I J R B A T, Vol. II, Issue (7), Nov 2015: 323-327 ISSN 2347 – 517X

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

www.vmsindia.org

ANTENNAL SENSILLA IN MEXICAN BEETLE *ZYGOGRAMMA BICOLORATA* (COLEOPTERA: CHRYSOMELIDAE): A POTENTIAL BIOCONTROL AGENT OF WEED *PARTHENIUM HYSTEROPHOROUS*

Rina S. Saha[1] and Manoj K. Bangadkar[2]

[1]S. M. M. College of Science, Nagpur, Maharashtra, India

[2]P. G. T. D. Zoology, RTM Nagpur University, Nagpur, Maharashtra, India

manoj.rtmnu@gmail.com

Abstract

In order to determine the type, distribution and structure of sensillae, the antennae of the adult Mexican beetle *Zygogramma bicolorata* (Coleoptera: Chrysomelidae), were examined by scanning electron microscopy. Antenna was composed of nine segments of which first and second segment is called scape (Sc) and pedicel (Pd) respectively and last nine segments was collectively called as flagellum (Fl). The surface of antenna is covered with placoid scales and nine types of sensillae were identified on it. Five types of sensillae including sensilla basiconica, uniporous cone, multiporous peg and very dense sensilla trichodea curvata were found on the surface of flagellum. Sensilla trichodea type I (ST-I) and Sensilla trichodea type II (ST-II) were found on scape and pedicel and Sensilla trichodea type III (ST-III) found only on pedicel. Sensilla trichodea curvata type I (STC-I) and Sensilla trichodea curvata type II (STC-II) were found on all the segments. Sensilla basiconica (SB), uniporous cone (UC) and multiporous pegs (MP) were found only on the flagellum. The various sensillae present on the surface of antennae may have different functions like mechanoreception, chemoreception and hygroreception etc. and involved in the feeding behavior of insect.

Keywords: *Zygogramma bicolorata,* Antenna, Sensilla, Scanning Electron Microscopy

Introduction

The mexican beetle *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) is a biocontrol agent of weed, *Parthenium hysterophorus* (Asteraceae: Heliantheae) (Withers, 1998). Both adults and larvae of *Z. bicolorata* are capable of feeding on leaves, terminal buds and leaf blades of *Parthenium*. It has proved highly effective in managing this weed, significantly decreasing weed density and flower production (Dhileepan *et al.,* 2000).

Antennae in insects are organs of taste, smell and stimulation (Wigglesworth, 1972). The antennae also play kinetic roles and normally keep the nervous system in a state of tone in which it responds to stimuli of all kinds. Antennae of insects vary greatly in length, overall size, size of the individual segment, segmentation, setation and other aspects with the structures being closely related to their functions (Srivastava and Omkar, 2003).

Despite the importance of sense organs on the antennae of mexican beetle (for oviposition, feeding and mating) there is little information about it. Therefore, the objective of current study is to describe the ultrastructure of antennae in *Z. bicolorata* using scanning electron microscopy.

Materials and Methods

The antennae of newly emerged Mexican beetle *Zygogramma bicolorata* (Coleoptera: Chrysomelidae) were carefully excised from the antennal sockets and washed thoroughly in distilled water. After washing, antennae were fixed in 70 % alcohol for a period of 12 hours. After which the antennae were dehydrated sequentially in ascending grades of alcohol followed by cleared in acetone. The antennae were observed under stereomicroscope to reveal the general morphology and the length of individual segments using an ocular micrometer. The air dried antennae were mounted on metallic stub which was precoated with carbon strip. The metallic stub with antennae was proceeded for the gold coating and scanned under the Jeol (JSM 6380 A) Scanning Electron Microscope (SEM) at Visvesvaraya National Institute of Technology (VNIT), Nagpur.

Observations and Results

A pair of antennae of adult Mexican beetle *Z. bicolorata* is located on the head capsule. The antenna consists of an elongated scape, followed by a pedicel and a flagellum of 9 segments. Each segment is called as flagellomere. The length of complete antenna from base to apex is measuring about 2502.25±66.65 μm (Figure 1, A). Surface of the antenna is covered with placoid scales and contain various types of sensillae on it. A pore like pit gland of 1.37±0.03 μm diameter is present throughout the surface of antenna

(Figure 4, G and H). The terminal five segments are densely covered with sensilla.

