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Zoological Studies

Descriptions of Six New Species of *Hydrochus* from South and North America (Coleoptera, Hydrochidae)

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Dewanand Makhan (1995) Descriptions of six new species of *Hydrochus* from South and North America (Coleoptera, Hydrochidae). *Zoological Studies* **34**(1): 18-20. Six new species of *Hydrochus* (Coleoptera, Hydrochidae), *Hydrochus ramdhanii* from South America, *H. jaechi, H. monishi, H. daviniaae, H. bakkeri* and *H. schereri* from North America, are described.

Key words: Coleoptera, Hydrophilidae.

The Naturhistorisches Museum, Wien, Austria and the Zoologische Staatssammlung München, Germany, sent me some *Hydrochus* samples for identification. Six new species were found among these samples: one new species collected from South America and five new species from North America. The holotype of *Hydrochus schereri* is deposited in the Zoologische Staatssammlung, München, Germany, while all other holotypes are deposited in the Coleoptera Collection of Naturhistorisches Museum, Wien, Austria.

Hydrochus ramdhanii sp. n.

Holotype: male. Colombia, 7/15.Apr.1970, (K. Köster leg.) (only the holotype).

Description (holotype male): Body elongated, 3.4 mm in length, 1.2 mm in width. Dorsal side shiny. Color of head, pronotum, scutellum and elytra coppery, with a blue-green metallic gloss. Head with coarse punctures. Pronotum longer than wide, lateral area smooth. Disc with seven deep depressions. Anterior margin of pronotum with three depressions, one in the center, two behind this. Posterior margin with four depressions.

Elytron length 2.1 mm, the posterior third widest, lateral area smooth, interstriae wider than stria punctures, tubercles absent, interstriae flat. Apical holes absent. Elytra apices rounded.

Male genitalia (Fig. 1): Basal piece short, median lobe as long as paramera.

Etymology: The species is named after my uncle Adjdhiapersad (Djien) Ramdhani.

Remarks: This species seems to be allied to *H. battjai* Makhan (1992) from Surinam, but there is a difference in the shape of the male genitalia. Paramera in *H. battjai* widened to apex, paramera in *H. ramdhanii* narrowed to apex.

Hydrochus jaechi sp. n.

Holotype: male. USA, Texas, Big Thicket, Kountze, 27/28.Nov. 1991, (Jäch leg.).
Paratype: 1♂ (same data as holotype).

Description (holotype male): Body elongated, 4.5 mm in length, 1.4 mm in width. Dorsal side shiny, color of head, pronotum, scutellum and elytra black, with a blue-green metallic gloss. Head with coarse punctures. Pronotum longer than wide, lateral area smooth. Disc with five large, shallow depressions. Anterior margin of pronotum with three depressions, one in the center, two behind this. Posterior margin with two depressions.

Elytron length 2.9 mm, the posterior third widest, lateral side smooth, stria punctures wider than interstriae. Interstriae convex, tubercles absent. Apical side with four holes. Elytra apices rounded.

Male genitalia (Fig. 2): Basal piece long,

paramera longer than median lobe.

Etymology: This species is named after Manfred Jäch, Curator of the Coleoptera Collection of Naturhistorisches Museum, Wien, Austria.

Remarks: This species is very similar to *Hydrochus bakkeri* and *H. monishi*. Interstriae in *H. bakkeri* and *H. monishi* flat, interstriae in *H. jaechi* convex.

Hydrochus monishi sp. n.

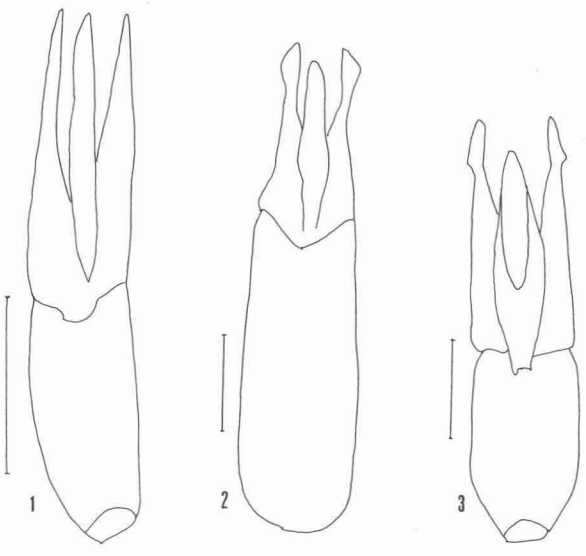
Holotype: male. USA, Texas, Palmetto State P. 70 km S. Austin, 26.Nov.1991, (Jäch leg.) (only the holotype).

Description (holotype male): Body elongated, 3.9 mm in length, 1.4 mm in width. Dorsal side shiny. Color of head, pronotum, scutellum and elytra black, with a blue-green metallic gloss. Head with coarse punctures. Pronotum longer than wide, and lateral area with granules. Disc with five large deep depressions. Anterior margin of pronotum with three depressions, one in the center, two behind this. Posterior margin with two depressions.

Elytron length 2.5 mm, the posterior third widest, lateral area smooth, stria punctures same width as interstriae, interstriae flat. Elytra apices rounded. Apical holes absent.

Male genitalia (Fig. 3): Basal piece short, paramera longer than median lobe.

Etymology: This species is named after my nephew Monish Makhan.



Figs. 1-3. 1. Male genitalia *Hydrochus ramdhanii* sp. n. 2. Male genitalia *Hydrochus jaechi* sp. n. 3. Male genitalia *Hydrochus monishi* sp. n.
(scale line 0.25 mm)

Remarks: This species is very similar to *Hydrochus bakkeri*. *Hydrochus bakkeri* with narrowed basal piece, *H. monishi* with widened basal piece.

Hydrochus daviniaae sp. n.

Holotype: male. USA, Texas, Santa Ana WR. S. McAllen, 20/21.Nov.1991, (Jäch leg.).
Paratype: 1 ♀ (same data as holotype).

Description (holotype male): Body elongated, 3.2 mm in length, 1.1 mm in width. Dorsal side shiny. Color of head, pronotum, scutellum and elytra black, with a blue-green metallic gloss. Head with fine punctures. Pronotum longer than wide, lateral area smooth. Disc with seven large, deep depressions. Anterior margin of pronotum with three depressions, one in the center, two behind this. Posterior margin with four depressions.

