



Scanning electron microscopic (SEM) observations of mandibles, legs and sensilla of carpenter ant (*Camponotus compressus*)- Hymenoptera- Formicidae

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Abstract

Investigations using scanning electron microscopy (SEM) on the legs and mandibular structures of the carpenter ant, *Camponotus compressus* were observed. The ants were taken from the formicarium (an *in-vitro* ant culture) at the Entomology Research lab, Department of Zoology, Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra; between March to October of 2022. Observation under SEM reveals that the mouth regions of the worker *Camponotus compressus* (Hymenoptera: Formicidae) carpenter ants are made for grabbing the prey and to feed upon it. The mandibles are large, shovel-like, cuticular, powerful, heavily sclerotized and unsegmented structures. In worker ants, the mandibles are made up of the Sensilla basiconica Bv, the Sensilla trichoidea Td-I and Td-II on the ventral side. Each mandible has three molar teeth and four incisor teeth in this species. The entire surface of the various leg sections showed that the coxa consists of two types of sensilla- sensilla trichoidea and fine hair like, trichomes, while the trochanter contains sensilla trichoidea, as seen under SEM structure. A smaller, spine-like tibial spur with fine cuticular bristles was visible on the mid and hind tibia. Sensilla trichoidea, trichomes and comb-like bristles were found on the metatarsus of the foreleg, whereas macrosetae, sensilla trichoidea and trichomes are found on the metatarsus of the mid and hind legs. All tarsomeres have many bristles, setae and trichomes covering their whole surface, but the pretarsus of the foreleg has macrosetae. It is new insight observed on these species of ants using SEM.

Keywords: *Camponotus compressus*, sensilla basiconica, sensilla trichoidea, mandibular structure, sem, hymenoptera: formicidae

Introduction

The *Camponotus compressus* (Fabricius 1787) is commonly known as Carpenter ants because in contrast to most of the other ant species the majority of species under this genus can build nesting chambers in solid wood including wooden structures found in homes. The worker ant builds the nest on the tree beneath the bark and these ants have essential qualities of legs and jaws for building its nests. The 12-segmented antennae and antennal insertion well behind the clypeal edge are characteristics of *Camponotus* workers. Contrary to *Polyrhachis*, the *Camponotus* never has spines on the thorax. *Camponotus*, the ant genus with the most diversity, is widespread worldwide. It is most diverse and plentiful in low latitude tropical forests and savannah environments. They are widely observed due to the enormous size of the workers and enormous colony sizes. Most of the species have a dimorphic worker caste, with tiny minor and also the bigger, big-headed major workers. The nests of the *Camponotus* can be constructed in the ground, under stones, in dead wood or in living plants. Okada Y, Miura T and Tsuji, (2015). reported that the distribution of sensilla and the architecture of the leg in *Diacamma* species. It has been reported that each leg is made up of six segments: i. coxa, ii. trochanter, iii. femur, iv. tibia, v. tarsus vi. pre-tarsus, all of which have produced paired claws. The majority of ant species have mouthparts that are made for gripping and eating on prey (Richard and Davies, 1987); (Richard and Davies, 1972); (Dumpert, 1972) [5]; (Chapman, 1982, 1998). Ants have taste receptors in their lower set of jaws that can distinguish between a variety of sweet and aromatic liquid flavours, (Paul *et al.*

2002). Mandibles of male *Mycetarotes carinatus* ant contained just two teeth whereas female and worker mandibles have seven teeth Mayhe-Nunes and Lanziotti (1995, 2002), demonstrated sexual dimorphism in various ant species. Adult ants have mechano and chemoreceptors in the mouth parts. A. Galewski (1971) [6] reported that the water beetle *Dytiscus arew* has a small sensilla that resembles a peg on the dorsal surface of the jaw. There are many reports on the morphology and scanning electron microscopic analysis of the other ants, but few on the *camponotus*. In order to discover more about the morphological structure of the legs and mandibles as well as the numerous sensilla found on the various parts of the legs and mandibles of the workers of the Carpenter ant, *Camponotus compressus*, the current investigation was carried out using scanning electron microscope (SEM).

Materials and Methods

Ant sample collection and in-situ morphological preparations

During present study the adult worker ants of *Camponotus compressus* species were collected from the formicarium or *in vitro* culture at School of Life Sciences SRTM University campus, Nanded, Maharashtra. These ants were cultured in formicarium during the month of March to October of 2022.