A single segment scape is measuring about 240.65±14.29 µm in length and 172.05±9.25 µm in width (Table 2). Small numbers of sensilla trichodea type I and sensilla trichodea type II as well as curved sensilla trichodea type I and curved sensilla trichodea type II are found on the surface of scape (Table 1 and Figure 1, B).

Pedicel is continued after the scape and composed of a single segment and fits in a comparatively large cavity at the distal end of the scape (Figure 1, B). Pedicel is measuring about 163.85±20.82 µm in length and 122.85±13.08 µm in width. On the surface of pedicel sensilla trichodea type I and sensilla trichodea type II as well as curved sensilla trichodea are found (Table 1 and 2).

Flagellum is composed of a nine segments, first four segments are collectively called as funicle and last five segments are collectively called as club (Figure 2, C and D). Flagellum is measuring about 2137.56±66.21 µm in length. The last flagellomere being the longest (324.28±6.04 µm) while the fourth flagellomere is shortest (167.75±10.01µm) (Table 2). On the surface of funicle a small numbers of sensilla trichodea type I and curved sensilla trichodea type I are found. A very dense sensilla trichodea type I, sensilla trichodea type II, sensilla trichodea type III and sensilla trichodea type IV as well as curved sensilla trichodea type I and curved sensilla trichodea type II are found on the surface of club (Table 1). On the tip of distal segment of flagellomere a uniporous cones and multiporous pegs are observed.

Trichodea sensillae type I, II and III were found on all segments of the antenna of *Z. bicolorata*. This sensilla is innervated by a single sensory neuron, attached to the base of the hair shaft. The average length of sensilla trichoidea type I, II and II was found to be 89.13±3.36, 55.53±4.40 and 26.46±1.63 respectively and average width of sensilla trichoidea type I, II and II was found to be 2.53±0.05, 2.30±0.08 and 2.05±0.05 respectively (Table 3).

Table 1: Type of Sensilla present on Antenna of *Z. bicolorata*

	Type of Sensilla
Scape (Sc)	ST-I, ST-II, STC-I and STC-II
Pedicel (Pd)	ST-I, ST-II, ST-III, STC-I and STC-II
Flagellum (Fl)	STC-I, STC-II, SB, UC and MP

Table 2: Average length and width of various segments of Antenna of *Z. bicolorata*

	Length (µm)	**Width (µm)**
Scape (Sc)	240.65±14.29	172.05±9.52
Pedicel (Pd)	163.85±20.82	122.85±13.08
Flagellum (Fl)	2137.56±66.21	-
F-1	298.18±8.26	104.23±6.10
F-2	223.33±6.15	114.49±5.08
F-3	234.84±6.05	113.20±6.03
F-4	167.75±10.01	134.95±6.45
F-5	174.37±6.42	193.97±8.09
F-6	224.26±6.33	235.56±5.42
F-7	233.14±9.60	235.89±6.30
F-8	251.10±7.78	236.02±7.11
F-9	324.28±6.04	223.53±6.17

Table 3: Average length and width of different type of sensilla found on antennae of *Z. bicolorata*

Type of Sensilla	**Length (µm)**	**Width (µm)**
ST-I	89.13±3.36	2.53±0.05
ST-II	55.53±4.40	2.30±0.08
ST-III	26.46±1.63	2.05±0.05
STC-I	72.23±3.88	3.57±0.06
STC-II	42.56±2.72	3.45±0.11
STC-III	38.56±3.79	2.66±0.07
SB	1.45±0.03	0.63±0.03
UC	5.97±0.28	3.26±0.06
MP	12.38±0.49	1.61±0.04

Abbr.: F- Flagellomere, ST- Sensilla Trichodea, STC- Sensilla Trichodea Curvata, SB- Sensilla Basiconica, UC- Uniporous Cone, MP- Multiporous Peg

