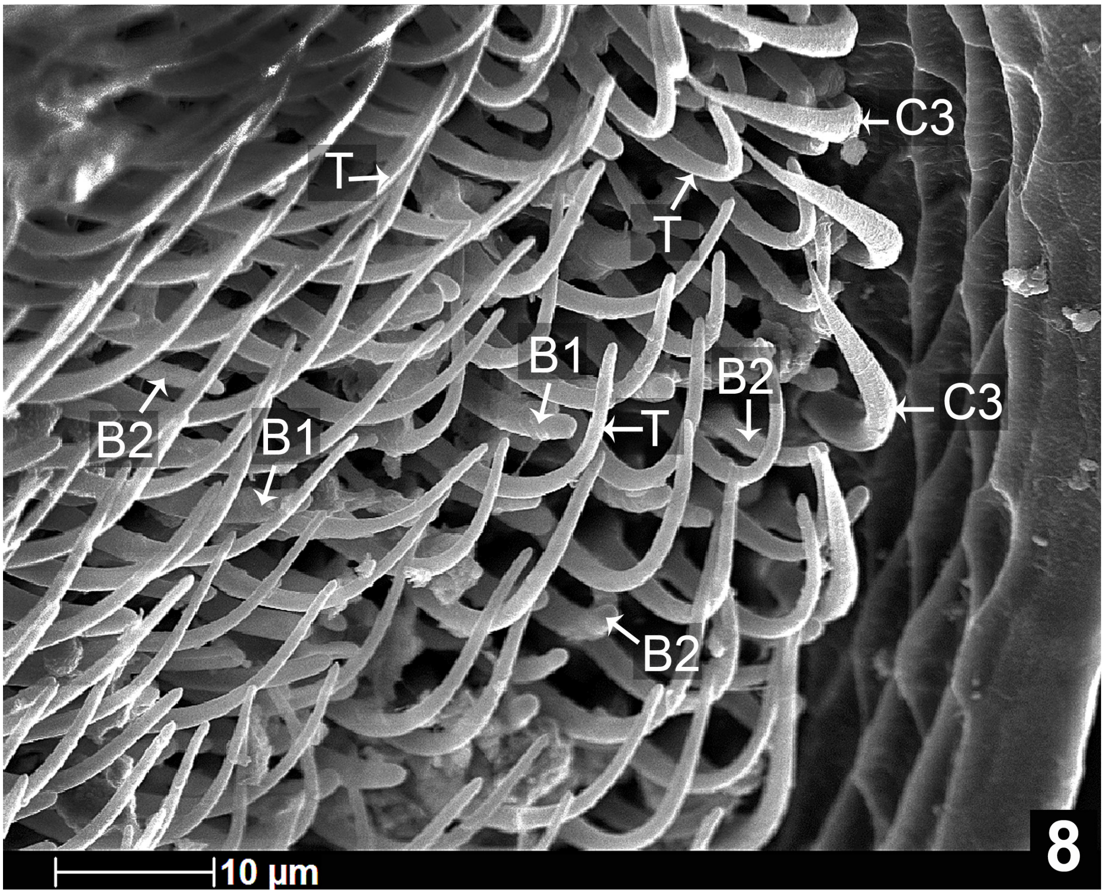


**Figure 8.** *Adelostoma sulcatum*, detail of cupule showing sensilla C3, T, B1 and B2 (SEM).

and gustatory s. chaetica. Sensilla T1 and T2, sensilla B1 and B2 of *P. impunctata* resemble sensilla T1, T2, B1, B2 present in the cupule of *A. sulcatum.* We have observed the antennae of various tenebrionids belonging to some tribes of subfamily Pimeliinae (unpublished observations). Sensilla fields were found in the following tribes studied: Tentyriini, Adesmiini, Akidini, Asidini, Erodiini, Pimeliini. Some fields had already been mentioned in Pimeliinae by Pierre (1958). In particular, the last antennal segment (segments 10 and 11 probably merged) in *Leptonychus* Chevrolat (tribe Erodiini) has a sensory field («prolongement sensoriel» of Pierre, 1954) more or less developed, whose form and size help to differentiate species (Pierre 1958, p. 184).