Scanning electron microscopy (SEM)

The separated ants were fixed in 70% ethanol for 12 hours and dehydrated in ascending grades of ethanol and cleared in xylene. The air-dried sample fixed on the pre coated carbon strip metallic stub made up of aluminium blocks

using carbon double adhesive tape in the manner that the ventral surface stick to the tape and sputtered with a layer of gold nano-particles in a gold coating unit (thickness 100A, JEOL JSM-6100) then kept under vacuum using electron gun at an accelerating voltage of 20.0 kV of SEM and dorsal surface will remain upward. SEM images of ants were captured at different magnifications using digital camera of the SEM facility at the Centre of Instruments Laboratory, University of Hyderabad, Hyderabad, India.

Results

1. Mandible of *Camponotus compressus*

The SEM of worker carpenter ant *Camponotus compressus* revealed that the mandibles are unsegmented strongly

sclerotized large, shovel-shaped cuticular mouth parts with powerful basal three molar and four incisor teeth. (Fig. 1, 4). The trichoid and basiconic sensilla are seen on the mandibular dorsal and ventral surfaces. Trichoid sensilla are classified as Td-I, Td-II and Td-III on the dorsal surface and Tv-I and Tv-II on the ventral surface (Table.3)

On the dorsal border of the mandibles, the sensilla Td-I are visible. The Td-II sensilla are long, pointed and somewhat curved, while the Td-III sensilla are short and dispersed across the dorsal surface (Fig. 2). Mandibular ventral surfaces have basiconic sensilla (Bv) on the posteroventral surface and trichoid sensilla (Tv-I and Tv-II types) on the anteroventral border.