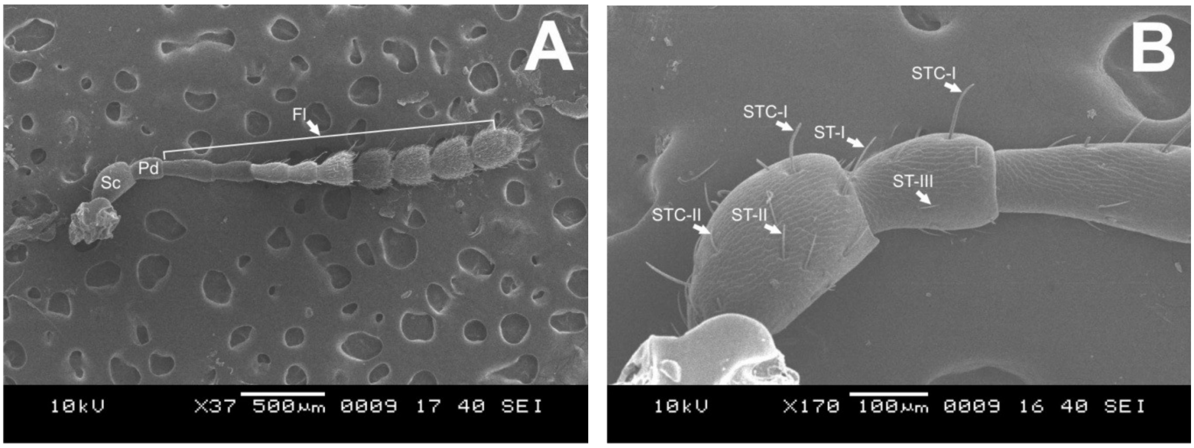

Figure 1: Scanning electron mocrographs of antenna of *Z. bicolorata*

- **A.** General overview of antenna showing Scape (Sc), Pedicel (Pd) and Flagellum (Fl)
- **B.** Magnified view of Scape (Sc) and Pedicel (Pd) showing ST-I, ST-II, ST-III, STC-I and STC-II.

Abbr.: Sc- Scape, Pd- Pedicel, Fl- Flagellum, ST- Sensilla Trichodea, STC- Sensilla Trichodea Curvata

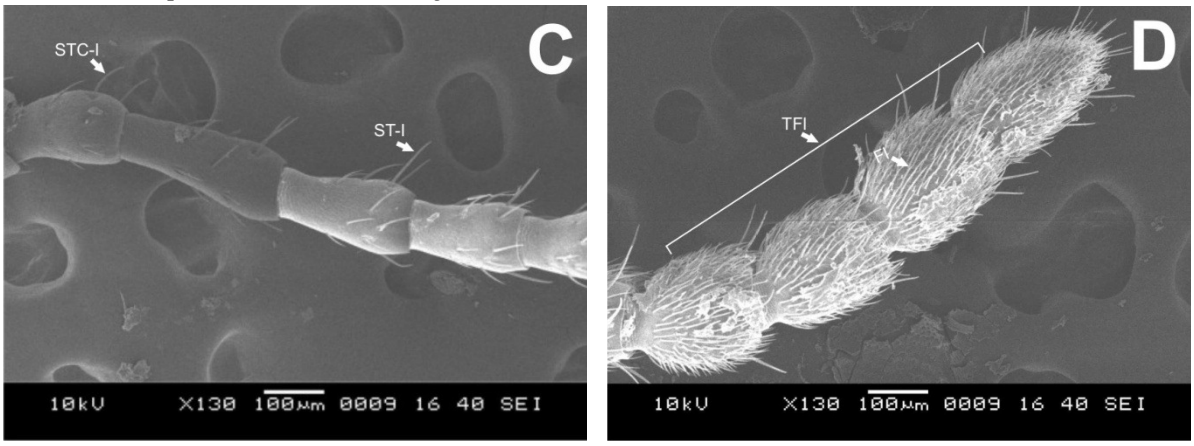

Figure 2: Scanning electron mocrographs of antenna of *Z. bicolorata*

- **C.** General overview of Antenna showing Scape (Sc), Pedicel (Pd) and Flagellum (Fl)
- **D.** Magnified view of Scape (Sc) and Pedicel (Pd) showing ST-I, ST-II, ST-III, STC-I and STC-II.

