Volume 7 Special Issue 2021

ISSN 2454-3055

Manuscripts published in Special issue were presented at National Virtual Conference on "Current Research Trends in Zoology" on 5-6 August, 2021 at Department of Zoology, Elphinstone College, Mumbai, India

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

***Forum for Biological and
Environmental Sciences***

Published by Saran Publications, India

Morphological and Surface Ultra-structural Studies of Legs in Polymorphs of Weaver Ant *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae) with Reference to Sensilla

Masram Parag P.^{1*} and Barsagade Deepak D.²

¹Dept. of Zoology, Elphinstone College, Mumbai, India

²Professor, Department of Zoology, MJF Education Campus, Nagpur University, Nagpur, India

**Corresponding Author*

Received: 14th August, 2021; **Accepted:** 4th September, 2021; **Published online:** 8th September, 2021

<https://doi.org/10.33745/ijzi.2021.v07i02s.005>

Abstract: *Oecophylla smaragdina* is a social Hymenopteran ant also known as Asian Weaver ant. It is a colonial insect with social structure of the colony consist of fertile and infertile castes. The fertile caste comprises of drone (male) and queen (female) whereas the infertile caste is of workers. Sensory capabilities are key determinants of insect behaviour as chemical senses in insects are well developed with a large repertoire of chemosensory structures. Presence of such sensory structures on cuticle of various castes of ants determines the role of individual in the colony. Specific sensilla for taste, temperature and vibration are distributed on body appendages in varied number and size. In the present study, legs of polymorphs in *Oecophylla smaragdina* were observed using scanning electron microscopy and light microscopy. Morphological variation in size of the legs in polymorph was an eminent character observed. Infertile members of the colony showed two types of sensillae, i.e. sensilla trichodea and sensilla trichodea curvata on the leg segments, whereas the leg segments of queen show presence of sensilla basiconica in addition to above two sensillae, confirming the sensory roles of legs along with locomotion in the *O. smaragdina* polymorphs.

Keywords: Sensilla, SEM, Chemoreceptor, Ant polymorphs, Social hymenopterans

Citation: Masram Parag P. and Barsagade Deepak D.: Morphological and surface ultra-structural studies of legs in polymorphs of weaver ant *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae) with reference to sensilla. Intern. J. Zool. Invest. 7 (Special Issue): 26-39, 2021. <https://doi.org/10.33745/ijzi.2021.v07i02s.005>

Introduction

Oecophylla smaragdina Fabricius (Hymenoptera: Formicidae) is a social ant commonly known as Asian weaver ant. Greenslade (1972) reported its distribution 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. Hölldobler and Wilson (1983) reported

two types of workers which have distinct responsibilities to perform in the colony. These workers show a clear size difference between minor (smaller ones) and major (bigger ones) workers. There is a division of labour associated with the size difference between workers. Workers perform tasks that are essential to colony survival including foraging, nest construction and colony defense. The exchange of information is

facilitated by the use of chemical and tactile communication signals. Along with chemical signals, workers also use tactile communication signals such as attention and body shaking to stimulate activity in signal recipients. Multimodal communication in *O. smaragdina* weaver ants importantly contributes to self-organization (Hölldobler and Wilson, 1977).

Although the economical aspect of weaver ant as biocontrol agent has been extensively studied by earlier workers (Peng and Christian, 2004, 2005, 2006), morphological variations of legs and its ultra-structure in the polymorphs of these ants are not yet studied. Therefore, in the present study we investigated morphological and ultra-structural variations of legs of polymorphs of *O. smaragdina*.

Materials and Methods

Morphological preparation:

For external morphology, freshly specimens were treated with 10% KOH (60 C) for 20 min. Dissections were carried out under a stereoscopic binocular microscope Olympus SZX7 and legs were separated. They were washed several times in the water and later on dehydrated by passing through ascending grades of alcohol, cleared in xylene and mounted in DPX.

Scanning electron microscopy:

For scanning electron microscopic (SEM) study, the dissected legs were washed thoroughly with distilled water and fixed in 10% formalin for 12 h. The specimens were then dehydrated in ascending series of alcohol grades, cleared in acetone and dried at room temperature. After that, these appendages were mounted on carbon-coated metallic stubs at different angles followed by platinum coating in JOEL coating unit. Specimens were observed in 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 data generated during observation was compiled and analyzed using simple measures of central tendency. The mean, standard deviation and standard error was calculated. All statistics presented in this study are mean $\pm$ standard error, Student 't' test was used for testing significance of difference between the means of experimental and control group using 5 % level of significance.

