“Surface Ultra-Structural Studies on Antennae in Polymorphs of Weaver Ant *Oecophylla smaragdina*; Fabricius” (Hymenoptera: Formicidae) with Reference to Sensilla

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**ABSTRACT**

*Oecophylla smaragdina* is an established biological pest control agent in south-east Asian continent for cash crops like cashew and mango. It is a cosmopolitan species found all over the Asian continent. Being a social hymenopteran insect, *Oecophylla smaragdina* has a colony comprising of polymorphs. The morphological and ultra-structural investigation of such polymorphs antenna was done with scanning electron microscopy to reveal presence of various chemosensory, thermo-sensory and tactile sensory sensillae on the antennal segments with their specific role in the polymorphs. The role of worker in foraging activity is supported with the presence of large number of sensilla compared to other castes.

**Key words:** Biological pest control, Hymenopteran, Sensilla, Scanning electron microscopy.

**INTRODUCTION**

*Oecophylla smaragdina* is a social Hymenopteran ant also known as Asian Weaver ant. Greenslade (1972) reported about the distribution of Asian weaver ant in Oriental region from India to Queensland and Solomon Islands. Social structure of the colony consists of fertile and infertile castes. The fertile caste comprises of drone (male) and queen (female) whereas the infertile caste is of workers. *Oecophylla smaragdina* is studied as biological pest control agent in Australia (Peng et al., 1995) and south-east Asian countries (Peng et al., 2004; 2005; 2006; 2007). Although the economical aspect of the ant is extensively studied for colony dynamics and role of various workers in colony function, the morphological variation of various individuals of the colony is not studied in detail of the species.

Therefore in the present investigation morphology and ultra-structural variation of antennae and antennal sensilla of polymorphs has been investigated.

**MATERIALS AND METHODS**

**Insect sources**

The fully mature castes of *Oecophylla smaragdina* were collected during the month of May – July 2018 from the colony established in the mango orchards of Central and Western India by hand picking. The insects were preserved in 70% alcohol for further studies. The present studies were carried out in research laboratory of Post Graduate Teaching Department of Zoology in RTM Nagpur University campus, Nagpur.

**Morphological preparation**

For external morphological studies, freshly preserved specimen treated with 10% KOH (60°C) for 20 minutes, as per the method of Barsagade et al., (2013). Dissections were carried out under a stereoscopic binocular microscope Olympus SZX7 and the head with antennae was separated. Photographs were taken at 5.6 X magnification.

**Scanning electron microscopy**

Scanning electron microscopic (SEM) studies, were carried out as per the method of Barsagade et al. (2013). The dissected appendages of both the castes were washed thoroughly with distilled water and fixed in 10% formalin for 12 hrs. The specimens were then dehydrated in ascending series of alcohol grades, cleared in acetone and dried at room temperature. Dehydrated appendages mounted on carbon-coated metallic stubs at different angles followed by platinum coating in JOEL coating unit. Specimens observed with a JOEL JSM- 7600 F SEM at 25-5500 X magnification at the Sophisticated Analytical Instrumentation Facility (SAIF) of Indian Institute of Technology (IIT) Mumbai, India.
Statistical analysis
The morphometric measurements were carried out with the help of Digimizer version 4.6.1 medcalc image analysis software package. All the measurement data for length and width of antennae as well as sensillae were subjected to arithmetic calculations. The mean, standard deviation and ± standard error was calculated, by using Microsoft Excel 2007 software package.

RESULTS AND DISCUSSION
The antennae of the polymorphic forms of *O. smaragdina* are geniculate type and consist of 3 regions viz; Scape, Pedicel and Flagellum. The antenna is fitted basally into antennal socket (AS) on the head. The length of antennae was bigger in queen followed by worker and drone (Table 1) (Fig 1.1). Ultra structural study of various segments of antenna in polymorphs of *O. smaragdina* showed presence of different types of sensilla (Table 2), Fig 1.2 to 1.16.