Abbr.: ST- Sensilla Trichodea, STC- Sensilla Trichodea Curvata, TFl- Terminal Flagellomere.

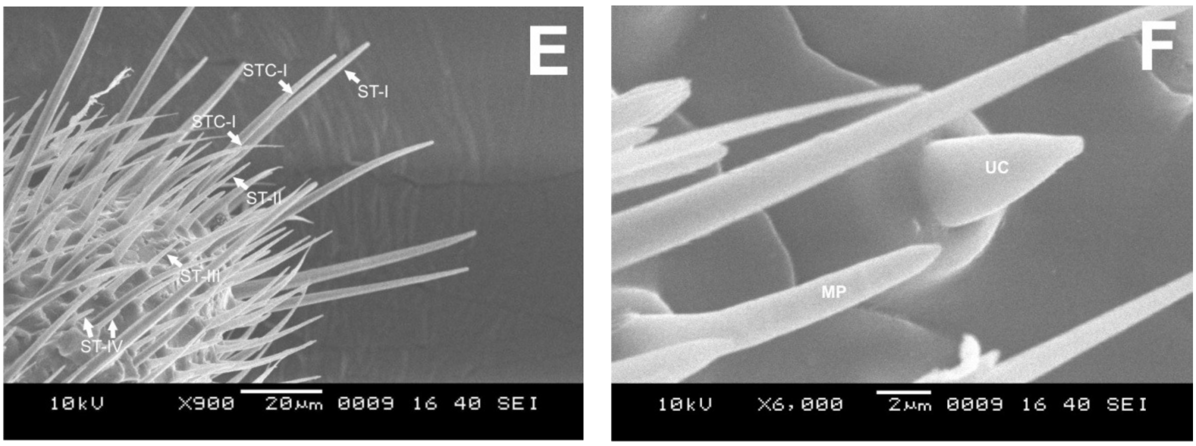

Figure 3: Scanning electron mocrographs of antenna of *Z. bicolorata*.

- **E.** Magnified view of the tip of lst flagellomere showing ST-I, ST-II, ST-III, ST-IV and STC-I.
- **F.** Magnified view of Uniporous cone (UC) and Multiporous peg (MP) present on 9th flagellomere.

Abbr.: ST- Sensilla Trichodea, STC- Sensilla Trichodea Curvata, UC- Uniporous Cone, MP- Multiporous Peg