Elytron length 2.0 mm, the posterior third widest, lateral side smooth, interstriae wider than stria punctures interstriae carinate. Apical side with two holes. Elytra apices rounded.

Male genitalia (Fig. 4): Basal piece short, parameres longer than median lobe.

Etymology: This species is named after my niece Davinia Makhan.

Remarks: This species similar to *Hydrochus schereri*. *H. schereri* with apical side with four holes, *H. daviniaae* with two holes.

Hydrochus bakkeri sp. n.

Holotype: male. USA, Texas, Santa Ana WR. S. McAllen, 20/21.Nov.1991 (Jäch leg.) (only the holotype).

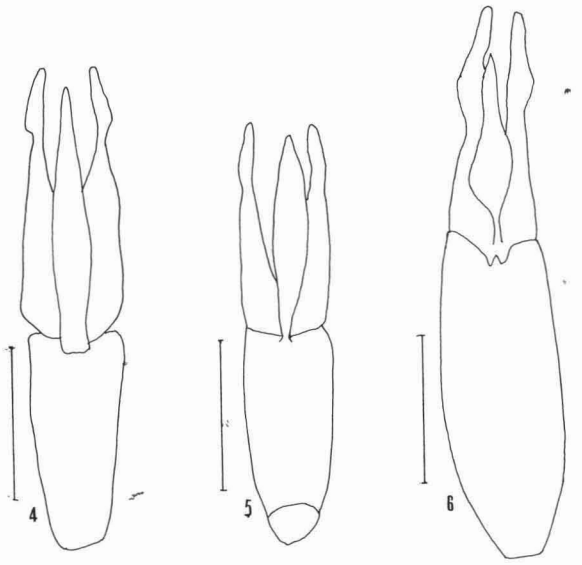
Description (holotype male): Body elongated, 3.1 mm in length, 1.2 mm in width. Dorsal side shiny. Color of head, pronotum, scutellum and elytra green, with a blue-green metallic gloss. Head with fine punctures. Pronotum longer than wide, lateral area smooth. Disc with five large, deep depressions. Anterior margin of pronotum with three depressions, one in the center, two behind this. Posterior margin with two depressions.

Elytron length 1.9 mm, the posterior third widest, lateral area smooth, stria punctures same size as interstriae, tubercles absent. Apical holes absent. Elytra apices rounded.

Male genitalia (Fig. 5): Basal piece as long as paramera, paramera longer than median lobe.

Etymology: This species is named after my friend Robert Arthur Bakker.

Remarks: This species is very similar to *Hydrochus monishi*. *H. bakkeri* with narrowed basal



Figs. 4-6. 4. Male genitalia *Hydrochus daviniaae* sp. n. 5. Male genitalia *Hydrochus bakkeri* sp. n. 6. Male genitalia *Hydrochus schereri* sp. n.
(scale line 0.25 mm)

piece, *H. monishi* with widened basal piece.

Hydrochus schereri sp. n.

Holotype: male. USA, GA. Mitchell Co. near Vada. 5.Jun.1954, (F.N. Young leg.).

Description (holotype male): Body elongated, 3.1 mm in length, 1.1 mm in width. Dorsal side shiny. Color of head, pronotum, scutellum, and elytra green, with a blue-green metallic gloss. Head with coarse punctures. Pronotum longer than wide, lateral area smooth. Disc with five large deep depressions. Anterior margin of pronotum with three depressions, one in the centre, two behind this.

Elytron length 1.9 mm, the posterior third widest, lateral area smooth, interstriae wider than stria punctures, tubercles absent, interstriae flat. Apical side with four holes. Elytra apices rounded.

Male genitalia (Fig. 6): Basal piece long, paramera longer than median lobe.

Etymology: This species is named after Gerhard Scherer, Curator of the Coleoptera Collection, Zoologische Staatssammlung, München, Germany.

Remarks: This species similar to *Hydrochus daviniaae. H. schereri* with long basal piece, *H. daviniaae* with short basal piece.

Acknowledgements: I wish to thank the Curators of Coleoptera, Dr. Gerhard Scherer (München, Germany) and Manfred Jäch (Wien, Austria) for the loan of the *Hydrochus* samples.

REFERENCES

Makhan D. 1992. Twelve new *Hydrochus*-species from South America (Coleoptera: Hydrophilidae). Phegea **20(2):** 95-103.

Makhan D. 1993. Nine new *Hydrochus*-species from South and Central America (Coleoptera: Hydrophilidae). Annls. Hist. Natn. Hung. **85:** 65-70.

Makhan D. 1994. Descriptions of a new species in a new genus, *Kiransus*, and five new species of *Hydrochus* (Coleoptera, Hydrophilidae). Zool. Stud. **33(2):** 160-164.

Makhan D. 1994. Thirty-five new *Hydrochus* species from the Old and the New World (Coleoptera: Hydrophilidae). Annls. Hist. Natn. Hung. **86:** 29-42.

美洲產*Hydrochus*屬六新種牙蟲(鞘翅目：牙蟲科)

Dewanand Makhan[1]

本文描述六新種採集自美洲，屬於鞘翅目牙蟲科*Hydrochus*屬的新種昆蟲，分別爲得自南美洲的*Hydrochus ramdhanii*，與來自北美洲的*H. jaechi, H. monishi, H. daviniaae, H. bakkeri,* 及 *H. schereri*。

關鍵詞：鞘翅目，牙蟲科。

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Zoological Studies

Ultrastructure of the Antennal Sensilla of the Oriental Fruit Fly *Bactrocera* (=*Dacus*) *dorsalis* (Hendel) (Diptera: Tephritidae)