Fig 1: Head and Mandibular part (ventral view) of *Camponotus compressus*

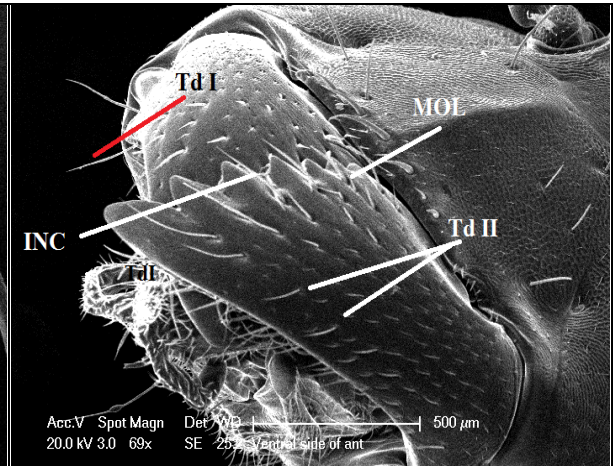


Fig 2: Mandibles of *Camponotus compressus*

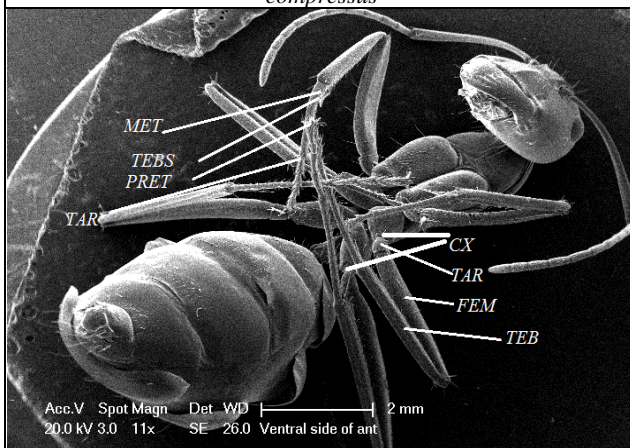


Fig 3: Parts of leg of *Camponotus compressus*

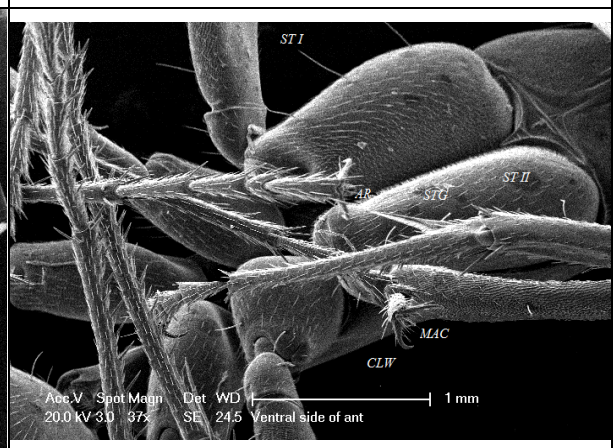


Fig 4: sensilla on legs of *Camponotus compressus*

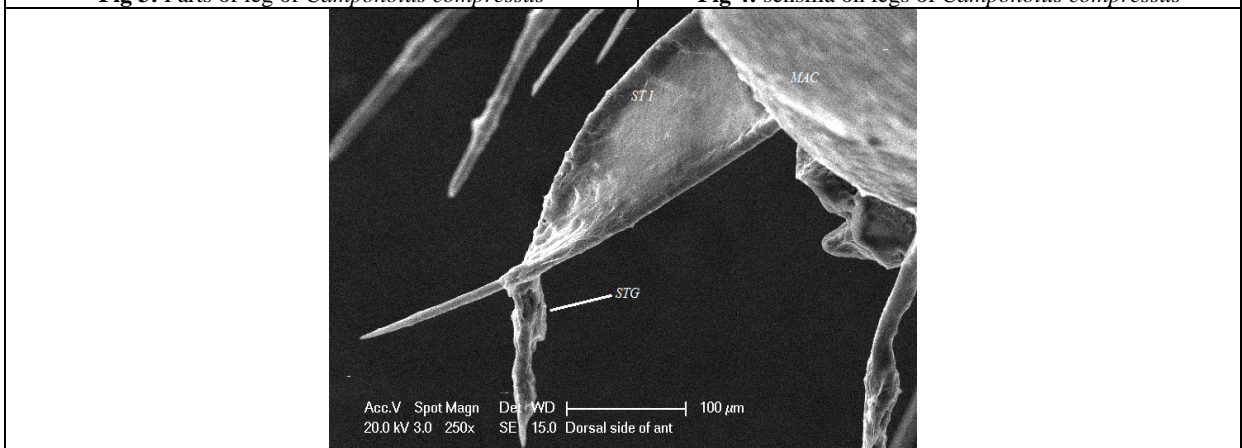


Fig 5; Legs ((ventral view) of *Camponotus compressus*

2. Legs of *Camponotus compressus*

The *Camponotus compressus* ant has three pairs of well-developed legs in its adult worker forms. The coxa, tarsus, pretarsus, trochanter, femur, tibia in the worker ants are highly developed. The paired claws have six segments in each leg (Figure 3).

I. Coxa

It is the first section with pronotal region. It has a triangular shape, dorsoventrally flattened, very muscular and is broad at the anterior joint and narrow toward the posterior end. Fine sensillary hairs cover the dorsal and ventral surfaces of the coxa on each leg of the worker ants (Fig.3). Trichoid sensilla and fine setae-like hairs, known as trichomes cover the entire surface of coxa in workers. The sensilla have a base diameter of $3.21 \pm 1.07 \mu\text{m}$ and a length of about $546.8 \mu\text{m}$. In worker ants, these sensilla are placed uniformly on the coxae of the foreleg, middle and hind legs.

II. Trochanter

It is the second segment of the leg is visible as a triangular plate-like structure that extends from the proximal region of the femur to the posterior articulation of the coxa. The trochanter is bigger in worker ants. The trochanter in each worker is covered in tiny trichoid sensilla on the entire surface (Fig. 4). While sensilla are distributed similarly on the trochanter of fore, mid and hind legs in workers and their sizes vary.

III. Femur

The third segment in a leg is long, sturdy and broad called femur. The structure is dorsoventrally flattened, heavily muscled and broad in the front and thin in the posterior distal end. The size of femur varies among adult polymorphic forms. In workers, the femur is bigger. Sensilla trichoidea of the trichoid type are present along the whole surface of the foreleg's of femur. In workers, the sensill trichoidea display a comparable distribution but differ in size on the fore, mid and rear legs (Fig.4).

IV. Tibia

The fourth longer section in a leg is the tibia. The tibial body is highly muscular and large at the anterior and thin toward the distal end and dorsoventrally flattened. The size of tibia in the worker is greater. At the terminal, a well-defined structure resembling a fibula is the strigil. The juncture of the tibia and tarsus cuticular bristles make up the foretibia strigil. Bristles that resemble comb teeth on the dorsal surface having varying length on the ventral surface in the adult worker forms. The macrosetae and trichoid sensilla found on the dorsal and ventral surfaces of the tibia in forelegs.

