

# Antennal Sensory Plaque Organs of the Delphacidae (Homoptera: Fulgoroidea)

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## ABSTRACT

Scanning electron microscopy was used to examine the antennal sensory plaque organs of 104 species in 81 genera of Delphacidae. The plaques have the same external morphology in all examined Delphacidae. Four types of sensory plaque organs are recognized based on the morphology of the denticle, and the evolutionary trends are proposed as Type 1→Type 2→Type 3 and Type 1→Type 2→Type 4.

**Key words:** Homoptera, Fulgoroidea, Delphacidae, antennae, sensory plaque organs.

## Introduction

Past investigations have suggested that the sensory plaque organs on fulgoroid antennae have strong variations occurring among or even within different families (Marshall and Lewis, 1971; Bourgoin and Deiss, 1994; Cheng and Yang, 1996). Therefore, these researchers believed that the sensory plaque organ characteristics (e.g. morphology of the denticle or plaque) have potential value for classification, and determining the phylogeny among the 20 Fulgoroidea families. Generic or fragmentary information on this topic has been furnished by Marshall and Lewis (1971), Aljunid and Anderson (1983), and Bourgoin and Deiss (1994). Bourgoin and Deiss (1994) described that each denticle of the sensory plaque organs in *Sogatodes cubanus* (Crawford) was pyramidal. Up to now, there has not been enough data to indicate that

the sensory plaque organs have structural variations in Delphacidae.

The objectives of this paper are to describe the different types of antennal sensory plaque organs in the Delphacidae, and to discuss their diversity and value for hypothesizing relationships among different types.

## Materials and Methods

The investigations were carried out on 104 species in 81 genera of Delphacidae by scanning electron microscopy (see Table 1 for a list of taxa examined). All the examined specimens, including males or females were placed in small vials containing 70% ethanol where they remained for at least 1 h. Whole adults became translucent in 10% KOH after 15 min at 60 °C, after which their antennae were removed in 70% ethanol and cleaned by sonification for about 15-20 sec.

Table 1. Sensory plaque organs of Delphacidae.