Results

Morphology of legs in polymorphic forms:

The basic structure of leg in polymorphs of *O. smaragdina* comprised of Coxa (Cx), Trochanter (Tr), Femur (Fm), Tibia (Tb), Tarsus (Tar) and Pretarsus (Ptar). The lengths of prothoracic and metathoracic legs are equal while mesothoracic legs are longer than other in all polymorphs. The comparative length of legs is given in Tables 1, 3 and 5.

Prothoracic legs:

The first pair of legs attached to the lateral pluerons supra-coxal arch of the prothoracic segment shows a basic modification for walking. The prothoracic leg in minor worker, major worker, drone and queen shows all basic segments modified for walking type of legs. The first segment, coxa is small and cylindrical, attached to the supra-coxa arch with a coxal corium membrane. The second segment, trochanter in minor worker is observed to be small and triangular structure attached to the coxa at an oblique angel forming a bend in the leg. At the posterior end, the trochanter is attached with the femur which is a stout and cylindrical structure showing a slight curve at the posterior end. The fourth segment tibia in minor worker is cylindrical and slightly shorter in length to the femur. The tibia articulated with the tarsus showing presence of a small tibial spur at the joint. The spur is brush like structure towards the proximal margin. The tarsus is a short-fused structure linking the claws to the leg. Pretarsus are four segmented and had a

Table 1: Length of prothoracic leg segments in polymorphic *O. smaragdina*

Caste	Segments of prothoracic leg (mm)						Total length
	Coxa	Trochanter	Femur	Tibia	Tarsus	Pre-tarsus	
Minor	0.77±0.07	0.76±0.07	2.38±0.08	2.28±0.07	1.12±0.03	1.02±0.04	8.33
Major	1.03±0.05	0.57±0.04	4.39±0.08	4.05±0.07	1.96±0.04	1.73±0.06	13.73
Drone	0.79±0.06	0.34±0.04	3.52±0.09	3.3±0.06	1.93±0.04	1.99±0.04	11.87
Queen	1.22±0.04	0.59±0.04	4.42±0.06	3.64±0.07	1.78±0.06	1.98 ±0.04	13.63

Table 2: Width of prothoracic leg segments in polymorphic *O. smaragdina*

Caste	Segments of prothoracic leg (mm)					
	Coxa	Trochanter	Femur	Tibia	Tarsus	Pre-tarsus
Minor	0.58±0.05	0.47±0.05	0.37±0.03	0.26±0.03	0.15±0.02	0.07±0.01
Major	1.08±0.04	0.41±0.02	0.49±0.07	0.36±0.02	0.17±0.03	0.18±0.02
Drone	0.54±0.03	0.20±0.02	0.28±0.01	0.2±0.02	0.09±0.02	0.08±0.01
Queen	1.28±0.04	0.53±0.04	0.82±0.05	0.58±0.04	0.28±0.03	0.31±0.04

Table 3: Length of mesothoracic leg segments in polymorphic *O. smaragdina*

Caste	Segments of mesothoracic leg (mm)						Total length
	Coxa	Trochanter	Femur	Tibia	Tarsus	Pre-tarsus	
Minor	0.75±0.03	0.3±0.03	3.17±0.04	3.41±0.03	1.31±0.03	1.37±0.03	10.31
Major	1.07±0.03	0.56±0.03	4.7 ±0.06	4.48±0.05	1.95±0.04	1.75±0.03	14.51
Drone	0.99±0.05	0.33±0.03	5.42±0.07	3.02±0.06	3.01±0.06	2.85±0.05	15.62
Queen	1.22±0.05	0.74±0.04	5.24±0.06	4.85±0.08	1.95±0.06	3±0.06	16.7

Table 4: Width of mesothoracic leg segments in polymorphic form of *O.smaragdina*

Caste	Segments of mesothoracic leg (mm)					
	Coxa	Trochanter	Femur	Tibia	Tarsus	Pre-tarsus
Minor	0.7±0.03	0.24±0.01	0.37±0.06	0.29±0.03	0.12±0.01	0.12±0.01
Major	1.3 ±0.05	0.48± 0.02	0.71±0.05	0.4±0.03	0.2±0.02	0.13±0.02
Drone	0.54±0.03	0.27±0.02	0.29±0.02	0.18±0.03	0.07±0.01	0.11±0.06
Queen	1.52±0.04	0.69±0.04	0.9±0.05	0.55±0.04	0.27±0.02	0.23±0.02