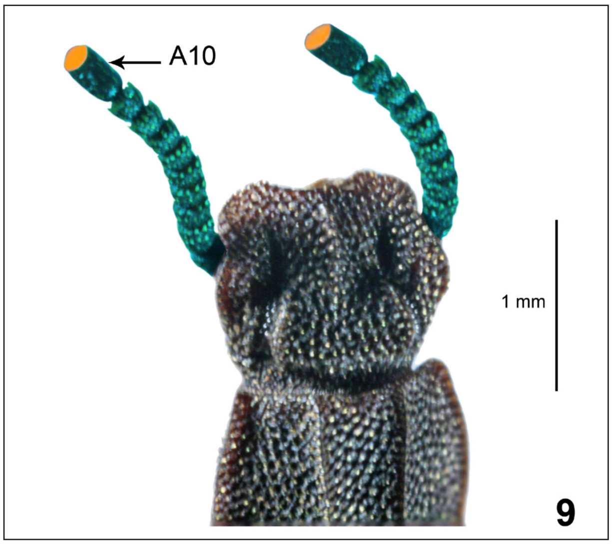


Figure 9. *Adelostoma sulcatum*, pronotum and head with antennae coloured green (tactile part) and orange (olfactory part) ; A 10, antennomere 10.

In *A. sulcatum*, the antenna with tactile antennomeres possesses a unique and dense sensory field which is apical and olfactive, situated in a circular cupule which is transverse and not very deep in which a large number sensilla (about 1255) are to be found at the same frontal level. The scape, pedicel, and flagellum have the same types of sensilla. The other species of genus *Adelostoma* Duponchel possess the same type of 10-segmented antennae with truncated apex (see Purchart 2012). Certain other genera of tribe Adelostomini have truncated antennae, for instance *Pogonobasis opatra* Koch, 1952, whose antennae seem identical to those of *A. sulcatum* as regards the type and distribution of sensilla.

Within the subfamily Pimeliinae, the tribe Adelostomini would show an extreme evolution of the antennal apical sensillar field by becoming transverse.

### 4 – Specificity of the antennal sensilla in relation to the life in galleries of termites

The possibility for *Adelostoma* to move about in underground galleries does not appear to have been described so far. The discovery of this tenebrionid living both under the stones and in contact with the galleries of *Microhodotermes* in Southern Morocco is an encouragement to envisage this way of life. The morphology of *A. sulcatus* appears to be quite well adapted to movement in a confined space: a slender body with sub-parallel sides, short legs, and the absence of raised structures. The thick antennae facilitate walking in galleries: they are rather short and stout, and can stand easily in the prolongation of the body. Their sensilla are neither long nor at right angles, without extending beyond the antennomeres; on the contrary, they are held close to the antennal tegument and therefore cannot hinder the insect's progress.

The fusiform s. chaetica C1 belong to a particular type not often observed on insect's antennae. They possess no really tactile function; their mechanoreceptive role is more properly

Figure 10. *Adelostoma sulcatum*, Djebel Saghro, Kouaouch, 2485 m, 16/04/2011 (photograph Lionel Casset).

proprioceptive. They would be stimulated by the more or less strong pressure exerted during the contact of the antennae with the wall of galleries; they would inform the insect about the narrowness of the latter. The distribution, the number, and the coverage rate of the fusiform sensilla chaetica exclude the presence of other sensillum types. This may justify the displacement and concentration of all other sensilla towards the antennal tip in the transversal cupule in which they are protected from outside contacts. The concentration of olfactive sensilla in front of antennae allows them to be directly informed of the approach of other insects.

Above ground, by curving its antennae towards the soil, the beetle can sense odors of the immediate environment with the antennal apices. A photograph of *Pogonobasis opatra* Koch, 1952, Adelostomini whose truncated antennae are identical to those of *Adelostoma,* showing an antenna directed towards the ground, circulate on the Worldwide Web. Similarly, the entomologist Lionel Casset who found some individuals of *A. sulcatum* under the stones in Southern Morocco and Egypt, shows a photograph of this beetle representing its antennae positioned forward with the two cupules side by side. Figure 10 shows one live Adelostomini, *A. sulcatum* whose antennae move towards the ground.