Subfamily	Type	SPO		Denticle	Plaque
Species (number examined)	(Subtype)	No.	Duam. ( $\mu\text{m}$ )	No.	No.
Asiracinae					
<i>Ugyops pelorus</i> Fennah (1)	1(1)	30-33	32.5-51.0	9-15	21-51
<i>Ugyops caelatus</i> (White) (1)	1(1)	39-43	34.5-50.0	10-15	18-52
<i>Ugyops tripunctatus</i> Kato (4)	1(1)	56-61	41.0-53.2	12-19	20-46
Delphacinae					
<i>Delphax pulchellas</i> (Curtis) (2)	1(1)	33-40	37.0-55.4	8-14	52-70
<i>Specinervures liguida</i> Yang and Yang (2)	1(2)	7-10	10.8-20.0	3-6	6-12
<i>Bambusiphaga taiwanensis</i> (Muir) (10)	1(2)	11-14	14.5-25.3	4-7	6-16
<i>Eoeyrsa flavocapitata</i> Muir (3)	1(2)	12-15	18.9-29.9	4-6	13-27
<i>Muellerianella brevipennis</i> (Boheman) (3)	1(2)	13-15	20.8-34.8	5-10	8-36
<i>Neometopina penghuensis</i> Yang (2)	1(2)	14-16	28.9-34.6	6-7	18-30
<i>Sogata hakonensis</i> (Matsumura) (2)	1(2)	13-15	19.2-27.2	4-6	13-27
Stenocraninae					
<i>Anypanconium aurantiacum</i> Dlab. (2)	1(2)	13-15	24.6-30.6	6-7	11-20
Asiracinae					
<i>Idiosystatus acutiusculus</i> (Spinola) (3)	2	36-40	24.0-29.9	5-9	10-21
Asiracinae					
<i>Asiraca clavicornis</i> (Fabricius) (3)	3	18-23	32.4-54.4	10-15	18-35
Kelisiinae					
<i>Anakelisia perspicillata</i> (Boheman) (2)	4	13-16	26.4-31.2	6-10	14-23
<i>Kelisia brucki</i> Fieber (1)	4	16-19	23.5-30.5	7-8	16-24
<i>Kelisia perrieri</i> Ribaut (2)	4	16-19	30.3-33.8	6-9	15-19
Stenocraninae					
<i>Stenocranus matsumurai</i> Metcalf (2)	4	28-35	23.5-42.7	8-11	22-36
<i>Stenocranus apamopsyche</i> Kirkaldy (1)	4	27-30	25.6-36.7	6-9	17-28
<i>Stenocranus longipennis</i> (Cortis) (2)	4	19-23	23.8-31.7	6-9	15-32
Delphacinae					
<i>Tsaurus dentatus</i> Yang (1)	4	15	28.4-37.2	6-8	20-33
<i>Vizcaya</i> sp. (1)	4	68-70	29.6-65.2	9-13	16-31
<i>Tropidocephala maculosa</i> Mats. (3)	4	7-9	24.5-30.2	6-11	6-18
<i>Chlorionidea bromi</i> Emeljanov (2)	4	8-9	24.0-28.0	7-8	22-36
<i>Formodelphax confusus</i> Yang (2)	4	9	20.6-32.4	3-7	8-20
<i>Epeuryrsa ramanei</i> Asche (2)	4	9-10	17.5-28.2	5-6	9-14
<i>Saccharosydne ornitapennis</i> Muir (2)	4	9-12	20.0-37.5	4-10	13-22
<i>Malaxa herioca</i> Yang (2)	4	10-11	22.7-28.0	5-9	12-24
<i>Coronacella sinhalana</i> (Kirk.) (2)	4	10-14	21.6-28.4	5-8	10-18
<i>Formodelphax formodus</i> Yang (1)	4	11-12	20.5-28.0	3-6	10-18
<i>Proscopus tricoloratus</i> (Dlab.) (3)	4	10-12	16.8-30.2	5-9	22-33
<i>Saccharosydne procerus</i> (Mats.) (2)	4	11-12	27.5-44.0	4-9	8-20
<i>Thymalops anderida</i> (Kirk.) (2)	4	11-13	17.5-19.2	5-8	12-22
<i>Unkanodes sapporona</i> (Mats.) (3)	4	11-13	25.7-33.6	8-10	16-27
<i>Garaga nagaragawana</i> Mats. (1)	4	11-12	21.6-30.5	6-9	25-30
<i>Garaga orchidensis</i> Yang (3)	4	11-13	23.8-32.8	6-8	23-32
<i>Hagamiodes limosugs</i> Yang (3)	4	12-14	17.2-20.7	5-7	10-20
<i>Laodelphax straitellus</i> (Fallen) (3)	4	12-15	20.0-26.7	5-8	22-32

Table 1 (Continued)

