HUMANS and NATURE, No.1, 57-62, March 1992

Unique Sensillum Structure of the Formicid Labial Palpi (Hymenoptera)

Yoshiaki Hashimoto

Division of Phylogenetics, Natural History Museum Projects, Administration Office, Nakayamate-dori 6-1-1, Chuo-ku, Kobe, 650 Japan

Abstract

Sensillum structure of the labial palpi in the Formicidae was compared with that in the other aculeate Hymenoptera. The labial palpi of the Formicidae had many setiform sensilla and a digitiform sensillum on the tip, showing the same sensilla pattern as in the Tiphiidae and the Mutillidae. Most formicids showed extreme reductions in the numbers of setiform sensilla and bristles. Some of them had elongated pegs of digitiform sensilla. These conditions were unique to the Formicidae in the Aculeata Hymenoptera.

Key words : Formicidae, sensilla, labial palpi, Aculeata

Introduction

Behavioral responses in host or mate selection, locomotion and defence are frequently elicited by chemical stimuli in insects. The major sensory organs for such stimuli are the antennal and labial sensilla (Chapman, 1982).

The formicids can perceive various chemical substances at lower concentrations than the other insects (Wilson, 1971). Despite such a capability, very little attention has been paid to the sensillum structure in this group of insects (cf. Hashimoto, 1990). Especially, the structure of labial sensilla of the Formicidae has never been closely investigated.

The present study aims to characterize structural features of the labial sensilla of major taxonomic groups of the Formicidae by means of the observations with use of SEM and to compare the basic structural featues with those of other aculeate Hymenoptera.

Materials and Methods

Materials: Only female specimens were examined in this study. In social groups such as the Formicidae, Vespidae and Apidae, worker specimens were used, because workers are the best known and most available caste in these insects.

The species examined in this study are in Table 1.

The classification of the Aculeata Hymenoptera adopted here is that of Brothers (1974); whereas the Formicidae are classified according to Wheeler and Wheeler (1985).

SEM observation: The labial palpi were examined by scanning electron microscope (Hitachi-Akashi MSM4C-102). The samples were cleaned by an ultrasonic-washer in chloroform-methanol (2:1), dried in air, mounted on stubs and then sputtered with gold. To show the inner aspect of the cuticlur structure, the samples were cut with a razor blade and the cellular material was

Table 1. List of taxa examined.

Vespoidea (Formiciformes)

Formicidae

Formicinae: *Acropyga baodaoensis* TERAYAMA, *Anoplolepis longipes* (JERDON), *Camponotus japonicus* MAYR, *Echinopla* sp., *Formica japonica* MOTSCHULSKY, *Lasius niger* (LINNAEUS), *Melophorous* sp., *Oecophylla samaragdina* FABRICIUS, *Paratrechina longicornis* (LATREILLE), *Plagiolepis* sp., *Polyergus samurai* YANO, *Polyrhachis dives* F. SMITH, *Prolasius* sp.

Dolichoderinae: *Bothriomyrmex* sp., *Dolichoderus bituberculatus* MAYR, *Iridomyrmex itoi* FOREL, *Tapinoma indicum* FOREL, *Technomyrmex gibbosus* (WHEELER)

Myrmeciinae: *Myrmecia gulosa* (FABRICIUS)

Pseudomyrmecinae: *Tetraponera allaborans* WALKER

Dorylinae: *Aenictus laeviceps* (F. SMITH), *Dorylus* sp.

Leptanillinae: *Leptanilla japonica* BARONI URBANI

Cerapachyinae: *Cerapachys sauteri* FOREL

Myrmicinae: *Aphaenogaster famelica famelica* (F. SMITH), *Cataulacus* sp., *Crematogaster matsumurai matsumurai* FOREL, *Epitritus hexamerus* BROWN, *Myrmecina* graminicola *nipponica* WHEELER, *Oligomyrmex sauteri* FOREL, *Pheidole pieli* MAYR, *Pristomyrmex pungenus* MAYR, *Smithistruma japonica* (ITO), *Tetramorium caespitum* (LINNAEUS), *Vollenhovia emeryi* WHEELER

Ponerinae: Amblyoponini: *Amblyopone australis* ERICHSON, Proceratiini: *Proceratium japonicum* SANTSCHI, *Discothyrea sauteri* FOREL, Ectatommini: *Gnamptogenys costata* (EMERY), *Rhytidoponera purpurea* (EMERY), Ponerini: *Brachyponera chinensis* (EMERY), *Cryptopone sauteri* (WHELLER), *Diacamma* sp., *Leptogenys kitteli* MAYR, *Odontoponera transversa* (F. SMITH), *Ponera japonica* WHEELER, *Trapeziopelta* sp. Odontomachini: *Odontomachus monticola* EMERY, *Anochetus* sp.