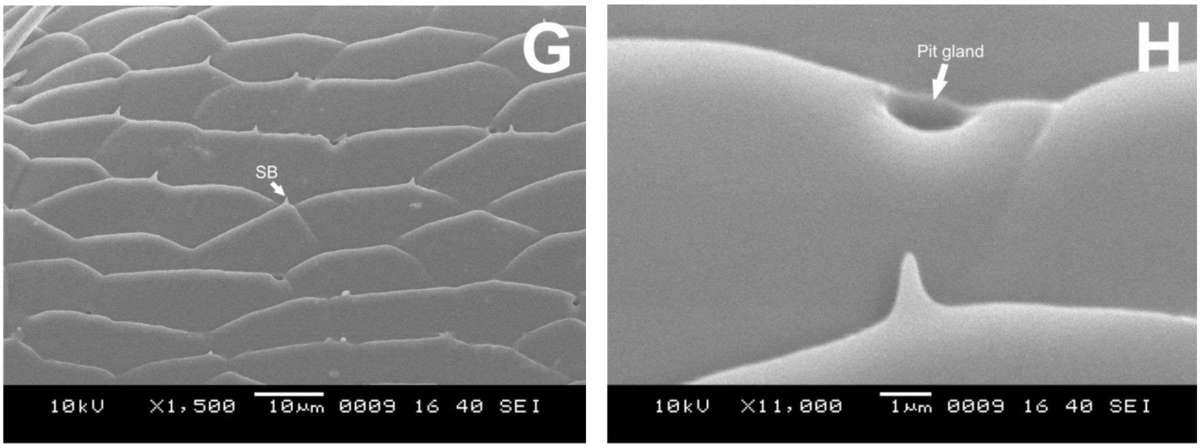

Figure 4: Scanning electron mocrographs of antenna of *Z. bicolorata.*

G. Magnified view of Sensilla Basiconica (SB).

H. Magnified view of pit gland. **Abbr**.: SB- Sensilla basiconica

Discussion

In the present study the *Zygogramma bicolorata* demonstrates that it contains 09 morphologically distinct types of sensillae that play important roles in a number of behaviors. In other insect species the various types of sensilla are described by Hu *et al*., 2009. These sensilla are capable of responding to various stimuli, viz. olfactory, gustatory, tactile as well as thermoreception and hygroreception (Hansen, 1978; Altner and Prillinger, 1980; McIver, 1975 and 1985; Zacharuk 1980 and 1985). However, the variations in sensillum length did not appear to correlate with sex, species, or genus, and the sensillum length appeared not to correlate with the size of the antennae (Payne *et al.,* 1973). Very dense sensillae present on the terminal flagellomere of the antenna. On the surface of scape and pedicel less number of sensilla are present as compared to number of sensilla present on flagellum.

Sensilla trichodea was the most abundant sensillar type on antenna of *Z. bicolorata*. This type of sensilla is described as long, slender, and hair-like (Ryan, 2002). In the present study it has been found that some trichoidae sensilla were curved which are called as curved trichodea sensilla. Mechanoreception is the most probable function of these types of sensilla (Zacharuk, 1985). Mustaparta (1973) found that similar sensillar types on the weevil *Hylobius abietis* (L) had either a mechanoreceptive function, or no receptor function, possibly acting as protective hairs (Bartlet *et al.,* 1999).

Sensilla basiconica (SB) were present on a terminal segments of funicle which were compact and formed a sort of palisade. Morphologically Z. bicolorata exhibits similar structure to previously studied ant species, in Tomicus sp. (Wang *et al.*, 2012) and Dendroctonus valens (Chen *et al.,* 2010) and may function as contact gustatory receptors, perhaps involved in nestmate recognition (Ozaki *et al.*, 2005; Nakanishi *et al.,* 2009; Mysore *et al.,* 2010). Antennal SB of fire ants, *Solenopsis invicta* are also known to function as contact chemoreceptors (Payne *et al.*, 1973).

A uniporous cone and multiporous peg were found on the tip of antenna of *Z. bicolorata.* They were sunken in deep pits surrounded with a basal socket membrane and ended with a pore at its terminal tip. These sensilla were described for the first time in N. pronuba (Faucheux, 1990). These sensilla might be sensitive to carbon dioxide or himudity as a hygroreceptor or may be olfactory because the side wall is porous. They have also been reported in dipteral (Bay and Pits, 1976).

Various types of sensillae present on the antennae revealed that antennae involved in the host selection and communication via olfaction was predominated in *Z. bicolorata.* This study herein supposedly stand to be the first attempt to describe the antennal sensilla of *Z. bicolorata* using scanning electron microscopy and might be considered as the first step towards future investigations of the odorant receptor. More detailed studies on the functional morphology of the antennal sensilla using transmission electron microscopy (TEM) coupled with electrophysiological recordings needs be conducted for confirmation of the function of the different sensilla.

Acknowledgements

The authors are thankful to the University Grant Commission, New Delhi for financial support under major research project (UGC-MRP) and Principal, S. M. Mohota College of Science, Nagpur, India is also acknowledged for providing necessary facilities and support.

References

Altner, H. and Prillinger, L. (1980). Ultrastructure of invertebrate chemo-, thermo-, and hygroreceptors and its functional significance. *Int. Revue of Cytology*, 67: 69-39.

Bartlet, E, Romani, R, Williams, I. H. and Isidoro, N (1999). Functional anatomy of sensory structure on the antennae of *Psylliodes chrysocephala* l. (Coleoptera: Chrysomelidae). *Int. J. of Insect Morphol. And Embryol.,* 28:291-300.

Bay, D. E. and Pitts, C. W (1976). Antennal olfactory sensilla of the face fly *Musca autumnalis* De Geer. *Int. J. Insect Morphol. Embryol.,* 5: 1-16.