<i>Muellerianella extrusa</i> (Scott) (2)	4	11-14	20.5-38.2	4-9	15-38
<i>Neoconon incensa</i> Yang (2)	4	11-14	20.5-30.4	6-7	20-28
<i>Nycheuma coronata</i> Asche (1)	4	12-13	33.0-42.3	5-10	5-48
<i>Parametopina yushaniae</i> Yang (3)	4	11-13	26.8-38.3	8-12	24-37
<i>Sogatella furcifera</i> (Horvath) (2)	4	12-13	23.6-32.8	8-10	22-33
<i>Smicrotatodelphax marilimus</i> Yang (3)	4	12-14	9.1-22.3	5-8	8-18
<i>Belocera sinensis</i> Muir (2)	4	12-14	30.6-40.2	7-16	25-55
<i>Smicrotatodelphax paupaucus</i> Yang (1)	4	13-14	12.5-23.1	6-9	11-22
<i>Cemus punctatus</i> Yang (2)	4	10-13	22.7-38.5	6-9	15-36
<i>Nycheuma coctum</i> Yang (2)	4	12-13	31.7-48.5	5-10	12-36
<i>Eoeurysa ribauti</i> Lbg. (3)	4	12-14	19.5-46.7	5-8	13-19
<i>Falcotoya formosana</i> Yang (2)	4	13-14	14.6-18.7	3-6	8-28
<i>Falcotoya shaluensis</i> Yang (2)	4	13-14	12.7-21.5	4-8	14-26
<i>Hyledelphax elegantulus</i> (Bohem) (2)	4	12-13	27.5-40.6	7-9	30-38
<i>Latistria eupompe</i> (Kirk.) (2)	4	11-13	27.5-31.2	7-8	17-23
<i>Numata corporaalli</i> (Muir) (2)	4	11-13	17.1-30.5	5-9	12-28
<i>Sardia rostrata</i> Melichar (2)	4	12-13	29.9-38.1	7-9	>10
<i>Sinolacme sinuosa</i> Yang (3)	4	11-15	25.9-30.1	5-7	15-27
<i>Thymobares longispinus</i> (Muir) (2)	4	11-13	23.4-42.3	7-8	14-30
<i>Eoeurysa lineata</i> Melichar (3)	4	12-14	22.8-39.1	7-10	13-19
<i>Hadeodelphax pluto</i> Kirk. (2)	4	12-14	28.2-36.6	6-9	18-36
<i>Harmalia commelinage</i> Yang (3)	4	14-16	16.3-32.6	5-8	15-23
<i>Muirodelphax anberi</i> (Perr.) (3)	4	12-15	24.6-38.7	7-11	21-37
<i>Syndelphax disonymos</i> (Kirk.) (1)	4	14-15	32.8-49.0	5-8	24-32
<i>Tagosodes incanus</i> (Distant) (2)	4	13-16	20.4-28.8	5-7	12-24
<i>Terthron africanus</i> Asche (1)	4	12-14	21.4-29.5	6-9	24-36
<i>Terthron triandulum</i> Asche (1)	4	11-14	26.5-36.1	5-7	12-30
<i>Toya lazulis</i> (Kirk.) (2)	4	13-14	19.2-35.2	7-11	16-32
<i>Triambus taiensis</i> Asche (1)	4	13-14	14.1-26.5	6-9	21-38
<i>Dicranotropis hamata</i> Bohem. (1)	4	15	20.0-36.0	6-11	22-36
<i>Toya fulva</i> (Yang) (1)	4	15	28.4-38.5	7-12	21-32
<i>Arcofaciella verrucosa</i> Fennah (2)	4	12-16	23.1-28.8	7-10	13-22
<i>Neoterthrona spinosa</i> Yang (2)	4	13-15	20.0-28.7	5-8	13-25
<i>Onidodelphax serratus</i> Yang (2)	4	14-15	15.6-32.4	7-9	23-38
<i>Opiconsiva albicollis</i> (Motschulsky) (2)	4	14-15	18.9-34.4	5-8	20-27
<i>Spinidelphacella hargreavesi</i> (Fabricius) (2)	4	13-16	23.7-36.0	6-9	20-33
<i>Malaxa semifurca</i> Yang and Yang (3)	4	14-16	25.4-30.6	7-11	16-24
<i>Taidelphax chishanensis</i> Yang (3)	4	13-16	16.3-32.6	7-9	16-23
<i>Toya lima</i> Yang (4)	4	13-16	31.3-40.6	8-11	20-34
<i>Yanunka incerta</i> Yang (1)	4	16	20.0-30.5	4-8	17-25
<i>Diodelphax obstipus</i> Yang (3)	4	16-19	16.5-28.7	5-8	20-25
<i>Harmalia heitensis</i> (Mats. & Ishihata) (2)	4	13-16	24.0-33.5	5-9	16-28
<i>Javesella pellucida</i> (F.) (2)	4	16-17	21.6-33.6	6-9	18-32
<i>Megadelphax sordidulus</i> Stal (2)	4	15-18	22.8-39.1	4-9	13-21
<i>Peregrinus maidis</i> (Ashmead) (2)	4	14-17	25.0-39.7	5-11	16-40
<i>Perkinsiella thompsoni</i> Muir (1)	4	16-17	28.2-35.2	6-10	22-32
<i>Sogatodes neomphalus</i> Asche (2)	4	14-17	26.8-36.7	5-8	25-45

Table 1 (Continued)