Vespoidea (Vespiformes)

Tiphiidae: *Methoca japonica* YASUMATSU, *Tiphia latistriata* ALLEN et JAYNES

Mutillidae: *Mutilla europaea mikado* CAMERON, *Myrmosa nigrofasciata* YASUMATSU

Pompilidae: *Auplopus* sp., *Cyphononyx dorsalis* (LEPELETIER)

Scoliidae: *Carinoscolia melanosoma fascinata* (F. SMITH), *Megacampsomeris grossa matsumurai* (BETREM)

Masaridae: *Pseudomasaris coquilletti* ROHWER

Eumenidae: *Discoelius japonicus* PEREZ, *Eumenes* sp.

Vespidae: *Polistes chinensis antennalis* PEREZ, *Vespa simillima xanthoptera* CAMERON

Sphecoidea

Sphecidae: *Ampulex dissector* (THUNBERG), *Ectemnius* sp.

Colletidae: *Colletes patellatus* PEREZ

Andrenidae: *Andrena mikado* STRAND et YASUMATSU

Halictidae: *Halictus* sp.

Melittidae: *Melitta japonica* YASUMATSU et HIRASHIMA

Megachilidae: *Megachile humilis* SMITH

Anthophoridae: *Xylocopa appendiculata circumvolans* F. SMITH

Apidae: *Trigona* sp.

Bethyloidea

Bethylidae: *Cephalonomia gallicola* (ASHMEAD)

Chrysididae: *Praestochrysis shanghaiensis* F. SMITH

Cleptidae: *Cleptes* sp.

Dryinidae: *Haplogonatopus apicalis* PERKINS dissolved with 10% KOH before the gold coating was applied.

Results

The types of labial-palp sensilla of the Aculeata Hymenoptera

The sensilla on the labial palpi are poorly known in the Aculeata in contrast to the other sensory organs. The only comprehensive morphological and electrophysiological investigations are those of Whitehead and Larsen (1976a,b) and Whitehead (1978) using *Apis mellifera*. These studies indicate that most sensilla on the labial palpi are contact chemoreceptors to the monitor chemical quality of food.

The present study showed that the aculeates showed very little variation in the structure of sensillum of the labial palpi, where these insects usually have setiform or digitiform sensilla on their labial palpi (Figs. 1–4, 6–8, 13). However, the Scoliidae are unique in having coeloconic sensilla on the labial palpi (Fig. 5), and the Masaridae in having only large bristles (Fig. 7).

The sensillum structure of Formicidae

The peculiarities found in the structure of sensillum of the labial palpi of Formicidae are as follows :