V. Tarsus

The tarsus is the fifth segment of a leg and is made up of four tarsal segments, the first of which is called the metatarsus and is considerably larger than the other four. In workers, the oftarsus is bigger. On each leg of the worker, the dorsal and ventral tarsal surfaces display various types of sensillary hairs. The tubular segment of the metatarsus is long and slender. There are various types of sensillary hairs visible on the metatarsal and ventral surfaces of the bone. However, the metatarsus of the middle and hind legs displays macrosetae, sensilla trichoidea and the trichomes in workers, but the foreleg metatarsus displays three types of sensilla, sensillatrichoidea, trichomes and comb-like bristles and cuticular bristles (Fig 4). On the entire surface, all tarsomeres have bristles, setae and trichomes, much like the metatarsus. The size of these sensilla varies while having a similar appearance.

VI. Pretarsus

The sixth terminal section of the leg is called the pretarsus. It is distinguished by having terminally bent legs, two well-developed pectinated claws on each, a median lobe that resembles a cushion and an arolium that is clearly defined and located in between the terminal claws. Worker ants have a smaller arolium. The pretarsi of worker ants display sensilla trichoidea curvata and macrosetae along the whole surface of the pretarsus foreleg. The trichoidsensilla and sensilla trichoidea curvata with macrosetae and trichome are visible on the middorsal surface of the claws (Fig. 3).

Table 1: Morphometric observation of legs in *Camponotus compressus*

Parts of leg	Fore leg		Mid leg		Hind leg	
	Width (µm)	Length (µm)	Width (µm)	Length (µm)	Width (µm)	Length(µm)
Coxa	0.7	0.9	0.8	0.9	567	896
Trochanter	362	121	0.5	0.5	377	424
Femur	321	1451	0.4	1434	1610	464
Tibia	361	145	0.4	1358	467	1479
Spur	63	579	62	613	54	578
Tarsus	245	745	0.65	0.8	264	899
Metatarsus	243	786	0.2	1.5	287	780

Table 2: Length and width of various sensilla present on legs of *Camponotus compressus*

Sr. No.	Fore Leg			Mid Leg			Hind Leg		
	Sensilla	Length(µm)	Width(µm)	Sensilla	Length(µm)	Width(µm)	Sensilla	Lengt(µm)	Widt(µm)
Coxa	Trichoidea	53	3.8	Trichoidea	29.8	15.1	Trichoidea	201	34.4
	Trichoidea II	21	3.4	TrichoideaII	43	16	Trichoidea	132	34
Trochanter	Trichoidea	94.4	6.56	Trichoidea	121.2	14.2	Trichoidea	488.7	72.4
Femur	Trichoidea	78.1	6.6	Trichoidea	111	11	Trichoidea	182	27.3
Tibia	Tibial Spur	385	28	Tibial Spur	898	72	Tibial Spur	466	52
Tarsus	Comb Like Bristle	20	8	Comb Like Bristle	22	8	Comb Like Bristle	22	8
	Microtrichia,	155	31	Microtrichia,	139	30	Microtrichia,	136	29

	Basitarsus	99	28	Basitarsus	99	28	Basitarsus	101	30
	Trichoidea	70	4	Trichoidea	72.	4	Trichoidea	77	5
Metatarsus	Macrosetae	60	9	Macrosetae	66	11	Macrosetae	64	10
	Trichomes	152	25	Trichomes	158	29	Trichomes	156	27
	Sensilla Trichoidea	26	3	Trichoidea,	28	3.6	Trichoidea,	29	4
	Basi conic Sensilla	4	2	BasiconicSensilla	4	1	Basiconic	4	2
Tarsomere	Tarsus I	442	202	Tarsus I	432	192	Tarsus I	437	199
	Trichoidea,	162	8	Trichoidea	156	6	Trichoidea	159	7
	Tarsus II	502	81	Tarsus II	482	76	Tarsus II	486	78
	Basiconic	5	0.7	Basiconic	4	0.4	Basiconic	4	0.5
Trichomes	72	6.3	Trichomes	72	6.8	Trichomes	72.1	6.9	Trichomes

Table 3: Morphometric observations on the mandibular sensilla of *Camponotus compressus*