The geniculate type of antennae observed in *O. smaragdina* is characteristic of aculeate Hymenoptera (Michener 1974; Richards and Davies 1988; Okada et al. 2006; Mysore et al. 2009; Nakanishi et al., 2009, Barsagade et al., 2013). During the present study it has been observed that *O. smaragdina* queen had longest antennae followed by worker. While, drone of *O. smaragdina* had shortest antennae compared to other polymorphs. The drone antenna of *O. smaragdina* comprises of 11 antennal flagellomere while worker and queen antenna has 10 flagellomeres as like as found in *Apis mellifera* Linnaeus (Esslen and Kais illness, 1976) in *Myrmicaria brunnea* (Barsagade et al., 2019) and *Componotus compressus*. (Barsagade et al., 2013; Nakanishi 2009, 2010; Mysore et al., 2010). The antenna in *O. smaragdina* shows clear demarcation of structure in scape, pedicel and flagellum. Okada et al., (2006) confirmed a ball-like modification at the base of antennal scape in ant *Diacamma sp.* and *Componotus compressus* (Nakanishi et al., 2009; Barsagade et al., 2013). Similar confirmation of scape modification is noticed in present study of *O. smaragdina*. In *O. smaragdina* the scape ball is covered with sensilla arranged in rows earlier confirmed by Barsagade et al., (2013) in *Componotus compressus* and Gathalkar and Barsagade (2018) in *Myrmicaria brunnea*.

The surface ultra structure of antennae in workers of ant species has been studied earlier and confirmed presence of sensilla trichodea, sensilla basiconica and sensilla trichodea curvata on the antennal segments of workers (Babu et al., 2011; Barsagade et al., 2013). In the present study the ultra-structure of scape ball in *O. smaragdina* shows presence of sensilla basiconica (SB), classified into three types SB-I, SB-II and SB-III on the basis of size. The presence of three types of sensilla basiconica on the scape ball in *Leptogynes chinensis* and other ants has been noticed earlier by workers Nakanishi (2009, 2010); Mysore et al. (2010); Barsagade et al. (2013); Gathalkar and Barsagade, (2018); Barsagade et al. (2019). The scape shaft observed in all the polymorphs of *O. smaragdina* had presence of sensilla trichodea. The queen of *O. smaragdina* also shows presence of sensilla trichodea curvata and sensilla basiconica apart from sensilla trichodea. Earlier, Dumpert (1972), has described sensitivity of sensilla trichodea curvata present on scape ball to various volatile compound including alarm pheromones; presence of sensilla trichodea curvata on *O. smaragdina* queen scape ball may serve possible role of chemical communication.

In the present study in polymorphs of *O. smaragdina* pedicel shows five basic types of sensilla viz., sensilla trichodea, sensilla basiconica, sensilla chaetica, sensilla coeloconica and sensilla coelocapitular. Many earlier workers have reported abundance of sensilla trichodea on insect antennal segments functioning as contact chemoreceptor (Hashimoto 1990, Onagbola et al., 2009, Barsagade et al., 2013; Esquivel et al., 2014; Barsagade et al., 2019). In the present study the minor and major worker pedicel shows presence of sensilla chaetica, sensilla coeloconica and sensilla coelocapitular may work as chemoreceptor. Ruchy et al., (2009), described sensory neuron activity of sensilla coeloconica to atmospheric temperature. Recently, Schneider et al., (2018), confirmed sensilla coeloconica use in thermo sensitivity in Orthoptera. Presence of sensilla coeloconica on the antenna of major worker in *O. smaragdina* may involve in response of thermal signals to other colony mates and might help in colony protection. Earlier workers have described sensilla chaetica as non porous filiform sensilla functioning as mechanoreceptor (Dumpert 1972; McIver 1975; Onagbola et al., 2009). In the present study sensilla chaetica was observed on the antennal pedicel of major worker indicating its role in tactile communication and colony propagation. Sensilla coelocapitular was observed distributed on the pedicel of worker antenna. Earlier many workers have reported presence of coelocapitular sensillae on various insects like *Camponotus japonicas* (Nakanishi et al., 2009), *Apis mellifera* (Yokohari et al., 1982; Yokohari, 1983), *Oecophylla smaragdina*.
Leptogenys chinensis (Barsagade et al., 2019). Nishino et al., (2009) have studied sensilla coelocapitular in honey bees and tested electro-physiologically its neural connections confirming the function of sensilla coelocapitular as hygro and thermo receptor. The presence of sensilla coelocapitular on O. smaragdina worker antenna may be playing possible role to detect atmospheric temperature and humidity.