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Wen-Yung Lee, Jui-Chun Chang, Tai-Lang Lin and Yu-Bing Hwang (1995) Ultrastructure of the antennal sensilla of the orienal fruit fly, *Bactrocera* (=*Dacus*) *dorsalis* (Hendel) (Diptera: Tephritidae). *Zoological Studies* **34**(1): 21-28. Ultrastructure of the antennal sensilla on the funiculus of *Bactrocera dorsalis* is distinguished into two groups: the single-walled sensilla and the double-walled sensilla. The single-walled sensilla are further divied into those with thick-walled-pore and those with thin-walled-pore. The former have thick cuticular sensillar wall about 0.18-0.38 μm in thickness. The pore openings are small and the density of pores is only 11 to 12 pores per square micron. One or two dendrites appear in each sensillar lumen and they connect with one or two sensory cells. The latter have a thin cuticular walls about 0.05-0.15 μm in thickness. The density of pores is about 25 pores per square micron. The pore openings are large with a circular pore below the cuticular wall. Twenty to sixty dendritic branches appear in the distal region of the sensillar lumen. In the clavate sensilla, besides the dendritic branches, there is a lamella or rolled dendritic structure on the midregion of the sensillar lumen, with one or two sensory cells at the base of the sensilla, below the cuticular part. The double walled sensilla contains an original cuticular sensilla wall and 10 to 12 ridges to make a double walled structure which appears as a stellate structure in cross section. These sensilla include two sensory neurons and two to four dendritic branches in the sensillar lumen.

Key words: Ultrastructure, Thick-walled-pore sensilla, Thin-walled-pore sensilla, Double-walled sensilla.

The antennae of insects are the major chemoreceptors for detecting and distinguishing airborne stimulants, as well as for evoking suitable behaviors, such as feeding, mating or oviposition. Seven types of sensilla on the funiculus (as referring to the third antennal segment) of *Bactrocera dorsalis* antennae have been morphologically described through use of the scanning electron microscopy by Lee et al. (1994). The seven morphological types are: the trichoid type I and type II, the basiconic type I and II, the clavate type I and II, and the styloconic (grooved) sensilla. The morphology and distribution, as well as the number, of each type of sensillum exhibits no sexual dimorphism in this fly. Although considerable information is available on the ultrastructure of antennal sensilla of Dipterans (Bay and Pitts 1976, Chu-Wang et al. 1975, Dickens et al. 1988, Hallberg et al. 1985, Lewis 1971, McIver 1960 1978, Slifer and Sekhan 1964, Sutcliffe et al. 1990, Venkatesh and Singh 1984), little is known about the detailed ultrastructure of the antennal sensilla of *B. dorsalis*. Accordingly, this investigation is along with our previous morphological studies on the antennal sensilla of *B. dorsalis*, extends our knowledge of the ultrastructure of the antennal sensilla in this insect.

MATERIALS AND METHODS

The *B. dorsalis* flies were obtained from the laboratory colony at the Institute of Zoology, Academia Sinica. The disected antennae of the flies were immersed in 2.5% glutaraldehyde in 0.1 M cacodylate buffer for 6 hrs at 6°C before

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shaking for two minutes to cleanse the surface of the antennae. A slight vacuum was applied to remove the air bubbles from inside and outside the tissue specimens. These antennae were post-fixed in 2% osmium tetraxide plus 0.1 M cacodylate buffer at 6°C for 2 hrs, then stained with 25% aqueous uranyl acetate after washing with distilled water. Dehydration was accomplished through a graded series of ethanol from fifty percent to absolute, then propylene oxide was used for infiltration. The specimens were embedded in Spurr's (1969) low viscosity medium. Thin sections (ca. 800 Å) were made with a diamond knife and were picked up on copper grids with 0.3% formvar supporting membrane, then stained with uranyl acetate in 50% alcohol and lead citrate. These preparations were viewed with Hitachi H-7000 transmission electron microscope at 75 kv or 100 kv a accelerating voltages.

RESULTS

The antennae of *B. dorsalis* consist of three segments; the scape, the pedicel and the funiculus. The chaetica and the microtrichoids occur on the scape and the pedicel. Many sensilla are distributed on the funiculus among the microtrichoids. A sensory pit is located on the external surface, about one-fifth of distance from the proximal region of the funiculus.

The ultrastructure of the cuticular wall of these sensilla on the funiculus of *B. dorsalis* can be distinguished into two groups: Single-walled sensilla and double-walled sensilla. Single-walled sensilla are further divided into those with thick-walled-pore and those with thin-walled-pore.

Thick-walled-pore sensilla

Thick-walled-pore sensilla characterize the trichoid type I sensilla (Fig. 1), with a thick cuticular wall. The thickness of the cuticular wall is about 0.25-0.38 μm at the base and about 0.18-0.2 μm at the distal region. The thickness appears to decrease from the base to the tip of the sensilla. The external openings of the pores are very small, ranging from 100 to 200 Å. The distance between any two openings is about 0.35-0.5 μm; thus, the density of the openings on the sensilla is only about 11-12 pores per square micron. Internally, each pore connects to the sensillar lumen through a funnel-like structure. The lumen is filled with an electron dense material. One or two dendrites appear in each sensillum. Individual dendrites contain different numbers of microtubules.

The structures at the base of the sensillum are composed of one or two sensory cells connected with the outer dendritic segment. A receptor lymph cavity surrounds the outer dendritic segment. Epidermal cells appear at the sides of the sensory cells (Fig. 1a).

Thin-walled-pore sensilla

Thin-walled-pore sensilla occur in several morphological types on the funiculus of the *dorsalis* fly antennae: trichoid type II sensilla, clavate sensilla and basiconic sensilla. Their ultrastructures (Figs. 2, 3) are similar and they have thin cuticular walls, ranging from about 0.05 to 0.15 μm. The external opening of each pore is about 300-800 Å. The distance between any two openings is about 0.1-0.2 μm or even less. Therefore, the density of the pores on these sensilla is about 25 pores per square micron. These sensilla are also called multiple-pore sensilla. Below the cuticular wall, each pore widens to form a cuticular chamber (Figs. 2b, 3b) referred to as the "pore kettle" by Ernst (1969) with diameters two or more times those of the pore openings. Several tubules radiate to the sensillar lumen from the pore kettle. The outer dendritic system (Figs. 2a, 3a) appears as one dendrite at the basal part of the sensillum which ramifies toward the distal region into about twenty to sixty dendritic branches scattered in the sensillar lumen (Figs. 2b, c). The dendritic branches contain a different numbers of microtubules.