Myrmecophilous species exist in some Adelostomini. Various species of *Brachymoschium* Fairmaire, whose apical antennomere is widened and truncated, are confined to the arid regions of Madagascar where, accompanied by ants, they live under stones (Dajoz 1979). *Cimiciopsis* sp., with truncated antennae from Namaqualand in South Africa, is associated with ants of the genus *Crematogaster* Lund (Schawaller 2007). No Adelostomini species had been discovered previously living with termites. However, certain Tenebrionidae Tenebrioninae belonging to tribes of Amarygmini and Rhysopausini are termitophilous (Bremer 2019, Jiang et al. 2019, 2021). It is striking that Lionel Casset is a frequent observer of *A. sulcatum* in Tunisia in the company of myrmecophilous *Stenosis* sp. (Pimeliinae Stenosini) under stones, in the absence of ants (pers. comm.).

## CONCLUSION

Olfaction plays a particularly important role in *A. sulcatum* because all odors are perceived at the same time by the sensilla of the cupule, according to a certain distance from the beetle corresponding to the length of the two antennae. The role of antennomeres A1-A9 could be principally mechanical in probing the substratum of a search for odors deposed by termites as the form of marking pheromones. The localisation at the same place of the sensilla trichodea and basiconica in an apical flat and shallow cupule, enables them to receive at the same time the odors emanating from another insect or plante and both to retain and concentrate these odors as well as to optimise their response. The optimisation of olfaction makes it possible to palliate the tenebrionid's poor eyesight. The supposed association of *Adelostoma* with termites is no doubt worthnoting, the darking beetles thus being able to profit from the fragments of stalks of grasses deposed in hay lofts, but this may be a particular case. Indeed, although dark beetles are a characteristic family in desert and dry environments, they may also be found in temperate and humid environments, though with a small number of species and less density (Sarhan et al. 2020). Thus, *A. sulcatum* is identified as the utiliser of dead material developing in a decomposing wood in Uzbekistan as well as in private houses or in natural biotopes (Zhuginisov et al. 2019).

**Acknowledgments**

My thanks to Nicolas Stephant (Service of scanning electronic microscopy and microanalyis X, SMEBM, Faculty of Science of Nantes, France) for his help in SEM observations, Gérard Beaulieu (Angers, France) for the photos of *Adelostoma sulcatum* as well as for the preparation of the photographic plates, and Vittorio Ballardini (La Roche-Bernard, France) for the English translation. I also thank Pr. Ahmed Taheri (Chouaïb Doukkali University, Faculty of El Jadida, Morocco) for fruitful review of the manuscript.

## REFERENCES

Ali S.A.I., Diakite M.M., Ali S. & Wang M.Q. 2016. Effect of the antennal sensilla distribution pattern on the behavioral responses of *Tribolium castaneum* (Coleoptera: Tenebrionidae). *Florida Entomologist,* 99 (1), 52-59.

Altner H. & Prillinger L. 1980. Ultrastructure of invertebrate chemo-, thermo-, and hygroreceptors and its functional significance. *International Review of Cytology*, 67, 69-130.

Bremer H.J. 2019. A new genus and species of Oriental termitophilous Amarygmini (Coleoptera: Tenebrionidae). *Mitteilungen der Münchner Entomologischen Gessellschaft,* 109, 59-63.

Dajoz R. 1979. Coléoptères de Madagascar, I. Description de deux nouveaux *Brachymoschium* Fairmaire (Tenebrionidae). *Bulletin de la Société entomologique de France*, 84 (7-8), 174-176.

Faucheux M.J. 1999. *Biodiversity and unity of sensory organs in lepidopteran insects.* Société des Sciences Naturelles de l'Ouest de la France (éd.), Nantes, 296 p.

Faucheux M.J. 2009. Coléoptères *Ténébrionidés* du Maroc atlantique: Prospections de 1996 à 2006. Considérations morphologiques et écologiques. *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France* (N.S.)*,* 31, 155-178.