<i>Ribautodelphax albostriatus</i> (Firber) (1)	4	17-18	20.5-32.3	5-8	8-18
<i>Neodicranotropis trunghaensis</i> Yang (2)	4	13-18	21.5-37.4	6-11	22-36
<i>Nilaparvata lugens</i> Stal (10)	4	16-17	26.5-35.3	6-9	20-30
<i>Afrocoronacella tuneri</i> (Muir) (2)	4	17-20	28.8-37.5	7-9	15-25
<i>Matutinus yanchinus</i> Khoh (2)	4	16-19	24.0-43.2	7-12	15-35
<i>Purohita sinica</i> Haung and Ding (3)	4	17-22	22.0-30.5	7-17	13-42
<i>Kakuna albipennis</i> (Mats.) (2)	4	16-19	23.8-37.5	6-10	18-25
<i>Florodelphax paryphasma</i> (Flor.) (2)	4	20-23	19.5-34.6	6-9	9-22
<i>Megamelus notula</i> (German) (2)	4	20-24	25.9-37.5	5-9	8-19
<i>Ditropis pteridis</i> (Spinola) (2)	4	23-25	28.0-40.2	4-9	6-32
<i>Ditropis ptericis</i> (Bohem) (2)	4	21-24	21.8-33.9	4-8	8-32
<i>Perkinsiella saccharicida</i> Kirk. (2)	4	22-24	30.8-46.7	6-11	16-34
<i>Caenodelphax teapae</i> Fowler (1)	4	>12	20.4-30.0	5-7	12-25
<i>Epeurysa nenqhaensis</i> Yang and Yang (2)	4	7-8	10.8-20.4	5-7	9-17
<i>Kormus artimisiae</i> Fieber (1)	4	>10	17.9-33.4	4-8	9-21
<i>Terachiana sagitta</i> Kusnezov (1)	4	>13	22.5-33.4	5-8	12-27
<i>Purohita picea</i> Yang and Yang (5)	4	30-33	24.1-36.8	6-15	16-28
<i>Purohita maculata</i> Muir (3)	4	42-48	12.9-32.5	7-15	17-24
<i>Preterkelisia magnispinosa</i> (Kouh) (1)	4	17-20	20.8-33.8	6-9	20-25
<i>Pseudaraeopus bolivari</i> (Mel.) (2)	4	30-33	14.9-32.8	5-8	8-21

SPO=sensory plaque organs.

The bold type represents the type species.

The antennae were finally dried in an acetone solution on a hotplate at 70°C.

The antennae of specimens were mounted on aluminum stubs by double-sided tape, coated with gold for 3 min in an Eiko EB-2 ion coater and examined under a scanning electron microscope (Hitachi S-570) at an accelerating voltage of 15 kV.

### Terminology (Figs. 1-6)

**Sensory plaque organ:** A kind of sensilla covers the surface of the pedicles of Fulgoroidea. It is composed of the cuticular ring, the denticles, the plate, and the plaques. The term "sensory plaque organs" was first used by Lewis and Marshall (1970). The sensory plaque organ is not plate-form except in Tettigometridae in Fulgoroidea. Therefore, in this paper, we use "sensory plaque organ" instead of the term "sensory plate organs" (Bourgoin and Deiss, 1994).

**Cuticular ring:** A sclerotized circu-

lar area which surrounds the plate for protection.

**Denticle:** The projectina part of the cuticular ring that it is believed to strengthen the protection.

**Plate:** The surface of the sensilla which is surrounded by a protective cuticular ring and denticles. In Tettigometridae, the plate is a true flat plate (Bourgoin, 1985; Cheng and Yang, 1996).

**Plaque:** The projection part of the plate which is innervated by many neurons arranged in groups (Marshall, 1973; Aljunid and Anderson, 1983).

**Circular pore:** The circular pore in the inner surface of the sensory plaque organ formed by the surface projection of the plate.