In the clavate sensilla (Fig. 3), in addition to the ultrastructure described above, the outer dendritic segment has lamellar membranes (Fig. 3b), or circular membranes (Fig. 3c) in a regular arrangement up to the midregion of the sensillar lumen, with several microtubules located between the membranes.

The sensory cell of the thin-walled-pore sensilla is commonly associated with the outer dendritic system. The enveloping epidermal cells are at the sides of the sensory cell (Fig. 3a).

Double-walled sensilla

Double-walled sensilla occur in the styloconic sensilla (the grooved sensilla). Dethier et al. (1963) referred to these sensilla as the stellate, or coronal pegs from their appearance in cross section. With the stellate grooved structure of the outer wall and the original cuticular wall as the inner wall,

these sensilla form a double-walled structure (Fig. 4c). In cross section, these sensilla show ten to twelve stellates for the most part (Figs. 4c, d) with numbers gradually decreasing toward the tip of the sensillum (Fig. 4b).

The thickness of the double walls is about 0.21-0.25 μm; the outer stellate cuticule is about 0.15-0.20 μm thick; the inner cuticular wall (the original wall) is about 0.05-0.08 μm thick. In cross section (Figs. 4b, c, d), the grooves appear as clefts between two stellates. A radial spoke channel leads from each groove to the sensillar lumen. The extrasensillar lumens within the double wall and the sensillar lumen are filled with an electron-dense material (referred to as the receptorlymph).

The double-wall sensillum usually includes two sensory neurons which connect to the outer dendritic system at the basal region. The dendrite

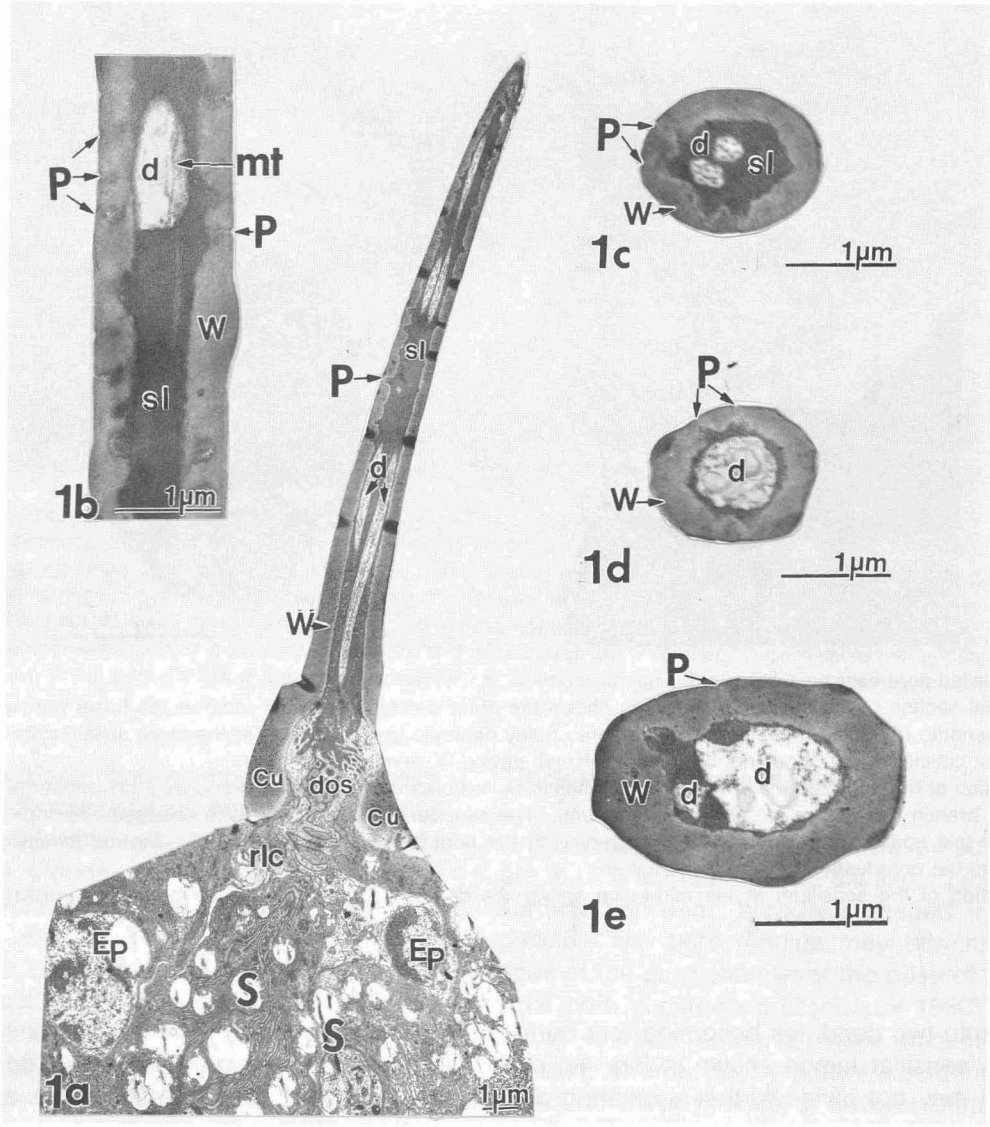

Fig. 1. Thick-walled-pore sensilla.

1a. The longitudinal section shows two dendrites (d) within the sensillar lumen (sl). Two sensory cells (S) appear between the epidermal cells (Ep) at the base of the sensillum. Cu: cuticle, dos: outer dendritic segment, P: pore opening, rlc: receptor lymph cavity, W: sensillar wall.

1b. A sensillum at the base has one dendrite (d) within the sensillar lumen (sl). The small openings of pores (P) are located in the thick cuticular wall (W). mt: microtubule.

1c-1d. Cross sections of the sensilla at the midregion; that in Fig. 1c has two dendrites (d) within the sensillar lumen (sl) and that of Fig. 1d has one. A few pores (P) can be seen in the cuticular wall (W).

1e. The cross section of a sensillum at the base which shows one big and one small dendrite (d) in the sensillar lumen. P: pore opening, W: sensillar wall.