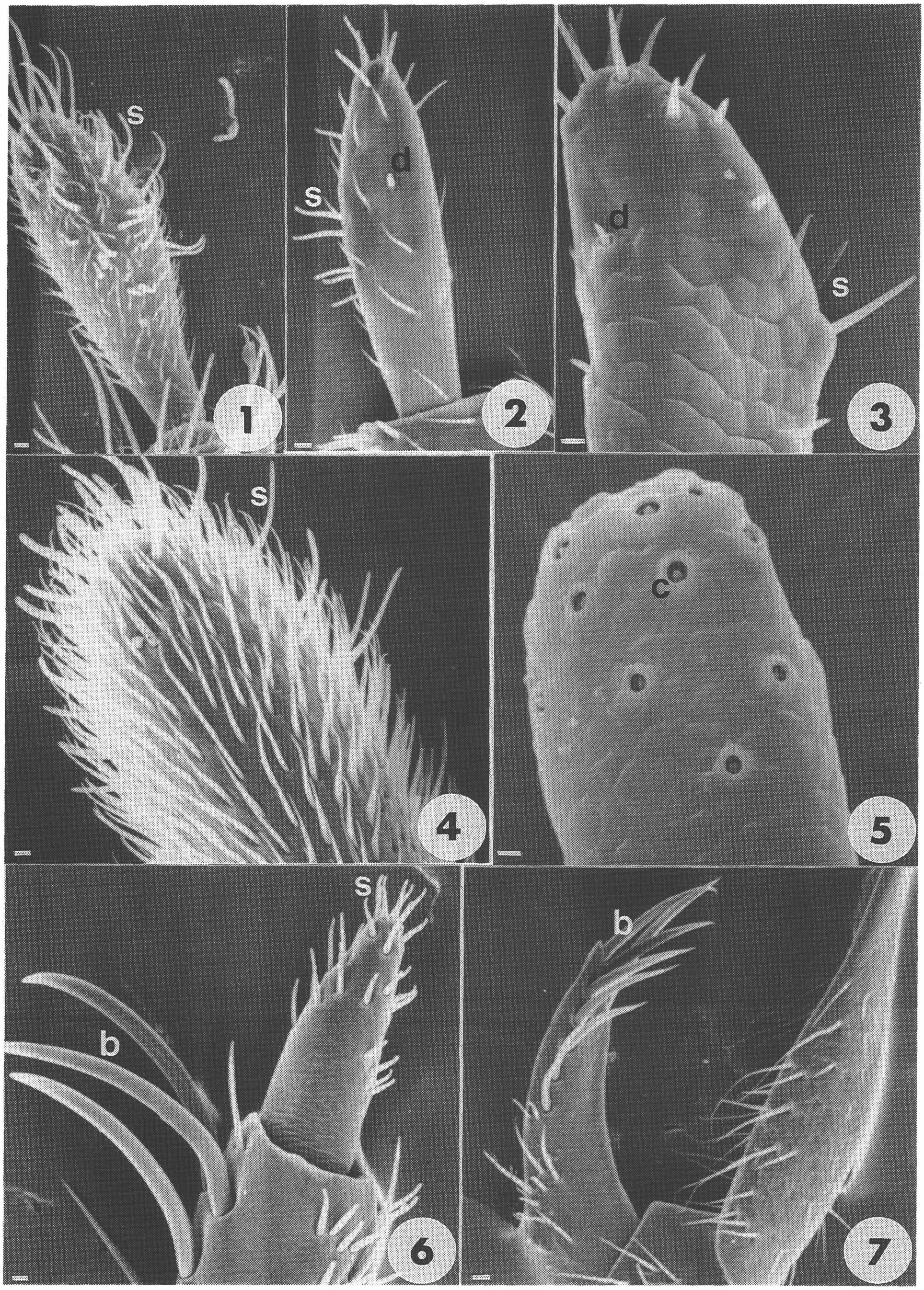
The labial palpi of most non-formicid aculeates are densely covered with setiform sensilla and bristles. This condition was maintained in the Formicinae, Pseudomyrmecinae, Myrmeciinae and Dolichoderinae. For example, the myrmeciines had 15–19 setiform sensilla and approximately 400 bristles on the distal segment (Fig. 10). On the other hand, the Dorylinae, Cerapachyinae, Leptanillinae, Ponerinae and Myrmicinae had very smooth labial palpi (Fig. 12); they have less than 5 setiform sensilla and no bristles on the distal segment. Such an extreme reduction in the numbers of setiform sensilla and bristles was found only in these formicid taxa among the Aculeata.

All the formicids examined had one digitiform sensillum on the tip of last labial-palp segment (Figs.10 and 12). The pegs on this type of sensilla are very small in the most formicids, usually less than 5 μm, and the ratio of peg length to distal segment length of labial palpus did not exceed 10%. This is also the case with other Aculeata, such as the Tiphiidae and Mutillidae (Fig. 9). Some Ponerinae including the Amblyoponini and Proceratiini, however, had long pegs; 8 μm to 14 μm, and the ratio ranged between 17% and 25% (Fig. 11). The Cerapachyinae and Leptanillinae had also relatively long pegs of 4–5 μm, the ratio being 14–45%.