Table 5: Length of metathoracic leg segments in polymorphic *O. smaragdina*

Caste	Segments of metathoracic leg (mm)						Total length
	Coxa	Trochanter	Femur	Tibia	Tarsus	Pre-tarsus	
Minor	0.68±0.07	0.26±0.07	3.01±0.08	3.25±0.07	1.54±0.03	1.21±0.04	9.95
Major	1.41±0.05	0.50±0.04	6.38±0.08	6.72±0.07	3.02±0.04	2.61±0.06	20.61
Drone	1.5±0.06	1.01±0.04	8.1±0.09	7.14±0.06	3.82±0.04	4.66±0.04	26.23
Queen	2.14±0.04	1.11±0.04	7.25±0.06	7.16±0.07	3.36±0.06	3.16±0.04	24.16

Fig. 1A-C: Photomicrograph prothoracic (A), mesothoracic (B) and metathoracic (C) leg of minor worker of *Oecophylla smaragdina*.

Fig. 2A-C: Photomicrograph prothoracic (A), mesothoracic (B) and metathoracic (C) leg of major worker of *Oecophylla smaragdina*.

lateral claw terminally (Tables 1, 2; Figs. 1A, 2A, 3A, 4A).

Mesothoracic leg:

The second pair of legs is attached to the lateral pluerons supra-coxal arch of the mesothoracic segment. The length and width of mesothoracic legs are more as compared to other legs in all polymorphs of *O. smaragdina* (Tables 3, 4). The mesothoracic legs in minor worker, major worker, drone and queen shows a typical walking type of leg structure. The coxa is a triangular segment attached to the supra-coxal arch of the lateral plueron. The coxa articulated with the second segment, trochanter at an angle giving a bend of 90 degrees. The trochanter is small and triangular segment articulating the coxa and femur. In the

mesothoracic leg of minor worker, the femur is stout, thick cylindrical segment articulating with the tibia again at angle of 90 degrees forming a bend. The tibial segment in minor worker was slightly thinner to the femur and found to be shorter than the femur. The tibia articulates with the tarsus in a linear joint. The tibia in case of minor worker is slender and cylindrical. Pretarsus is four segmented and ends up in lateral claws in minor workers, while in major workers, drone and queen the pretarsus end with lateral claw with hook like structure (Figs. 1B, 2B, 3B, 4B).

Metathoracic legs:

The third pair of legs is attached to the lateral pluerons supra-coxal arch of the metathoracic segment. In *O. smaragdina*, the metathoracic

Fig. 3A-C: Photomicrograph prothoracic (A), mesothoracic (B) and metathoracic (C) leg of drone of *Oecophylla smaragdina*.

Fig. 4A-C: Photomicrograph prothoracic (A), mesothoracic (B) and metathoracic (C) leg of queen of *Oecophylla smaragdina*.

Table 6: Width of metathoracic leg segments of in polymorphic *O. smaragdina*

Caste	Segments of metathoracic leg (mm)					
	Coxa	Trochanter	Femur	Tibia	Tarsus	Pre-tarsus
Minor	0.53±0.04	0.21±0.01	0.35±0.06	0.21±0.01	0.14±0.01	0.11±0.03
Major	0.88±0.04	0.39±0.02	0.47±0.07	0.3±0.01	0.18±0.03	0.2±0.01
Drone	0.69±0.03	0.61±0.04	0.68±0.04	0.42±0.04	0.2±0.01	0.27±0.04
Queen	1.68±0.07	0.49±0.07	0.88±0.03	0.73±0.06	0.28±0.03	0.29±0.03

segment is represented by small meta-notal notch dorsally and by a reduced lateral plueron. The polymorphic forms show distinct variation in size (Tables 5, 6). The third pair of legs in the minor worker, major worker, drone and queen showed

thin slender structure of all the segments. The coxa is bell shaped and triangular structure narrowing down posteriorly at the junction with trochanter. The trochanter is triangular and short segment linearly articulated with coxa anteriorly

and the femur posteriorly. The femur in minor worker is long, slender and cylindrical in shape. Posteriorly, the femur is articulated with the tibia at angle forming a knee like bend. The tibia is thin and cylindrical. The tarsus is slender and anterior to the pretarsus. The pretarsus is four segmented and ended up in lateral claws with hook like structure (Figs. 1C, 2C, 3C, 4C).

Scanning electron microscopic structure of legs:

Minor worker:

The ultra-structural observation of legs in minor worker of *O. smaragdina* shows the presence of two types of sensillae-- sensilla trichodea and sensilla trichodea curvata. The detail description and measurements of these sensillae are given below:

Coxa: Sensilla trichodea is a hair like sensilla present all over the surface and measured 18.05 ± 0.05 μm in length and 1.03 ± 0.05 μm in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed prominently on the posterior border of coxa and measured 13.01 ± 0.04 μm in length and 1.02 ± 0.02 μm in width at the base (Table 7; Figs. 5 A-C).