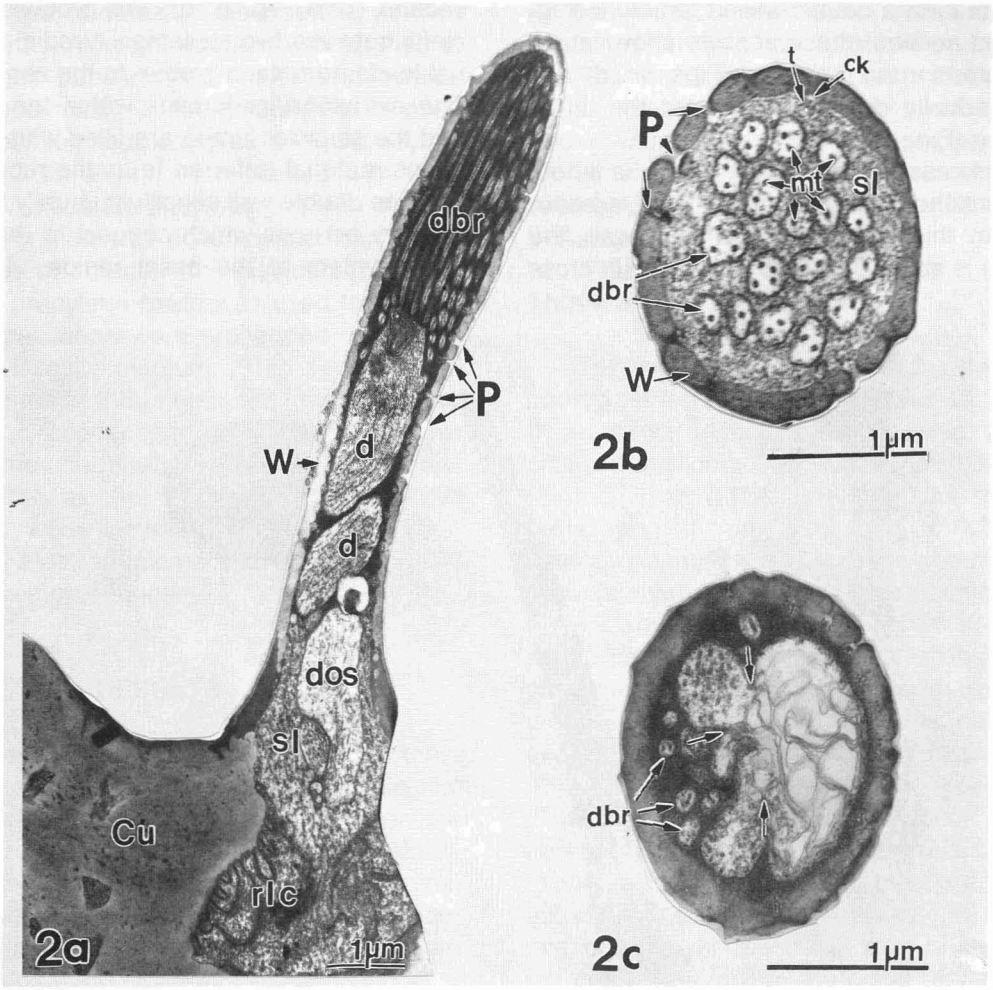

Fig. 2. Thin-walled-pore basiconic sensillum.

2a. Longitudinal section of the basiconic sensillum shows the outer dendritic segment (dos) at the basal part of the sensillum. A single dendrite (d) at the midregion is divided into many dendritic branches (dbr) in the more distal region of the sensillar lumen. Cu: cuticle, P: pore opening, rlc: receptor lymph cavity, W: sensillar wall.

2b. Cross section of the upper region of the basiconic sensillum features many dendritic branches (dbr) within the sensillar lumen (sl). Each branch has one or more microtubules (mt). The sensillar wall (W) is thin with enlarged openings of pores (P). A pore kettle (ck) appears continuous with the opening of the pore below the cuticular wall. Several minute pore tubules (t) extend from the pore kettle to the sensillar lumen.

2c. Cross section of the sensillum at the midregion shows the dendrite dividing into many branches (arrows). dbr: dendritic branches.

may divide into two dendrites becoming four dendrites in the sensillar lumen shown in Fig. 4c, or the dendrite may not divide further appearing as two dendrites in the sensillar lumen as in Fig. 4d. At the terminal region, the sensillar lumen is filled with the electron-dense material and no dendritic endings can be observed (Fig. 4b).

The sensory pit

The sensory pit contains the thin-walled basiconic sensilla, the grooved double-walled sensilla and several small microtrichial hairs. The ultrastructure of the thin-walled basiconic sensilla and the grooved double-walled sensilla are the same as thin-walled-pore sensilla and double-walled sensilla on the funicular surface. It is not necessary to described them here.

DISCUSSION

The typical insect sensillum is a hairlike structure with the upper cuticular part protruding from