### Results

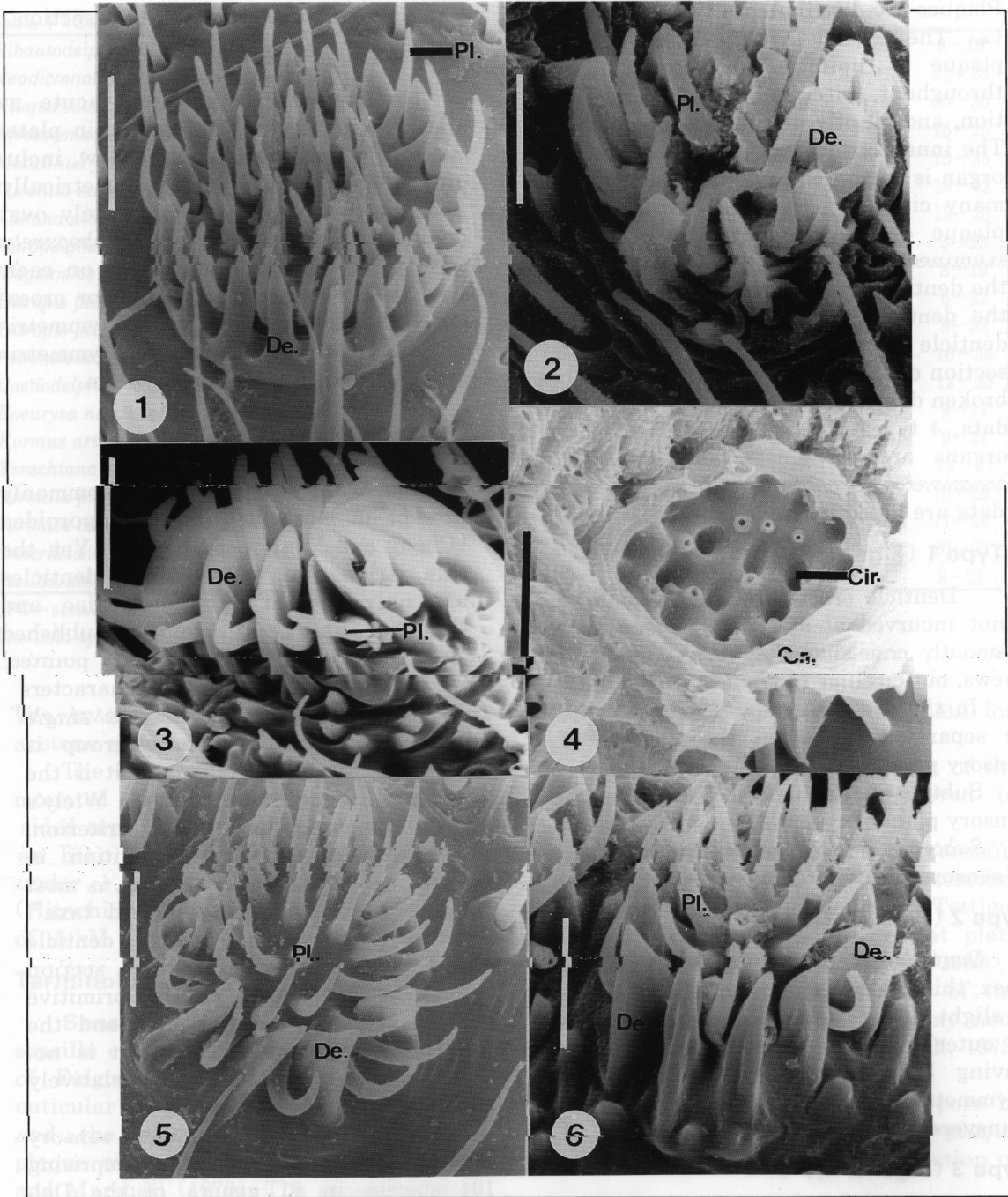
There are 3 joint characters of the antennal sensory plaque organs found in all examined Delphacidae (Figs. 1, 4): (1)

Plaques are distributed all over the plate; (2) The external morphology of each plaque is uniform, which is filiform throughout, circular in transverse section, and bluntly pointed at the apex; (3) The inner surface of each sensory plaque organ is composed of a cuticular ring and many circular pores. Hence the sensory plaque organs of the Delphacidae are

like a gear notched in transverse section.

**Type 4 (Figs. 5, 6.7-4)**

Denticle erect, thin, and acute at apex; having several different thin plate-shaped projections in lateral view, including symmetrically or asymmetrically triangular, pentagonal, and acutely oval ones; each denticle having 0.5 obscurely



Figs. 1 to 6. The sensory plaque organs of Delphacidae. 1. Type 1, *Ugyops tripunctatus* (Kato) (Scale=20.0 mm); 2. Type 2, *Idiosystatus acutiusculus* (Spinola) (Scale=10.0 mm); 3 and 4. Type 3; 3. *Asiraca clavicornis* (Fabricius) (Scale=14.8 mm); 4. The inner surface of the sensory plaque organ of *Asiraca clavicornis* (Fabricius) (Scale=13.6 mm); 5 and 6. Type 4; 5. *Spinidelphacella hargreavesi* (Fabricius) (Scale=15.2 mm); 6. *Kelisia perrieri* Ribaut (Scale=15.2 mm). Cir.=Circular pore; C.r.=Cuticular ring; De.=Denticle; Pl.=Plaque.