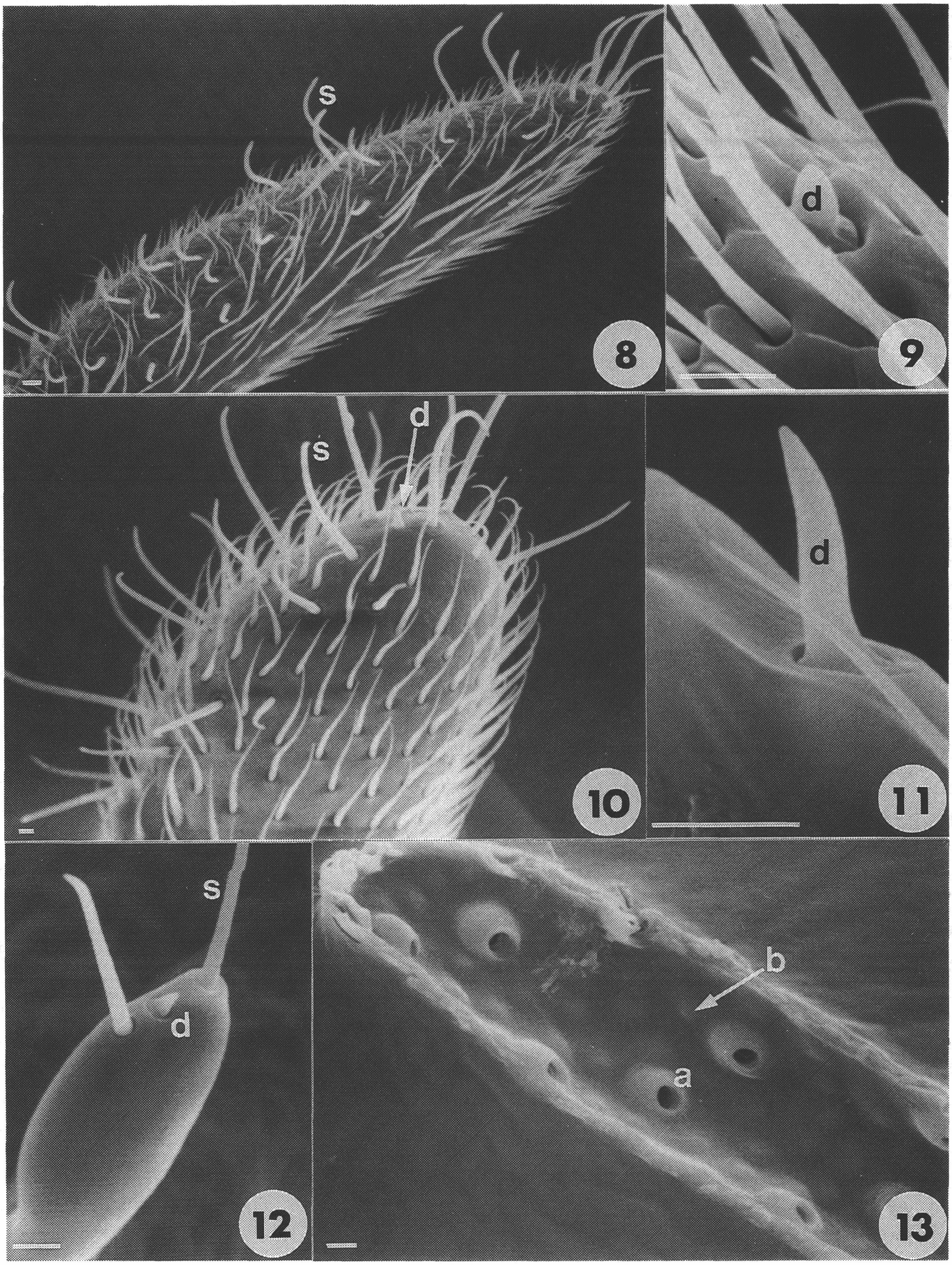
Discussion

The labial palpi of the Formicidae have many setiform sensilla, and one digitiform sensillum on the tip. It is of great interest that the same sensilla pattern is found in the Tiphiidae and Mutillidae, which have frequently been considered to be the closest relatives of the Formicidae (Mosley, 1938; Wilson, 1971). Although the Scoliidae are also considered to be a sister-group of the Formicidae (Walther, 1984), the sensilla pattern on labial palpi in this wasp group is unique among the aculeates and quite different from that of the Formicidae.

Chapman (1982) stressed that large numbers of the sensilla should provide responses to a wider range of environmental stimuli. If this is correct, the species that have a broad range of diet should have larger numbers of the labial sensilla. However, the Formicidae dose not fit the expected pattern.