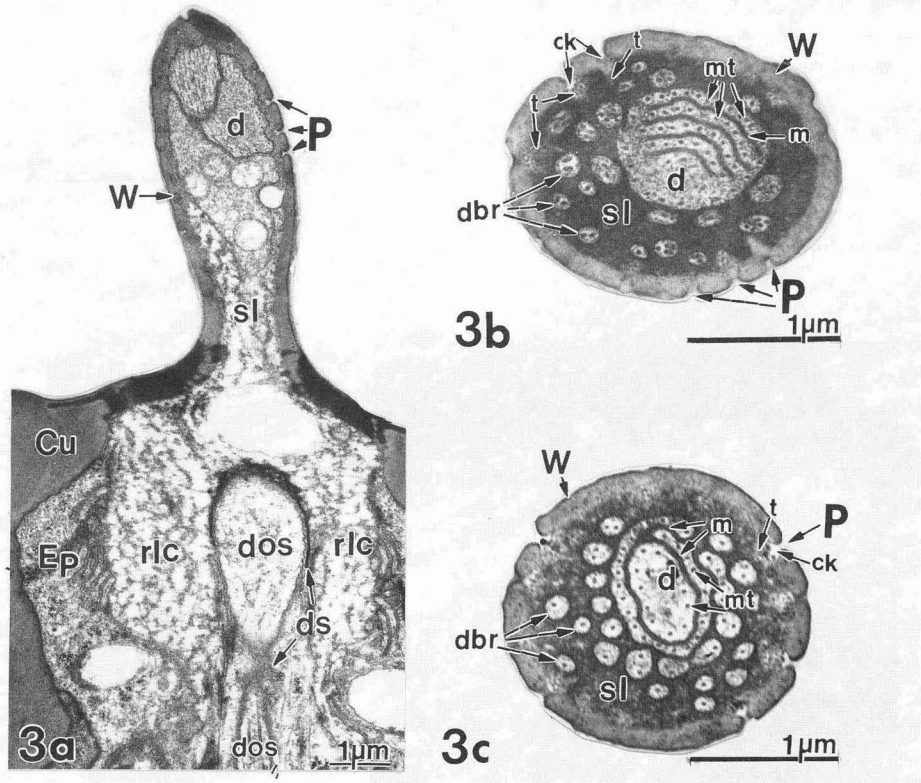

Fig. 3. Thin-walled-pore clavate sensillum.

3a. Longitudinal section of the clavate sensillium, two dendrites (d) appear within the sensillar lumen (sl). An outer dendritic segment (dos) is surrounded by the dendritic sheath (ds) within the receptor lymph cavity (rlc). Epidermal cells (Ep) are at the sides of the sensory cell. Cu: cuticle, P: pore opening, W: sensillar wall.

3b-3c. Cross sections of a clavate sensillum at the midregion, the dendrite (d) has a lamellar (Fig. 3b) and a circular (Fig. 3c) structure. The microtubules (mt) are arranged between two membranes (m) of lamella. A pore kettle (ck) appears continuous with the opening of the pore (P) below the cuticular wall (W). sl: sensillar lumen. dbr: dendritic branches, t: pore tubules.

the antennal surface; one or more sensory cells and related epidermal cells are below the antennal surface. The epidermal cells usually involve sheath producing cells, tricogen cells and tormogen cells. The bipolar sensory neuron projects an outer dendritic segment toward the hairlike structure and an axon to the central nervous system. A large subcuticular cavity, the receptor space, joins the hair lumen and surrounds the dendrite (Keil and Steinbrecht 1982, Zacharuk 1980).

The outer dendrite system usually ramifies into two branches or remains single in the sensillar lumen of thick-walled-pores sensilla. It may subdivide into more than ten branches in thin-walled-pore sensilla. All these outer dendritic segments are within the receptorlymph of the sensillar lumen. Air or odor molecules are presumed to enter or diffuse to the lumen along the pores of the cuticular hair wall and reach the dendrites either via direct contacts or via the receptorlymph (Keil and Steinbrecht 1982).

Thick-walled-pore sensilla

The cuticular wall of thick-walled-pore sensilla are thick and the pores are slit-like on the sensillar surface becoming broadly v-shaped in the wall cuticle. The pore tubules may terminate at the apex of the pore channel at the base of the superficial pore constriction (Zacharuk 1980). Besides on *B. dorsalis* antenna, these thick-walled-pore sensilla, referred to by different terminology, are found on the antennae of several Dipterans: the long single walled sensilla of *B. oleae* (Hallberg et al. 1980), the thick-walled multiporous pitted sensilla of *Anastrapha ludens* (Dickens et al. 1988), the thick-walled sensilla tricholea of *Musca autumnalis* (Bay and Pitt 1976), the thick-walled multiporous sensilla of the syrphid flies (Hood Henderson and Wellington 1982), the sharp-tipped trichodea of *Culicoides furens* (Chu-Wang et al. 1985), the short, pointed tipped sensillum tricho-

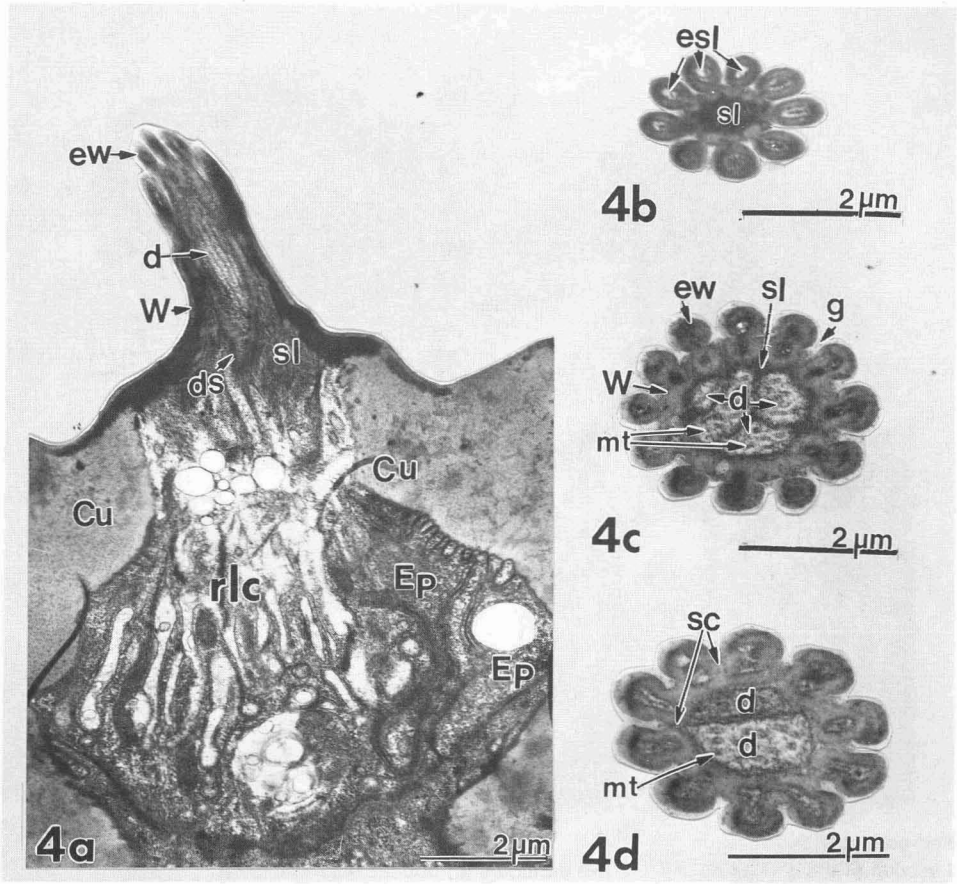

Fig. 4. Double-walled sensillum.