Antennal flagellum of polymorphs in O. smaragdina shows diversity in types of sensilla, where some of the sensilla absent on other segments are compensated in flagellum as observed by Li et al., (2013) in Quadrasthicus erythrinae: Hymenoptera. In the present study the worker flagellum shows distribution of highest numbers of sensilla trichodea, sensilla basiconica, sensilla trichodea curvata, sensilla coeloconica, sensilla chaetica and sensilla coelocapitular present over there. As discussed earlier by various workers (Dumpert 1972; McIver 1975; Hashimoto 1990; Ruchy et al., 2009; Nishino et al., 2009;

**Table 2:** Types of sensilla present on antennal segments in polymorphs of O.smaragdina.

| Structure   | Caste | Sensilla | Measurement |
|-------------|-------|----------|-------------|
|             |       |          | Length (µm) | Width (µm) |
| Scape ball  | Worker| SB-I     | 18.35±0.65 | 1.42±0.34 |
|             |       | SB-II    | 6.81±0.48  | 1.42±0.05 |
|             |       | SB-III   | 6.7±0.78   | 1.2±0.05  |
|             | Drone | SB-I     | 22.92±0.61 | 1.2±0.65  |
|             |       | SB-II    | 11.5±0.66  | 1.2±0.54  |
|             |       | SB-III   | 6.7±0.78   | 1.2±0.65  |
|             | Queen | SB-I     | 24.8±0.61  | 3.2±0.57  |
|             |       | SB-II    | 6.86±0.62  | 3.2±0.73  |
|             |       | SB-III   | 3.2±0.62   | 1.56±0.68 |
| Scape shaft | Worker| ST       | 16.07±0.65 | 2.1±0.47  |
|             | Drone | ST       | 26.21±0.10 | 2.1±0.68  |
|             | Queen | ST       | 20.2±0.11  | 2.5±0.46  |
|             |       | STC      | 6.6±0.65   | 2.1±0.54  |
|             |       | SB       | 41.8±0.87  | 2±0.10    |
| Pedicel     | Worker| ST       | 16.07±0.65 | 1.25±0.73 |
|             |       | SB       | 20.96±0.18 | 1.41±0.87 |
|             |       | SCo      | 1.1±0.11   | -          |
|             |       | SCP      | 231.1±0.56 | -          |
|             |       | STC      | 12.5±0.05  | 2.5±0.65  |
|             |       | SB       | 15±0.76    | 2±0.63    |
|             |       | SCh      | 21.25±1.23 | 1.69±0.02 |
|             | Drone | ST       | 35±0.37    | 2.5±0.53  |
|             |       | SB       | 15±0.76    | 2±0.63    |
|             |       | SCh      | 21.25±1.23 | 1.69±0.02 |
|             | Queen | ST       | 35±0.28    | 2.3±0.89  |
|             |       | SB       | 16±0.45    | 2.5±0.95  |
| Flagellum   | Worker| ST       | 20±1.47    | 2±0.05    |
|             |       | STC      | 22.5±0.66  | 1.4±0.15  |
|             |       | SB       | 22.93±1.72 | 1.48±0.05 |
|             |       | SCo      | 1.6±0.5    | -          |
|             |       | SCP      | 1.5±0.50   | -          |
|             |       | SCh      | 14.5±0.65  | 1.57±0.45 |
|             | Drone | ST-I     | 30±0.90    | 1.47±0.06 |
|             |       | SB-I     | 52±0.85    | 1.4±0.06  |
|             |       | STC      | 15.76±0.18 | 3.19±0.20 |
|             |       | SB-II    | 22±1.69    | 1.4±0.06  |
|             |       | SCp      | 2±0.05     | -          |
|             | Queen | ST-I     | 10±0.50    | 1.42±0.65 |
|             |       | SB-I     | 24.14±0.39 | 1.5±0.76  |
|             |       | STC      | 26.5±0.67  | 1.8±0.38  |
|             |       | SB-II    | 23±0.79    | 1.25±0.67 |

ST-Sensilla trichoidea, SB- Sensilla basiconica, STC-Sensilla trichodea curvata, SCh-Sensilla chaetica, SCo-Sensilla coeloconica, SCP-Sensilla coelocapitular.
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**Fig 1.1:** Comparative morphometry of antennal segments of polymorphs of *Oecophylla smaragdina*.

**Fig 1.2:** Photomicrograph showing the structure of antenna in workers of *Oecophylla smaragdina*.

**Fig 1.3:** Photomicrograph showing the structure of antenna in drone of *Oecophylla smaragdina*.

**Fig 1.4:** Photomicrograph showing the structure of antenna in drone of *Oecophylla smaragdina*.

**Fig 1.5:** SEM photomicrograph of antennal scape ball of workers in *O. smaragdina* showing presence of sensilla basiconica I, II and III.