Trochanter: The sensilla trichodea is a hair like sensilla present all over the surface and measured 17.75 ± 0.04 μm in length and 1.02 ± 0.04 μm in width at the base (Table 7; Figs. 5 A-C).

Femur: Sensilla trichodea is a hair like sensilla present all over the surface and measured 17.95 ± 0.03 μm in length and 1.35 ± 0.05 μm in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex and are observed prominently on the posterior border of femur at the joint with tibia and measured 12.02 ± 0.03 μm in length and 1.25 ± 0.04 μm in width at the base (Table 7; Figs. 5 A-C).

Tibia: Sensilla trichodea is hair like sensilla present all over the surface and measured 18.05 ± 0.05 μm in length and 1.50 ± 0.02 μm in width at the base. Sensilla trichodea curvata is

also hair like with bend at the apex present all over the surface and are observed very few but prominently on the posterior border of tibia at the joint with tarsus and measured 12.06 ± 0.02 μm in length and 1.40 ± 0.06 μm in width at the base (Table 7; Figs. 5 A-C).

Tarsus: The sensilla trichodea is a hair like sensilla present all over the surface and measured 19.03 ± 0.02 μm in length and 1.60 ± 0.05 μm in width at the base (Table 7; Figs. 5 A-C).

Pretarsus: Sensilla trichodea is a hair like sensilla present all over the surface and measured 18.50 ± 0.05 μm in length and 1.35 ± 0.05 μm in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed very few but prominently on the last pretarsal segment and measured 11.75 ± 0.01 μm in length and 1.35 ± 0.07 μm in width at the base (Table 7; Figs. 5 A-C).

Major worker:

The ultra-structural observation of legs in major worker of *O. smaragdina*, like minor worker shows the presence of two types of sensillae-- sensilla trichodea and sensilla trichodea curvata. The detail description and measurements of these sensillae are given below:

Coxa: The sensilla trichodea is a hair like sensilla present all over the surface and measured 15.05 ± 0.35 μm in length and 1.35 ± 0.02 μm in width at the base (Table 7; Figs. 6 A-F).

Trochanter: The sensilla trichodea is a hair like sensilla present all over the surface and measured around 15.15 ± 0.25 μm in length and 1.50 ± 0.01 μm in width at the base (Table 7; Figs. 6 A-F).

Femur: Sensilla trichodea is hair like sensilla present all over the surface and measured 14.75 ± 0.15 μm in length and 1.40 ± 0.02 μm in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed prominently on the posterior border of femur at the joint with tibia and measured 11.78 ± 0.02 μm

Table 7: Types of sensilla observed on the leg surface in polymorphic *O. smaragdina*

Caste		Types of sensilla	Length and width of sensilla	
			Length	Width
Minor worker	Coxa	Sensilla trichodea (ST)	18.05±0.05	1.03±0.05
		Sensilla trichodea curvata (STC)	13.01±0.04	1.02±0.02
	Trochanter	Sensilla trichodea (ST)	17.75±0.04	1.02±0.04
	Femur	Sensilla trichodea (ST)	17.95±0.03	1.35±0.05
		Sensilla trichodea curvata (STC)	12.02±0.03	1.25±0.04
	Tibia	Sensilla trichodea (ST)	18.05±0.05	1.25±0.04
		Sensilla trichodea curvata (STC)	12.06±0.02	1.40±0.06
Tarsus	Sensilla trichodea (ST)	19.03±0.02	1.60±0.05	
Pretarsus	Sensilla trichodea (ST)	18.50±0.05	1.35±0.05	
	Sensilla trichodea curvata (STC)	11.75±0.01	1.35±0.07	
Major worker	Coxa	Sensilla trichodea (ST)	15.05±0.35	1.35±0.02
	Trochanter	Sensilla trichodea (ST)	15.15±0.25	1.50±0.01
	Femur	Sensilla trichodea (ST)	14.75±0.15	1.40±0.02
		Sensilla trichodea curvata (STC)	11.78±0.02	1.25±0.06
	Tibia	Sensilla trichodea (ST)	15.65±0.35	1.35±0.03
		Sensilla trichodea curvata (STC)	11.80±0.02	1.25±0.06
	Tarsus	Sensilla trichodea (ST)	14.35±0.25	1.25±0.01
Pretarsus	Sensilla trichodea (ST)	15.25±0.15	1.35±0.04	
	Sensilla trichodea curvata (STC)	12.05±0.03	1.20±0.05	
Drone	Coxa	Sensilla trichodea (ST)	25.15±0.02	1.25±0.02
	Trochanter	Sensilla trichodea (ST)	24.35±0.01	1.50±0.01
	Femur	Sensilla trichodea (ST)	25.26±0.03	2.76±0.02
	Tibia	Sensilla trichodea (ST)	25.36±0.04	1.30±0.01
	Tarsus	Sensilla trichodea (ST)	24.37±0.02	1.25±0.01
	Pretarsus	Sensilla trichodea (ST)	23.25±0.01	1.05±0.01
Sensilla trichodea curvata (STC)		38.60±0.05	3.05±0.05	
Queen	Coxa	Sensilla trichodea (ST)	36.06±0.01	1.06±0.01
	Trochanter	Sensilla trichodea (ST)	34.37±0.02	1.45±0.01
	Femur	Sensilla trichodea (ST)	45.75±0.03	1.47±0.02
	Tibia	Sensilla trichodea (ST)	35.00±0.03	2.30±0.02
	Tarsus	Sensilla trichodea (ST)	36.00±0.02	1.75±0.03
		Sensilla basiconica (SB)	38.85±0.05	3.00±0.05
Pretarsus	Sensilla trichodea (ST)	35.00±0.01	1.35±0.02	
	Sensilla basiconica (SB)	60.00±0.65	1.05±0.01