4a. Longitudinal section shows the extrawall (ew) as the outer wall of the sensillum. The original cuticular wall (W) is near the sensillar lumen (sl). In the basal region of the sensillum, the dendrite (d) is surrounded by the dendritic sheath (ds). The epidermal cells (Ep) are at the sides of the receptor lymph cavity (rlc). Cu: cuticle.

4b. Cross section of the distal region of the sensillum shows the sensillar lumen (sl) without a dendrite, filled with electron-dense material. The extrasensillar lumens (esl) form a stellate pattern which surrounds the sensillar lumen.

4c. Cross section at the midregion, four dendrites (d) appear in the sensillar lumen (sl). Different numbers of microtubules (mt) occur in each dendrite. The sensillar wall (W) and the extrawall (ew) comprise a double wall. A groove (g) is located between each two stellates.

4d. Cross section shows two dendrites (d) occupying the sensillar lumen. A spoke channel (sc) leads from the groove (g) to the sensillar lumen. mt: microtubules.

deum of *Aedes aegypti* (McIver 1978) and the sensillum trichodeum of *Simulium arctieum* (Sutcliffe et al. 1990).

Thin-walled-pore sensilla

Thin-walled-pore sensilla on the funiculus of *B. dorsalis* have larger pores with greater density than in thick-walled-pore sensilla. Meanwhile, these sensilla show evidence of pore kettles and pore tubules associated with the dendrites in the sensillar lumen, which thick-walled-pore sensilla do not show. Zacharuk (1980) mentioned that in thin-walled-pore sensilla, the pores open into an enlarged circular pore kettle, the pore tubules extend from the inner wall and scatter into the underlying dendritic chamber. He also stated in 1985 that the thin-walled multiple pores sensilla (MPPS) have a wider odor response spectrum than the thick-walled MPPS because of their enlarged pore openings. As to the postantennal organ of Collembola, their pore kettles have external openings and provide channels from the kettles to underlying sensillar chambers. A dense secretion often underlines the sensory cuticle and fills the pore kettle. This apparently serves as an outward secreting and inward stimulus-conducting mechanism (Altner and Thies 1976).

Thin-walled-pore sensilla are common on dipteran antennae, such as the short single-walled

sensilla of *B. oleae* (Hallberg et al. 1984), the thin-walled multiporus pitted sensilla of *A. ludens* (Dickens et al. 1988), the sensilla basiconica of *Drosophila melanogaster* (Venkatesh and singh 1984), the thin walled peg of *Sarcophaga argyrostoma* (Slifer and Sekhon 1964) the basiconic sensilla of *Stomoxys calcitrans* (Lewis 1971), the thin-walled sensillum basiconcium of *M. autumnalis* (Bay and Pitt 1976), the blunt tipped sensilla trichodea of *Ae. aegypti* (McIver 1978), the multiporous thin sensilla of some Syrphidae (Hood Henderson and Wellington 1982) and the sensilla basiconic of *S. arcticum* (Sutcliffe et al. 1990). An atypical thin-walled-pore sensillum with unbranched dendrites appears in some sensilla basiconic of *S. arcticum* (Sutcliffe et al. 1990). These sensilla are not found in *B. dorsalis* antenna, nor are there any records from other Dipterans.

The ultrastructures of lamellar and circular menbranes at the midregion of the outer dendritic segment appear in the clavate sensilla of *B. dorsalis* antenna. These sensilla belong to the thin-walled-pore snesilla based on the presence of a thin cuticular sensillar wall and the multiple pores. These lamellated structures are also reported in the clavate sensilla of *S. calcitrans* antennae by Lewis (1971), in the sensilla coeloconic and internal sensilla of the antennal tip of the mosquito *Deinocerites cancer* by McIver and Siemicki (1976), and in the thin-walled sensilla (mpp) of several *Syrphus* with a large rolled dendrite rolled by Hood Henderson and Wellington (1982). The lamellation can be the result of different processes in which the outer dendritic segment is branched, one of them is flattened and interdigitated or rolled (Altner and Prillinger 1980). McIver and Siemicki (1976) discribed ussed the function of the lamelled dendrite as possibily sensitive to infrared radiation or mechanical stimuli.

Double-walled sensilla

Double-walled sensilla are not numerous in most insects and are located primarily on the antennae (Zacharuk 1985). However, these sensilla are found in large numbers on *B. dorsalis* and *B. tryoni* (Giannakakis and Fletcher 1985) and also known from the antennae of *B. oleae* (Hallberg et al. 1984), *Sarco. argyrostoma* (Slifer and Sekhon 1964), *S. calcitrans* (Lewis 1971), *M. autumnalis* (Bay and Pitts 1976, *Syrphus* (Hood Henderson and Wellington 1982), and *S. arcticum* (Sutcliffe et al. 1990). The main characteristic of these sensilla is a stellate, grooved appearence in cross section. These sensilla do not have pore tubules. Zacharuk (1985) reported that a dense substance from the dendritic chamber (sensillar lumen) fills the spoke canals and apparently flows out over the groove surface. This was presumed to be the trapping and conduction mechanism for the chemical stimulant.

Thick-walled-pore sensilla have a thick cuticular wall and small pore openings while thin-walled-pore sensilla have a thin cuticular wall and enlarged pore openings. Both types of sensilla have pore tubules and have been shown to be chemosensory, and primarily olfactory. Thick-walled-pore sensilla seem to be more selective, some may be stimulated by pheromones, and thus are referred to as "specialist" sensilla on this basis. Thin-walled-pore sensilla generally have a wider range of chemosensitivity and are referred to as "generalist." Some of thin-walled-pore sensilla with lamelled dendrites were shown in some biting flies to respond to carbon dioxide (Zacharuk 1985). Double-walled sensilla consist of the original cuticular wall plus a ridged structure. These sensilla do not have pore tubules but have spoke canals, some of which are thermo- and hygrosensory, and some are thermo- and chemosensory (Altner and Prillinger 1980).