Chen, H-bo, Zhang, Z., Wang, H-bin, Kong, Xbo. (2010). Antennal morphology and sensilla ultrastructure of *Dendroctonus valens* LeConte (Coleoptera: Curculionidae, Scolytinae), an invasive forest pest in China. *Micron,* 41(7): 735–741.

Dhileepan, K., Setter, S. D. and McFadyen, R. E. (2000). Response of the weed Parthenium hysterophorus (Asteraceae) to defoliation by the introduced biocontrol agent, Zygogramma bicolorata (Coleoptera: Chrysomelidae). *Biological Control*, 19: 9–16.

Faucheux, M. J. (1990). Antennal sensilla in adult *Agathiphaga vitiensis* Dumbl. and *A. queenslandensis* Dumbl. (Lepidoptera: Agathiphagidae). *Int. J. Insect Morphol. Embryol.*, 19: 257-268.

Hu, F., Zhang, G. N., Wang, J. J. (2009). Scanning electron microscopy studies of antennal sensilla of bruchid beetles, *Callosobruchus chinensis* (L.) and *Callosobruchus maculates* (F.) (Coleoptera: Bruchidae). *Micron,* 40(3): 320–326.

McIver, S. B. (1975). Structure of cuticular mechanoreceptors of arthropods; *Annu. Rev. Entomol.,* 20: 381–397.

Mustaparta, H. (1973). Olfactory sensilla on the antennae of the pine weevil. *Zeitsdchrift fÜr Zellforschung und Mikroskopische Anatomie,* 144: 559-571.

Mysore. K., Shyamala, B. V. and Rodrigues, V., (2010). Morphological and developmental analysis of peripheral antennal chemosensory sensilla and central olfactory glomeruli in worker caste of *Camponotus compressus* (Fabricius, 1787). *Arthropod Str. and Dev.,* 39: 310-321.

Nakanishi, A., Nishino, H., Watanabe, H., Yokohari, F. and Nishikawa, M., (2010). Sex-specific antennal sensory system in the ant *Camponotus japonicus*: glomerural organizations of antennal lobes. *J. of Comp. Neurology,* 518: 2186-2201.

Ozaki, M., Wada-Katsumata, A., Fujikawa, K., Iwahasi, M., Yokaharif, Satoji, Y. and NishimuratandYamaoka, Y., (2005). Ant nestmate and nonnestmate discrimination by a chemosensory sensillum. *Science,* 309: 311-314.

Ryan, M. F. (2002). *Insect Chemorecepcion: Fundamental and Applied*. Kluwer Academic Publishers. Hansen K 1978 Insect chemoreception; in *Taxis and behavior (ed.) G L Hazelbauer (New York: John Wiley),* 5: 233–292.

Srivastava, S., Omkar. (2003). Scanning electron microscopy of antennae of coccinella septempunctata (Coleoptera: Coccinellidae). *Entomological Sinica,* 10(4): 271-279.

Wang, G. R., Guo, Y. Y., Wu, K. M. (2002). Study on the ultrastructures of antennal sensilla in *Helicoverpa armigera. Agricultural Sciences in China*, 1: 896–899.

Wang, G. R., Guo, Y. Y., Wu, K. M. (2002). Study on the ultrastructures of antennal sensilla in *Helicoverpa armigera. Agricultural Sciences in China,* 1: 896–899.

Wigglesworth, V.B. (1972). The principles of insect physiology. *Chapman and Hall Publications*. 827.

Withers, T. M. (1998). Influence of plant species on host acceptance behaviour of the biocontrol agent Zygogramma bicolorata (Coleoptera: Chrysomelidae). *Biological Control*, 13: 55–62.

Zacharuk, R. Y. (1980). Ultrastructure and function of insect chemosensilla. *Annu. Rev. Entomol.,* 25: 27-47.

Zacharuk, R.Y. (1985). Antennae and sensilla. *Comprehensive Insect Physiol., Chem. and Pharmacol. (Kerkut, G .A. and Gilbert, L.I., eds.),* 6: 1-69.