Fig. 5A-C: SEM Photomicrograph of segments of leg in minor worker of *Oecophylla smaragdina* showing presence of sensilla trichodea (ST) and sensilla trichodeacurvata (STC). A. Coxa, trochanter, femur and tibia, B. Tibia and tarsus, C. Tarsus and pretarsus.

Fig. 6A-F: SEM Photomicrograph of segments of leg in major worker of *Oecophylla smaragdina* showing presence of sensilla trichodea (ST) and sensilla trichodeacurvata (STC). A. Coxa, B. Trochanter, C. Femur, D. Tibia, E. Tarsus, F. Pretarsus.

in length and $1.25 \pm 0.06 \mu\text{m}$ in width at the base (Table 7; Figs. 6 A-F).

Tibia: Sensilla trichodea is a hair like sensilla present all over and measured $15.65 \pm 0.35 \mu\text{m}$ in length and $1.35 \pm 0.03 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed very few but prominently on the posterior border of tibia at the joint with tarsus and measured about $11.78 \pm 0.02 \mu\text{m}$ in length and $1.25 \pm 0.06 \mu\text{m}$ in width at the base (Table 7; Figs. 6 A-F).

Tarsus: The sensilla trichodea is hair like sensilla present all over the surface and measured $14.35 \pm 0.25 \mu\text{m}$ in length and $1.25 \pm 0.01 \mu\text{m}$ in width at the base (Table 7; Figs. 6 A-F).

Pretarsus: Sensilla trichodea is a hair like sensilla present all over the surface and measured $15.25 \pm 0.15 \mu\text{m}$ in length and $1.35 \pm 0.04 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also hair like sensilla with bend at the apex, present all over the surface. These are observed very few but prominently on the last pretarsal segment and measured $12.05 \pm 0.03 \mu\text{m}$ in length and $1.20 \pm 0.05 \mu\text{m}$ in width at the base (Table 7; Figs. 6 A-F).

Drone:

The ultra-structural observation of legs in drone of *O. smaragdina*, like worker shows the presence of two types of sensillae-- sensilla trichodea and sensilla trichodea curvata. The detail description and measurements of these sensillae are given below:

Coxa: The sensilla trichodea is hair like sensilla present all over the surface and measured $25.15 \pm 0.02 \mu\text{m}$ in length and $1.25 \pm 0.02 \mu\text{m}$ in width at the base (Table 7; Figs. 7 A-F).

Trochanter: The sensilla trichodea is hair like sensilla present all over the surface and measured about $24.35 \pm 0.01 \mu\text{m}$ in length and $1.50 \pm 0.01 \mu\text{m}$ in width at the base (Table 7; Figs. 7 A-F).

Femur: The sensilla trichodea is a hair like sensilla present all over the surface and measured

$25.26 \pm 0.03 \mu\text{m}$ in length and $2.76 \pm 0.02 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface, observed prominently on the posterior border of femur at the joint with tibia and measured $42.75 \pm 0.05 \mu\text{m}$ in length and $2.25 \pm 0.05 \mu\text{m}$ in width at the base (Table 7; Figs. 7 A-F).