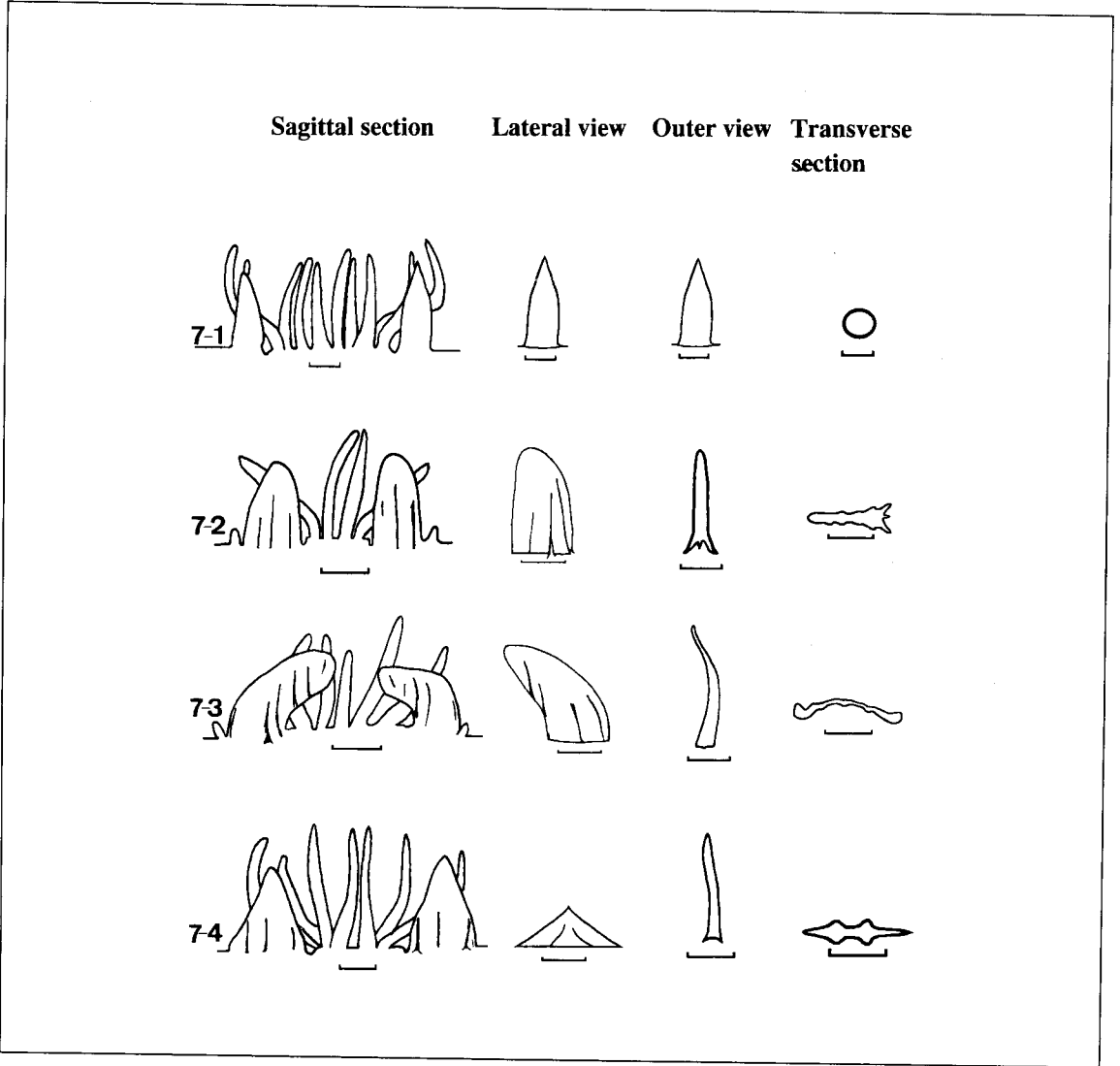


Fig. 7. The sensory plaque organs of Delphacidae. 7-1. Type 1; 7-2. Type 2; 7-3. Type 3; 7-4. Type 4. (Scale=5 mm).