Sr.no.	Total mendibular length (mm)			Width (mm)		
	1.9			Anterior region	Posterior region	
01				1.2	1.3	
02	Sensilla on Dorsal region	Length(µm)	Width(µm)	Sensilla on Ventral region	Length(µm)	Width(µm)
	Sensilla Trichoidea Td-I	298	22	Sensilla Trichoidea Tv-I	369	17
	Sensilla Trichoidea Td-II	124	12	Sensilla Trichoidea Tv-II	139	12.5
	Sensilla Trichoidea Td-III	75	7.8	Sensilla Basiconica Bv	14	0.4

Discussion

The mandibles of the carpenter ant, *Camponotus compressus* are large and strong structures useful for collecting prey, fighting, digging, sowing, chopping, scraping wood, grooming, caring for the brood and trophallaxis (Hölldobler and Wilson, 1990^[9, 16]; Gronenberg *et al.*, 1998; Paul, 2001). The mandibles of the *Camponotus compressus* resembles those of the ant *Mycetarotes carinatus* in terms of structure. (Mayhé-Nunes and Lanziotti, 1995; 2002). In *Camponotus compressus*, the dorsal side of the mandibles have trichoid sensilla, Td- I and Td- II, which are widely distributed, but the ventral side has Tv- I and Tv- II, which predominate and the mandibles of worker ants have basiconica sensilla, Bv. On the dorsal and ventral surf aces of the mandibles of the dragon fly, the trichoid sensilla and the tiny piglike sensilla basiconica, respectively, were described as the mechanoreceptors and chemoreceptors. (Corbiere Tichane, 1971; Petryszak, 1977; Zacharuk, 1980; Kapoor, 1989; Wazalwar and Tembhare, 1999)^[4, 27]. Carpenter ants, *Camponotus compressus*, have mandibles that likewise contain comparable sensilla basiconica. The seven teeth, four incisors and three molars seen in *Camponotus compressus* worker ants show that includes the mandibles have been modified specifically for each species in accordance with feeding behaviour and sexual dimorphism, as seen in the ant, *Mycetarotes carinatus*. (Mayhé Nunes and Lanziotti, 1995, 2002). As found in the present study, the legs are divided into six segments: the coxa, trochanter, femur, tibia, tarsus, and pretarsus. Each segment is securely connected to the others. On the leg of the worker ant *Camponotus compressus*, there is a notch and a fore tibial spur comb. Okada observed a comparable outcome in the Ponerinae ant, *Diacamma*. (Okada, 2010) suggested that both sexes of *Diacamma* sp. have the comb-like structures known as the comb of notch on the inside of the fore tibia. In both male and female *Diacamma* sp., a single comb is provided for thoroughly cleaning the L-shaped antennae. (Dumpert K, 1989). A spur found on *T. rufonigra* is used to clean the antenna. In *T. rufonigra*, the comb of the notch is made up of a single tibial spur and two rows of wide bristles. The Okada 2014 recorded a comparable outcome. (Okada Y, Miura T, Tsuji K, 2015).

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References

1. Billen J. Etude morphologique des glandes tarsales chez la gue *Polistesannularis* (L.) (Vespidae, Polistinae). Actes coll. Insects Soc.,1986:3:51-60.
2. Billen JA. survey of the glandular system of fire ants. In: Applied Myrmecology. A World Perspective.Chap. 8, Eds. R.K. Vander Meer, K. Jaffe, A. Cedero, Westview Press, Boulder, CO, 1990, 85 -94.
3. BILLEN, J. Ultrastructural organization of the exocrine glands in ants. Ethol. Ecol. Evolut, 1991, 67-73.
4. Corbiere Tichane G. Ultrastructure de l' equipment sensorial de la mandibule chez la larvae du *Spephyes lucidus* Delar (Coleoptera, cavernicule de la sous-famille des Bathyscinae). Zeitschrift fuer Zellforschung und Mikroskopische Anatomie,1971:112:129-138.
5. Dumpert K. Alarm stoffrezeptorem auf der Antenne von *Lasius fluliginosus* (Hymenoptera: Formicidae). Zeitschrift fuer Verglei chende Physiologie,1972:76:403-425.
6. Galewski KA. study on morphobiotic adaptation of European species of *Dytiscidae* (Coleoptera). Bulletin entomologique de Pologne,1971:61:487-702.
7. Gotwald WH. Jr. Comparative morphological studies of ants with particular reference to the mouthparts (Hymenoptera: Formicidae). Memoirs of Cornell University Agricultural Experiment Station Ithaca New York,1969:408:1-150.
8. Grogenberg W, Hölldobler B, Alpert GD. Jaws that snap: The mandible mechanism of the Mystrium. Journal of Insect Physiology,1998:44:241-253.
9. Hölldobler B, Wilson EO. The Ants. Cambridge: Belknap Press, 1990.