Tibia: Sensilla trichodea is a hair like sensilla present all over the surface and measured $25.36 \pm 0.04 \mu\text{m}$ in length and $1.30 \pm 0.01 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed very few but prominently on the posterior border of tibia at the joint with tarsus and measured $41.7 \pm 0.05 \mu\text{m}$ in length and $3 \pm 0.10 \mu\text{m}$ in width at the base (Table 7; Figs. 7 A-F).

Tarsus: The sensilla trichodea is hair like sensilla present all over the surface and measured $24.37 \pm 0.02 \mu\text{m}$ in length and $1.25 \pm 0.01 \mu\text{m}$ in width at the base (Table 7; Figs. 7 A-F)

Pretarsus: Sensilla trichodea is a hair like sensilla present all over the surface and measured $23.25 \pm 0.01 \mu\text{m}$ in length and $1.05 \pm 0.01 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed very few but prominently on the last pretarsal segment and measured $38.6 \pm 0.05 \mu\text{m}$ in length and $3.05 \pm 0.05 \mu\text{m}$ in width at the base (Table 7; Figs. 7 A-F).

Queen:

The ultra-structural observation of legs in queen of *O. smaragdina*, like other morphs shows the presence of three types of sensillae-- sensilla trichodea and sensilla trichodea curvata and sensilla basiconica. The detail description and measurements of these sensillae are given below:

Coxa: The sensilla trichodea is a hair like sensilla present all over the surface and measured $36.06 \pm 0.01 \mu\text{m}$ in length and $1.06 \pm 0.01 \mu\text{m}$ in width at the base (Table 7; Figs. 8 A-F).

Fig. 7 A-F: SEM Photomicrograph of segments of leg in drone of *Oecophylla smaragdina* showing presence of sensilla trichodea (ST) and sensilla trichodea curvata (STC). A. Coxa and trochanter, B. Femur, C. Tibia, D. Tarsus, E. Posterior end of tarsus, F. Pretarsus.

Fig. 8 A-F: SEM Photomicrograph of segments of leg in queen of *Oecophylla smaragdina* showing presence of sensilla trichodea (ST), sensilla trichodea curvata (STC) and sensilla basiconica (SB). A. Coxa and trochanter, B. Femur, C. Tibia, D-E. Tarsus, F. Pretarsus.

Trochanter: The sensilla trichodea is hair like sensilla present all over the surface and measured $34.37 \pm 0.02 \mu\text{m}$ in length and $1.45 \pm 0.01 \mu\text{m}$ in width at the base (Table 7; Figs. 8 A-F).

Femur: Sensilla trichodea is a hair like sensilla present all over the surface and measured

$45.75 \pm 0.03 \mu\text{m}$ in length and $1.47 \pm 0.02 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also a hair like sensilla with bend at the apex present all over the surface. These are observed prominently on the posterior border of femur at the joint with tibia and measured $39.65 \pm 0.05 \mu\text{m}$

in length and $2.95 \pm 0.03 \mu\text{m}$ in width at the base (Table 7; Figs. 8 A-F).

Tibia: Sensilla trichodea is a hair like sensilla present all over the surface and measured $35 \pm 0.03 \mu\text{m}$ in length and $2.3 \pm 0.02 \mu\text{m}$ in width at the base. Sensilla trichodea curvata is also hair like sensilla with bend at the apex present all over the surface. These are observed very few but prominently on the posterior border of tibia at the joint with tarsus and measured $38.85 \pm 0.05 \mu\text{m}$ in length and $3 \pm 0.05 \mu\text{m}$ in width at the base (Table 7; Figs. 8 A-F).

Tarsus: The sensilla trichodea is hair like sensilla present all over the surface and measured $36 \pm 0.02 \mu\text{m}$ in length and $1.75 \pm 0.03 \mu\text{m}$ in width at the base. Sensilla basiconica also hair like sensilla and measured $38.85 \pm 0.05 \mu\text{m}$ in length and $3.00 \pm 0.05 \mu\text{m}$ in width at the base (Table 7; Figs. 8 A-F).

Pretarsus: Sensilla trichodea is a hair like sensilla present all over the surface and measured $35 \pm 0.01 \mu\text{m}$ in length and $1.35 \pm 0.02 \mu\text{m}$ in width at the base. Sensilla basiconica is also a hair like sensilla at the apex present all over the surface. These are observed very few but prominently on the last pretarsal segment. It measured $60.0 \pm 0.65 \mu\text{m}$ in length and $1.05 \pm 0.01 \mu\text{m}$ in width at the base (Table 7; Figs. 8 A-F).