to 4, the plate-shaped denticle, and thin laterally ridged transverse section are the advanced character states. In Type 2, the denticle in transverse section based on outer portion which is still wider than the inner portion, but in Types 3-4, outer and inner portion is nearly same. In Type 3, the denticle at the apex turns to the central area of the plate; it is like a gear notched in transverse section and transformed from Type 2. In Type 4, the

denticle is symmetrically notched in transverse section, which is transformed from Type 2. Base on the above data, the evolutionary trends among the 4 types are proposed to be Type 1→Type 2→Type 3 and Type 1→Type 2→Type 4.

The distribution pattern of sensory plaque organs is related to the total number. For example, in some species which have more than 40 sensory plaque organs, these organs are usually dis-

tributed over the entire pedicle. But, Table 1 indicates that the total number of sensory plaque organs is not related to the types.

Furthermore, among most species of the same genus in Delphacidae sensory plaque organs have stable morphology except for some of the genera, for example, the genus *Muellerianella*. The denticle of *Muellerianella brevipennis* (Boheman) is conical, but that of *Muellerianella extrusa* (Scott) is thin and plate-shaped. On the other hand, all genera in the same subfamily do not always possess a stable morphology. In the rank of subfamily in Delphacidae, there are 3 observational results as follows. (1) In Asiracinae, the denticles of *Ugyops*, *Idio-*

*systatus* and *Asiraca* belong to 3 different types: Types 1-3 respectively. (2) All examined species of Kelisiinae and Stenocraninae, conformably belong to Type 4. (3) For all examined genera of Delphacinae, most belong to Type 4, only 8 examined genera belong to Type 1.

From the ontogenetic view, the number of sensory plaque organs increased with nymphal development stage in Delphacidae, and similar conditions can be found in Cixiidae (Table 2), as well as in Fulgoroidea. However, if there are sufficient studies of ontogeny among the Fulgoroidea, these data should be expected to provide useful characters for analyzing phylogeny in the future.

Table 2. The number of sensory plaque organs of nymphs and adults in some species of the Delphacidae and Cixiidae. Those values which have not been described by previous authors or the present study are presented by question marks.

Family Subfamily Species	No. of sensory plaque organs						Reference
	Nymphal instar					Adult	
	1st	2nd	3rd	4th	5th	Adult	
<b>Delphacidae</b>							
<b>Asiracinae</b>							
<i>Pentagramma longistylata</i> Penner	?	?	5	13	25	?	Wilson and Wheeler, Jr. (1986)
<b>Stenocraninae</b>							
<i>Stenocranus lautus</i> Van Duzee	0	0	4	9	14	?	Calvert and Wilson (1986)
<b>Delphacinae</b>							
<i>Delphacodes bellicosa</i> Muir & Giffard	0	2	4	6	9	?	Wilson (1985) Aljunid and Anderson (1983)
<i>Nilaparvata lugens</i> Stal	0	1	?	5	10	17	
<b>Cixiidae</b>							
<b>Cixiinae</b>							
<i>Pentastiridius pachycephs</i> (Mats.)	0	3	7	10	11	14-16	Present study Present study
<i>Oliarus polyphemus</i> Fennah	?	?	?	?	15	16-18	



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- Received for publication September 13, 1996;*  
*Revised manuscript accepted October 30, 1996.*

## 稻蝨科之觸角瓦楞感覺器(同翅目：蠟蟬總科)

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### 摘要

本文藉由掃描式電子顯微鏡共檢查稻蝨科81屬104種之觸角瓦楞感覺器，得知稻蝨科觸角瓦楞感覺器的瓦楞突起外形一致，透過錐狀突起的形態可發現瓦楞感覺器共有四型，它們的進化趨勢推論為第一→二→三型和第一→二→四型。

**關鍵詞：**同翅目，蠟蟬總科，稻蝨科，觸角，瓦楞感覺器。