10. Imran B, Muhammad TR, Muhammad AB. New distributional records of *Tetrapodean rufonigra* (Jerdon) from Gilgit Baltistan, Pakistan. *Asian J Agri & Biol.*,20175(2):56-59.
11. Okada Y, Miura T, Tsuji K. Morphological differences between sexes in the ponerinae ant *Diacamma* Sp. (Formicidae: Ponerinae). *Lib. Hokudai, Jap /2115 /17077 /Sociobio.* Hokkaido University, Sapporo, 060-0810, Japan, 2006, 48-2.
12. Barsagade DD, Thakare RP, Anande SM, Chankapure PN. SEM structure of Legs of ant, *Components sericeous* with special reference to antenna cleaner (Hymenoptera: Formicidae). *Proc. Nat. Semi on Rec. Tred. Bioinfor. And Biostat*, 2015, 168-171.
13. Schonitzer K, Lawitzky G. A phylogenetic study of the antenna cleaner in Formicidae, Mutillidae and Tiphidae (Insecta: Hymenoptera). *Zoomorphology*,1987:107:273-285.
14. De Boer G. The role of the antennae and maxillary palps in mediating food preference by larvae of the tobacco hornworm *Menduca sexta*. *Entomol. Exp. Appl.*,2006:119:29-38.
15. Skiri HT, Strandén M, Sandoz JC, Menzel R, Mustaparta H. Associative learning of plant odors activating the same or different receptor neurons in the moth *Heliothis virescens*. *J Exp. Biol.*,2005:208:787-796.
16. Holldobler B, Wilson EO. *The Ant Belknap* (Harvard University Press), Cambridge, MA, 1990, 732.
17. Hashimoto Y. Unique Features of Sensilla on the Antennae of Formicidae (Hymenoptera). *Applied Entomology and Zoology*,1990:25(4):491-501.
18. Betz O. Performance and adaptive value of tarsal morphology in rove beetles of the genus *Stenus* (Coleoptera: Staphylinidae). *The Journal of Experimental Biology*,2002:205:1097-1113.
19. Dumpert K. Alarmstoffrezeptoren auf der Antenne von *Lasius fuliginosus* (Lart.) (Hymenoptera, formicidae). *Z. Vergl. Physiol*,1972:76:403-425.
20. Chouvin R. Sur l' epagine at. Sur les glands tarsales d' arnhart, *Insects Soc.*,1962:9:311-321.
21. Lensky Y, Slabezki. The inhibiting effect of the queen bee, *Apis mellifera* foot print pheromone on the construction of swarming queen cups. *J Insect Physiol*,1981:27:313-323.
22. Federle W, Fiala B, Zizka G, Maschwitz U. Incident day light as orientation cue for hole-boring Ants: Prostomata in *Macaranga* ants plants. *Ins. Socio*,2001:48:165-177.
23. Saini Dhillion MS. Functional modifications of the metatibial spurs in order Hymenoptera. *J Anim. Morphol. Physiol*,1978:25:54-60.
24. Hashimoto Y. Phylogenetic study of the family Formicidae based on the sensillum structures on the antennae and labial palpi (Hymenoptera, Aculeata). *Japanese Journal of Entomology*,1991:59:125-140.
25. Ozaki M, Wada - Katsumata A, Fujikawa K, Iwasaki M, Yokahari F, Satoji Y *et al.* Ant nest-mate and non nest-mate discrimination by a chemosensory sensillum; *Scienc*,2005:309:311-314.
26. Markin GP. Nest relationship of the Argentine ant, *Iridomyrmex humilis*, (Hymenoptera: Formicidae). *J Kans. Entomol. Soc*,2005:41(51):1-516.
27. Zacharuk RY. Ultrastructure and functional of insect Chemosensilla. *Annu. Rev. Entomol*,1980:25:27-47.
28. Creighton WS, Gregg RE. *Phragmatic Soldiers.* *Psyche*,1954:61:41-57.
29. Orivel J, Malherbe MC, Dejean A. Relationships between pretarsus morphology and arboreal life in ponerine ants of the genus *Pachycondyla* (Formicidae: Ponerinae). *Ann. Entomol. Soc. Am*,2001:94:449-456.