Faucheux M.J. 2011a. Coléoptères *Ténébrionidés* de Larache et Oualidia (Maroc atlantique): prospections de 2006 à 2009. *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France* (N.S.), 33, 54-56.

Faucheux, M.J. 2011b. Antennal sensilla of the yellow beetle *Phoracantha recurva* Newman, 1840: distribution and comparison with *Phoracantha semipunctata* (Fabricius, 1775) (Coleoptera: Cerambycidae). *Bulletin de l'Institut Scientifique*, Rabat, section Sciences de la Vie, 33, 19-29.

Faucheux M.J. 2013. Morphologie fonctionnelle des sensilles antennaires de *Scaurus gigas* Walt, 1835 (Coleoptera: Tenebrionidae). *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France* (N.S.), 35, 109-125.

Faucheux M.J. 2017. Coléoptères Ténébrionidés du Maroc atlantique: 3ème liste (Lagriinae, Pimeliinae, Tenebrioninae, Alleculinae, Diaperinae). *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France* (N.S.), 39, 115-124.

Faucheux M.J. 2023. Le sensilles antennaires de *Pachychila (Pachychila) impunctata* Fairmaire, 1860 (Coleoptera: Tenebrionidae: Pimeliinae: Tentyriini). *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France* (N.S.), 45, 54-62.

Faucheux M.J., Kundrata R. 2017. Comparative antennal morphology of male Drilini with special reference to the sensilla (Coleoptera: Elateridae: Agrypninae). *Zoologischer Anzeiger–A Journal of Comparative Zoology,* 266, 105-119.

Faucheux M.J., Hamidi R., Mercadal M., Thomas M. & Frérot B. 2019. Antennal sensilla of male and female of the nut weevil, *Curculio nucum* Linnaeus, 1758 (Coleoptera: Curculionidae). *Annales de la Société entomologique de France* (N.S.), 55 (5), 395-409.

Faucheux M.J, Németh T. & Kundrata R. 2020a. Comparative antennal morphology of *Agriotes* (Coleoptera: Elateridae) with special reference to the typology and possible functions of sensilla. *Insects,* 11, 137; doi:10.3390/insects11020137.

Faucheux M.J., Németh T., Hoffmannova J. & Kundrata R. 2020b. Scanning electron microscopy reveals the antennal micromorphology of *Lamprodila (Palmar) festiva* (Coleoptera: Buprestidae), an invasive pest of ornamental Cupressaceae in Western Palaearctic. *Biology,* 9, 375; doi: 10.3390/biology9110375

Grassé P.P. 1985. *Termitologia: Anatomie – Physiologie – Biologie - Systématique des termites. Tome III: Comportement – Sociabilité – Écologie – Évolution – Systématique.* Masson, Paris, 715 p.

Harbach, R.E., Larsen, J.R. 1977a. Fine structure of antennal sensilla of the adult mealworm beetle, *Tenebrio molitor* L. (Coleoptera: Tenebrionidae). *International Journal of Insect Morphology & Embryology,* 6 (1), 41-60.

Jeannel R. 1949. Ordre des Coléoptères. Partie générale. Antennes: p. 786-789. In Grassé P.- P. (éd.), *Traité de Zoologie, tome IX: Insectes,* Masson et Cie, Paris.

Jiang R.X., Wang T.S., Li B.Y., Lin Y.J., Liu L. , Wang S. 2019. Discovery of termitophilous tenebrionid beetles in China (Coleoptera: Tenebrionidae). *Acta Entomologica Musei Nationalis Pragae,* 59 (1), 341-349.

Jiang R.X., Song H.T., He X.Y., Engel M.S., Wang S. 2021. A new termitophilous genus and species of the tribe Amarygmini Gistel, 1848 from China (Coleoptera: Tenebrionidae). *Zootaxa*, 5004 (4), 573-586.

Labrique H. & Chavanon G. 2001. Résultats d'une campagne de prospection entomologique dans le Maroc oriental (Coleoptera: Tenebrionidae). *Cahiers scientifiques,* Muséum d'Histoire naturelle de Lyon, 2, 75-87.