Figs. 1–7. Sensilla on the labial palpi. 1, *Chrysis shanghaiensis* (Chrysididae). 2, *Ectemnius* sp. (Sphecidae). 3, *Megachile humilis* (Megachilidae). 4, *Auplopus* sp. (Pompilidae). 5, *Carinoscolia melanosoma fascinata* (Scoliidae). 6, *Vespa simillima xanthoptera* (Vespidae). 7, *Pseudomasaris coquilletti* (Masaridae). Abbreviations used for figures are as follows. a: aperture br: bristle c: coeloconic sensillum d: digitiform sensillum s: setiform sensillum. (Scale bar= 5 μm)



Figs. 8– 13 . Sensilla on the labail palpi. 8 and 9, *Mutilla europaea mikado* (Mutillidae), 9, close-up of the tip of labial palpus; note digitiform sensillum. 10, *Myrmecia gulosa* (Myrmeciinae, Formicidae). 11, *Proceratium watasei* (Ponerinae, Formicidae); close-up of the tip of labial palpus showing digitiform sensillum. 12, *Cryptopone sauteri* (Ponerin, Formicidae), 13, *Camponotus japonicus* (Formicinae, Formicidae); longitudinal section of labial palpus to show the apertures of setiform sensilla; note that the bristles have no apertures at the base. (Scale bar= 5 μ m)

Although many formicids have a widest variety of food among the aculeates (i.e. live prey, dead animal remains, flower nectar, nectar secreted by extrafloral nectaries, honeydew secreted by insects, seeds, fungi, etc.), they show an extreme reduction in the number of sensilla on labial palpi. This suggests that either there is no relationship between the abundance of sensilla and diet breadth, or the fewer sensilla have resulted in a broad diet range perhaps because the assumed decrease in sensitivity allowed less accurate discrimination between different type of food. Further study, by the aid of electrophysiology, is needed to clarify these points and to better understand ecology and phylogeny of this unique group of insects.

Acknowledgements

I thank to Drs. S. Momoi and T. Naito of Kobe University for their guidance and Dr. M.Takeda of Kobe University for critical reading. I am indebted to the following entomologists for their offering valuable materials and useful information: Drs. R. H. Crozier, M. Kubota, K. Masuko, K. Ogata, M. Terayama, J. R. Walther, Sk. Yamane, and K. Yamauchi.

Reference

Brothers, D. J. (1974) Phylogeny and classification of the aculeate Hymenoptera, with special reference to Mutillidae. *Univ. Kansas. Sci. Bull.*, **50**, 483-648.

Chapman, R. F. (1982) Chemoreception: the significance of receptor numbers. *Adv. Insect Physiol.*, **6**, 247-355.

Hashimoto, Y. (1990) Unique features of sensilla on the antennae of Formicidae (Hymenoptera). *Appl. Ent. Zool.*, **25**, 491-501.

Mosley B. D. (1938) An outline of the phylogeny of the Formicidae. *Bull. Soc. Entomol. Fr.*, **43**, 190-194.

Walther J. R. (1984) The antennal patterns of sensilla of the Plathythyreini (Ponerinae) in comparison to those of other ants (Hym. Formicoidea), abstract, Int Congr. Entomol., vol 17, p 28.

Wheeler, G. C. and Wheeler, J. M. (1985) A simplified conspectus of the Formicidae. *Trans. Amer. Ent. Soc.*, **111**, 255-264

Whitehead, A. T. (1978) Electrophysiological response of honey bee labial palp contact chemoreceptors to sugars and electrolytes. *Physiol. Ent.*, **3**, 241-248.

Whitehead, A. T. and Larsen, J. R. (1976a) Ultrastructure of the contact chemoreceptors of *Apis mellifera* L. (Hymenoptera : Apidae). *Int. J. Insect Morphol. and Embryol.*, **5**, 301-315.

Whitehead, A. T. and Larsen, J. R. (1976b) Electrophysiological responses of gallal contact chemoreceptors of *Apis mellifera* to selected sugars and electrolytes. *J. Ins. Physiol.*, **22**, 1609-1616.

Wilson, E. O. (1971) *The insect societies*. Belknap Press of Harvard University Press, Cambridge, x+ 548 p.

(Accepted February 19, 1992)