**Fig 1.6:** SEM photomicrograph of antennal scape shaft of workers in *Oecophylla smaragdina* showing presence of sensilla trichoidea.
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Fig 1.7: SEM photomicrograph of antennal pedicel of workers in *Oecophylla smaragdina* showing presence of sensilla trichoidea (ST), sensilla basiconica (SB), sensilla trichodea curvata (STC), sensilla chaetica (SCh), sensilla coeloconica (SCo), sensilla coelocapitular (SCp).

Fig 1.8: SEM photomicrograph of antennal flagellum of worker in *Oecophylla smaragdina* showing presence of sensilla trichoidea, sensilla basiconica, sensilla trichodea curvata, sensilla chaetica, sensilla coeloconica, sensilla coelocapitular.

Fig 1.9: SEM photomicrograph of antennal scape ball of drone in *Oecophylla smaragdina* showing presence of sensilla basiconica I, II and III.

Fig 1.10: SEM photomicrograph of antennal scape shaft of drone in *Oecophylla smaragdina* showing presence of sensilla trichoidea.

Fig 1.11: SEM photomicrograph of antennal pedicel of drone in *Oecophylla smaragdina* showing presence of sensilla trichoidea and sensilla basiconica.

Fig 1.12: SEM photomicrograph of antennal flagellum of drone in *Oecophylla smaragdina* showing presence of sensilla trichoidea, sensilla basiconica, sensilla trichodea curvata, sensilla coelocapitular.
Fig 1.13: SEM photomicrograph of antennal scape ball of queen in *Oecophylla smaragdina* showing presence of sensilla basiconica I, II and III.

Fig 1.14: SEM photomicrograph of antennal scape shaft of queen in *Oecophylla smaragdina* showing presence of sensilla trichodea, sensilla trichodea curvata and sensilla basiconica.

Fig 1.15: SEM photomicrograph of antennal pedicel of queen in *Oecophylla smaragdina* showing presence of sensilla trichodea and sensilla basiconica.

Ramirez *et al.*, 2009) the flagellar sensilla of *O. smaragdina* are working as chemoreceptor, contact chemoreceptor, thermo receptor, hygroscopeceptor and mechanoreceptor, making the flagellum of major worker most efficient in the colony for searching food, protecting colony using alarm pheromones, chemical communication, temperature and humidity sensation. The drone antennal flagellum shows diverse types of sensillae viz. sensilla trichodea, sensilla basiconica, sensilla trichodea curvata, sensilla coeloconica, sensilla chaetica and sensilla coelocapitular. The drone in *O. smaragdina* was found to be attracted towards the queen during the mating period and presence of sensilla trichodea curvata and sensilla basiconica on the flagellum of drone may have a role in detecting the sex attractant pheromones to locate the queen during mating period (Hölldobler and Wilson, 1990). The drones were observed emerging and being active during rainy season (Lokkers, 1990), presence of thermo receptor sensilla coelocapitular may be useful for temperature and humidity sensation for nuptial flight (Nishino *et al.*, 2009). The queen antennal flagellum shows few sensilla viz. sensilla trichodea, sensilla basiconica and sensilla trichodea curvata with respect to other polymorphs. As earlier discussed, the sensilla trichodea and sensilla basiconica are contact chemoreceptor (Hashimoto 1990; Onagbola *et al.*, 2009; Barsagade *et al.*, 2013; Esquivel *et al.*, 2014; Crozier *et al.*, 2010), whereas, sensilla trichodea curvata is sensitive to volatile compound like pheromones (Dumpert, 1972). As the queen does not play an active role in maintenance of colony, the sensilla on the workers has possible role for chemical communication with the queen and other workers during egg laying.

**CONCLUSION**

The morphological dimension of antennal segments in polymorphs of *Oecophylla smaragdina* shows distinct variations. The queen has the longest antenna followed by
worker and the drone. Even though shorter in length the drone antenna has one extra flagellomere than the queen and worker antenna. The ultra-structural study reveals various types of sensilla on antennal segments in polymorphs of *Oecophylla smaragdina*. The worker caste plays an important role in use of *Oecophylla smaragdina* as biological pest control agent. The presence of chemo-sensory and thermo-sensory sensilla on the worker antennae indicates role of workers in foraging activity and controlling population of other insects in the vicinity of their nest.

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