Najjari A., Taheri A., Hernández Teixidor D. & Wetterer J.K. 2023. First outdoor records in the Old World of the invasive drywood temite, *Crypytotermes brevis* (Walker, 1853) (Kalotermitidae). *Journal of Applied Entomology*, 00, 1-3. https://doi.org/10.1111:jen.13156.

Paulian R. 1949. Ordre des Coléoptères, Partie systématique, Heterogastra. Famille des Tenebrionidae: p. 910-912. In Grassé P.-P. (éd.), *Traité de Zoologie, tome IX: Insectes,* Masson et Cie, Paris.

Pierre F. 1954. Le genre *Leptonychus* Chevrolat (Col. Tenebrionidae). *Annales de la Société entomologique de France,* 123, 17-33.

Pierre F. 1958. *Écologie et peuplement entomologique des sables vifs du Sahara nord-occidental.* Publications du Centre de Recherches sahariennes, série Biologie n°1. Centre National de la Recherche Scientifique, Paris, 332 p.

Purchart L. 2009. Review of the genus *Adelostoma* Duponchel, 1827 (Coleoptera: Tenebrionidae: Adelostomini) from the Socotra Archipelago, with description of a new species. *African Entomology,* 17 (1), 23-27. DOI:10.4001/003.017.0103

Purchart L. 2012. Revision of the genus *Adelostoma* (Coleoptera: Tenebrionidae), Part 1: subgenus *Zarudnionymus* Semenov & Bogatchev, 1947). *Zootaxa,* 3164, 17-31.

Purchart L. 2017, Revision of the genus *Adelostoma* (Coleoptera: Tenebrionidae), Part 2: A new subgenus and species from Oman. *Zootaxa*, 4258 (3), 281-286.

Purchart L. 2022. Revision of the genus *Pogonobasis* (Coleoptera: Tenebrionidae). Part 1: Two new species from Eastern Africa and catalogue of genus. *Annales Zoologici*, 72 (1), 174-176.

Ricart M.G., Roca C.B. & Baltanas R.M. 2015. Clase Insecta: Orden Isoptera. *Revista Ibero Diversidad Entomologia* @ccesible, 49, 1-17. https://seaentomologia.org/IDE@revista_49.pdf

Sarhan H., Samour M. & Shahadi F. 2020. Contribution to the study of darkling beetles (Tenebrionidae: Coleoptera) from Bmanneh, Syria. *Noyabr* 11 (50), tome 1, 13-20.

Schawaller W. 2007. A new myrmecophilous species of *Cimiciopsis* Koch from Namaqualand in South Africa with a stridulatory organ, and a checklist of the genera of Adelostomini (Coleoptera:Tenebrionidae). *Annals of the Transvaal Museum*, 44 (1), online.

Scholtz C.H. & Holm E. 1985. *Insects of Southern Africa*. Durban: Buttterw.

Seada M.A. & Hamza A.M. 2018. Differential morphology of the sensory sensilla of antennae, palpi, foretarsi and ovipositor of adult *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). *Annals of Agricultural Sciences*, 63, 1-8.

Solier A.J.J. 1837. Essai sur les Collaptérides (suite), 8^e^ tribu: Adélostomites. *Annales de la Société entomologique de France*, 6, 151-171.

Zacharuk R.Y. 1980. Ultrastructure and function of insect chemosensilla. *Annual Review of Entomology*, 25, 27-47.

Zacharuk R.Y. 1985. Antennae and sensilla: 1-70. In G.A. Kerkut & L.I. Gilbert (eds.), *Comprehensive Insect Physiology, Biochemistry and Pharmacology* vol. 6, Pergamon Press, London.

Zhuginisov T.I., Lebedeva N.I., Ganieva Z.A., Kaniyazov S.J. & Mirzaeva G.S. 2019. Xylophagous insects in the dead wood of Uzbekistan. *International Journal of Research and Development*, 4 (10): 149-154.

Casset Lionel: photo in Jordania. Al Sedra, 1115 m in altitude, 11/05/2017. In insecte.org/forum/wiewtoic.phpt:185390.

Manuscrit reçu le 02/06/2023
Version révisée acceptée le 12/11/2023
Version finale reçue le 23/11/2023
Mise en ligne le 29/11/2023