Discussion

Taylor and Adedoyin (1978) and Jackson (1988) reported arboreal habitat of *O. smaragdina* and the worker ants travel from one tree to other by ground or through the interconnected branches. During the present observation the polymorphs of *O. smaragdina* were found with long walking type of leg travelling on the branches of tree and walking inverted on the leaves. Snodgrass (1910) described the detailed structure of legs in insect as jointed appendage made up of six segments namely coxa, trochanter, femur, tibia, tarsus and pretarsus and modification in the structure of segment is correlated to the kind of locomotion in insect. During the present study the leg segments

of *O. smaragdina* were found to be following the generalized structure of walking type of locomotion in insects. The legs of *O. smaragdina* are walking type having slender segments. Such type of legs helps in convective cooling of the body and also reduces foraging time (Sommer and Wehner, 2012). According to the size-grain theory of Kaspari and Weiser (1999), larger ants tend to be slimmer and large legged. In the present study the polymorphs of *O. smaragdina* are found to be medium sized ants. The legs in minor worker, drone and queen are morphometrically proportional to the size of the body, whereas the major workers of *O. smaragdina* shows slim and long legs confirming the role of major worker in maximum activity in the colony including foraging and guarding. It is also observed that during construction of new nest they form live chain holding legs of other major workers with mandibles. The major worker of *O. smaragdina* was observed to be very active and quick confirming that long legs have a benefit to become efficient and fast (Kaspari and Weiser, 1999). Federle *et al.* (2001) observed the role of arolium in attachment of legs to the smooth surface in *O. smaragdina* and honey bees. In *O. smaragdina*, adhesion is mediated by a two phase liquid secretion and the friction is probably caused by the rubbery deformation of the viscoelastic pad cuticle when it slides on the surface (Federle *et al.*, 2002). The role of dense arrays of fine hairs present on the ventral side of the third and fourth tarsal segments were found to support the arboreal ant in climbing vertical surfaces easily (Endlein and Federle, 2015; Billen *et al.*, 2017). In *O. smaragdina*, a well developed arolium was observed ventral to claws, and tuft of hairy setae on pretarsus of all the legs in polymorphs possibly helping the ant to walk on smooth leaf surface even during the monsoon, even dead workers were found attached to the leaf surface. Adhesive performance of *O. smaragdina* has been observed to decrease with high temperature because of excess fluidity of tarsal pad secretion at high temperature and hence, the ant cannot maintain

adhesion on hot surface (Stark *et al.*, 2018). The major workers of *O. smaragdina* are found attached on the leaves of tree during month of May in central India where the average temperature is 47-48 C in the afternoon.

Okada *et al.* (2006) described the role of sex specific tibial spur as antennal cleaners in ponerine ant *Diacamma* sp. The prothoracic leg in polymorphs of *O. smaragdina* showed the presence of tibial spur. Mesothoracic leg in major worker also shows presence of tibial spur confirming bigger contribution of major worker in colony activity with additional antennal cleaner. The sensory role of legs other than locomotion has already been established in many insects (Stokes, 1893; Pringle, 1938; Cruse *et al.*, 1984; Barsagade *et al.*, 2018). The presence of sensilla trichoidea, sensilla trichoidea curvata, sensilla basiconica and macro trichoid setae demonstrated that legs in *O. smaragdina* perform as sense organ other than merely walking. Sensilla trichodea curvata has been observed to be sensitive to various volatile compounds including alarm pheromones (Dumpert, 1972). Similarly, sensilla trichodea and sensilla basiconica also functions as a chemoreceptor (Hashimoto, 1990).

In the present work it is observed that the minor and major worker of *O. smaragdina* showed presence of sensilla trichoidea and sensilla trichoidea curvata, the sensilla may be used in chemical communication in the colony. The leg segments of queen *O. smaragdina* show presence of sensilla basiconica on the pretarsus confirming the use of legs as chemosensory organ. The ultra-structural observation of drone legs showed presence of only sensilla trichoidea and macro trichoid setae. These sensilla trichoidea may be used as mechanoreceptor and proprioceptor while mating to sense vibration and pressure.

Conclusion

Adult polymorphs of *O. smaragdina* show walking type of legs attached to the thoracic segments with distinct leg structure comprising of segments viz, coxa, trochanter, femur, tibia, tarsus and

pretarsus. The prothoracic leg in polymorphs of *O. smaragdina* shows presence of comb like tibial spur at the junction of tibia and tarsus. The major worker shows a distinguishing presence of tibial spur on the mesothoracic leg as well. The number of tarsus and pretarsus in all the three pair of legs are equal and ends in a curved claw terminally. All the three pairs of leg show presence of well-developed areoleum on the base of terminal pretarsus segment for efficient grip on the surface, while walking on the smooth surface of leaves and branches in arboreal habitat. All the three pairs of legs show sensory function with the presence of tactile sensilla like trichoidea and trichoidea curvata.