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REFERENCES

Altner H, L Prillinger. 1980. Ultrastructure of invertebrate chemo, thermo and hygroreceptors and its functional significance. Intern. Rev. Cyto. **67:** 69-132.

Altner H, G Thies. 1976. The postantennal organ: A specialized unicellular sensory input to the protocerebrum in apterygotan insect (Collembola). Cell Tiss. Res. **167:** 97-110.

Bay DE, W Pitts. 1976. Antennal olfactory sensilla of the face fly *Musca antumnalis* Degreer (Diptera: Muscidae). Int. J. Insect Morphol. Embryol. **5:** 1-16.

Chu-Wang IW, RC Axtell, DL Kline. 1975. Antennal and palpal sensilla of the sand fly *Culicoides furens* (Pocy) (Diptera: Ceratopogonidae). Int. J. Insect Morphol. Embryol. **4:** 131-149.

Dethier VG, JR Larson, JR Adams. 1963. The fine structure of the olfactory receptors of the blowfly. *In* Olfaction and Taste I. Oxford: Zotterman y Pergamon Press, pp. 105-110.

Dickens JC, WG Hart, DM Light, EB Jang. 1988. Tephritid olfaction: Morphology of the antennae of four tropical species of economic importance (Diptera: Tephritidae). Ann. Entomol. Soc. Am. **81:** 325-332.

Ernst KD. 1969. Die Feinstruktur von Richsensillen out der Antenna des *Aaskafers Necrophorus* (Coleoptera). Z. Zellforsch. Mikr. Anat. **94:** 72-102.

Giannakakis A, BS Fletcher. 1985. Morphology and distribution of antennal sensilla of *Dacus tryoni* (Froggatt) (Diptera: Tephritidae). J. Aust. Entomol. Soc. **24:** 31-35.

Hallberg E, JNC Van der Pers, GE Haniotakis. 1984. Funicular sensilla of *Dacus oleae*: Fine structural characteristics. Entomol. Hellenica **2:** 41-46.

Hood Henderson DE, WG Wellington. 1982. Antennal sensilla of some aphidophagous Syrphidae (Diptera): fine structure and electroantennograme study. Canad. J. Zool. **60:** 3173-3186.

Keil TA, RA Steinbracht. 1982. Mechanosensitive and olfactory sensilla of insect. *In* Insect Ultrastructure Vol. 2, eds. RC King, H Akai. New York: Plenum Pub. Co., pp. 477-513.

Lee WY, JC Chang, YB Hwang, TL Lin. 1994. Morphology of the antennal sensilla of the oriental fruit fly, *Dacus dorsalis* Hendel (Diptera: Tephritidae). Zool. Studies **33:** 65-71.

Lewis CT. 1971. Superficial sense organs of the antennal third segment of the stable fly, *Stomoxys calcitrans*. J. Insect Physiol. **17:** 449-461.

McIver SB. 1969. Antennal sense organs of female *Culex tarsalis* (Diptera: Culicidae). Ann. Entomol. Soc. Am. **62:** 1455-1461.

McIver SB. 1978. Structure of sensilla trichodea of female *Aedes aegypti* with comments on innervation of antennal sensilla. J. Insect Physiol. **24:** 383-390.

McIver SB, R Siemicki. 1976. Fine structure of the antennal tip of the crabhole mosquito, *Deinocerites cancer* Theobald (Diptera: Culicidae). Int. J. Insect Morphol. Embryol. **5(6):** 319-334.

Slifer EH, SS Sekhon. 1964. Fine structure of the sense organ on the antennal flagellum of a flesh fly, *Sarcophaga argyrostoma* R.D. (Diptera, Sarcophagidae). J. Morphol. **114:** 185-208.

Spurr AR. 1969. A low viscosity epoxy resin embedding medium for electron microscopy. J. Ultrastruct. Rs. **26:** 31-43.

Sutcliffe JF, EG Kokko, JL Shipp. 1990. Transmission electron microscopic study of antennal sensilla of female black fly, *Simulium arcticum* (IIL3; IIS10, 11) (Diptera: Simuliidae). Canad. J. Zool. **68:** 1443-1453.

VenKatesh S, RN Singh. 1984. Sensilla on the third antennal segment of *Drosophila melanogaster* Meigen (Diptera: Drosophilidae). J. Int. Morphol. Embryol. **13:** 51-63.

Zacharuk RY. 1980. Ultrastructure and function of insect chemosensilla. Ann. Rev. Entomol. **25:** 27-47.

Zacharuk RY. 1985. Antennae and Sensilla. Comparative Insect Physiol. Biochem. Pharmacol. **6:** 1-69.

東方果實蠅 *Bactrocera* (=*Dacus*) *dorsalis* 觸角感覺毛之微細結構

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利用穿透性電子顯微鏡研究東方果實蠅觸角感覺毛之微細結構，可分爲兩類，單層感覺毛(single-walled sensilla)和雙層感覺毛(double-walled sensilla)。單層感覺毛又分有厚壁有孔感覺毛(thick-walled-pore sensilla)和薄壁有孔感覺毛(thin-walled-pore sensilla)。形態學上之毛狀第一型感覺毛(trichoid type I sensilla)屬於厚壁感覺毛，毛壁厚，厚度約0.18-0.38μm，壁孔小而疏。毛腔內具神經細胞(sensory cell)一或兩個。在形態上之毛狀第二感覺毛(trichoid type II sensilla)，突出感覺毛(basiconic sensilla)和棒狀感覺毛(clavate sensilla)屬薄壁有孔感覺毛，其毛壁薄，厚度約0.05-0.15μm，壁孔大而密，感覺毛上部之毛腔具有許多經樹突分支(dendritic branches)，基部在體壁內具一或兩個神經細胞。棒狀感毛之微細構造，毛腔內除樹突分支外，還有呈層狀或環狀之樹突。雙層感覺毛爲形態學上之時針感覺毛(styloconic sensilla)或稱爲溝感覺毛(grooved sensilla)。由於原來體壁外著腔內具 2 或 4 條樹突，係由兩個基部之神經細胞發出之神經樹突，不分支或分支而呈 2 或 4 條樹突。

關鍵詞：微細構造，厚壁有孔感覺毛，薄壁有孔感覺毛，雙層感覺毛。

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