Acknowledgements

I am grateful to Director IIT Powai, Mumbai for allowing me to use the Sophisticated Analytical Instrumentation Facility (SAIF) to carry out the Scanning.

References

- Barsagade DD, Nagose SB, Kirsan JR and Thakare MP. (2018) SEM studies on the worker legs of arboreal bicoloured ant, *Tetraponera rufonigra* with reference to the sensilla present on it (Hymenoptera: Formicidae). J Ent Zool St. 6(6): 848-852.
- Billen J, Al-Khalifa MS and Silva RR. (2017) Pretarsus structure in relation to climbing ability in the ants *Brachyponera sennaarensis* and *Daceton armigerum*. Saudi J Biol Sci. 24: 830-836.
- Cruse H, Dean J and Suilmann M. (1984) The contributions of diverse sense organs to the control of leg movement by a walking insect. J Comp Physiol. A.154: 695-705.
- Dumpert K. (1972) Alarm receptor on the antenna of *Lasius fuliginosus* (Latr.) (Hymenoptera, Formicidae). J Comp Physiol. 76: 403-425.
- Endlein T and Federle W. (2015) On heels and toes: how ants climb with adhesive pads and tarsal friction hair arrays. PLoS ONE 10(11): e0141269.
- Federle W, Brainerd EL, McMahon TA and Hölldobler B. (2001) Biomechanics of the movable pretarsal adhesive organ in ants and bees. PNAS 98(11): 6215-6220.
- Federle W, Riehle M, Curtis ASG and Full RJ. (2002) An integrative study of insect adhesion: mechanics and

- wet adhesion of pretarsal pads in ants. *Integr Comp Biol.* 42: 1100-1106.
- Greenslade PJM. (1972) Comparative ecology of four tropical ant species. *Ins Sociaux* 19: 195-212.
- Hashimoto Y. (1990) Unique Features of sensilla on the antennae of Formicidae (Hymenoptera). *Appl Ent Zool* 25(4): 491-501.
- Hölldobler B and Wilson EO. (1983) Queen control in colonies of weaver ants (Hymenoptera: Formicidae). *Ann Entomol Soc Amer.* 76: 235-238.
- Hölldobler B and Wilson EO. (1977) Weaver ants – social establishment and maintenance of territory. *Science* 195: 900-902.
- Jackson RV. (1988) Territorial defence and foraging in the ant *Oecophylla smaragdina virescens*. Honours Thesis, Univ. New England.
- Kaspari M and Weiser MD. (1999) The size-grain hypothesis and interspecific scaling in ants. *Funct Ecol* 13: 530-538.
- Okada Y, Kazuki T and Miura T. (2006) Morphological differences between sexes in the ponerine ant *Diacamma* sp. (Formicidae: Ponerinae). *Sociobiol.* 48(2): 527-541.
- Peng RK and Christian K. (2005) The control efficacy of the weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae), on the mango leafhopper, *Idioscopus nitidulus* (Hemiptera: Cicadellidea) in mango orchards in the Northern Territory. *Int J Pest Manag.* 51: 297-304.
- Peng RK and Christian K. (2006) Effective control of Jarvis's fruit fly, *Bactrocera jarvisi* (Diptera: Tephritidae), by the weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae), in mango orchards in the Northern Territory of Australia. *Int J Pest Manag.* 52: 275-282.
- Peng RK and Christian K. (2004) The weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae), an effective biological control agent of the red-banded thrips, *Selenothrips rubrocinctus* (Thysanoptera: Thripidae) in mango crops in the Northern Territory of Australia. *Int J Pest Manag.* 50: 107-114.
- Pringle JWS. (1938) Proprioception in insects. II. The action of the campaniform sensilla on the legs. *J Exp Biol.* 15(1): 114-131.
- Sommerer S and Wehner R. (2012) Leg allometry in ants. Extreme long-leggedness in thermophilic species. *Arthropod Str Develop.* 41:71-77.
- Stark AY, Arstingstall K and Yanoviak SP. (2018) Adhesive performance of tropical arboreal ants varies with substrate temperature. *J Exp Biol.* 221(1): jeb171843.
- Stokes, AC. (1893) The sense-organs on the legs of our white ants, *Termes flavipes* Koll. *Science* 22(563): 273-276.
- Taylor B and Adedoyin S. (1978) The abundance and inter-specific relations of common ant species (Hymenoptera: Formicidae) on cocoa farms in western Nigeria. *Bull Entomol Res.* 68(1): 105-121.