Entomon 42(3): 239-244 (2017)
Short Communication No. ent. 42310

Satellite nest architecture and demography of the plant - visiting ant, *Camponotus compressus* (Fabricius)

Priya Aradhya Ekka and Neelkamal Rastogi*

Insect Behavioural Ecology Laboratory, Department of Zoology, Institute of Science, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India.
Email: neelkamalrastogi@yahoo.co.in

ABSTRACT: In the present study the satellite nest architecture and demography of the common and widespread sugar-loving carpenter ant, *Camponotus compressus,* were determined. The nests were located in soft and moist soil. The dental plaster casts revealed that the vertically oriented satellite nests harbouring brood (42.8 ± 21.12) and worker ants (29.2 ± 8.94) were 51.2 ± 8.17 cm deep. The nests were characterised by the concentration of 4 ± 1.09 chambers, in the upper part of the nest and a single narrow shaft at the lower end. We suggest that the location of the nests chambers close to the nest exit/entrance hole may facilitate rapid communication among the *C. compressus* worker ants on discovery of extra floral-nectary bearing or homopteran-harbouring plants by a colony member. This study can lead to a better understanding of nest construction mechanisms and the effect of nest architecture on foraging behaviour and organization of an ant colony.

KEYWORDS: Satellite nest architecture, demography, carpenter ants, polydomy

Ground dwelling ant species excavate species-typical subterranean nests (Tschinkel, 1987, 1999, 2003, 2005; Mikheyev and Tschinkel, 2004; Moreira *et al*., 2004) which are made by an active soil removal process (Tschinkel, 2005). The subterranean nest constructed by an ant colony is a functional part of the superorganism (Tschinkel, 2011). The underground nests provide a protected environment and stable microclimatic conditions to the queen and the brood of the ant colony (Frouz, 2000). The worker ants locate, forage and retrieve food from the surrounding environment which is then carried either singly or in groups of 2 or more to the nest. Hence, the colony's success in finding food such as plant-derived extra floral nectar (Agarwal and Rastogi, 2008 a) and honeydew from the sap sucking insects (Way, 1963) may be affected by the nest site and structure. Moreover, since worker ants recruit colony members by short or long-range recruitment strategies (Rastogi *et al*., 1997) the position and location of the nest chambers may be important for social interactions and speed of food retrieval. Consequently, the nest architecture may be an important regulator of social activity in an ant colony (Stickland and Franks, 1994).

Variations in the shape, size, number and arrangement of chambers within ant nests gives rise to species-typical architecture (Tschinkel, 2005). However, the study of the subterranean ant-nest architecture is still in its infancy. Ant nests of most species studied till now consist of two basic elements: the vertical shafts and the horizontal

* Author for correspondence

chambers (Tschinkel, 2003). A few descriptive studies of *Pogonomyrmex badius*, *Camponotus socius* and *Odontomachus brunneus* have outlined the range of architectural variations commonly found within and among these ant species (Tschinkel, 2004, 2005; Cerquera and Tschinkel, 2010).

Carpenter ants belong to the hyper disperse genus *Camponotus* which is ubiquitous in distribution (Bolton *et al.,* 2007) and includes polydomous species (Pfeiffer and Linsenmair, 1998; Buczkowski, 2011). Polydomous ant species have multiple spatially separated but socially connected colonies (Robinson, 2014). *Camponotus compressus* (Fabricius, 1787) is widespread in Asia (Nettimi and Iyer, 2015) and is common in many parts of India (Agarwal and Rastogi, 2008 a; Bharti *et al*., 2016). This ant species frequents a variety of habitats including forests, grasslands, agricultural land and even urban areas (Sonune and Chavan, 2016). Surprisingly, these ants abound in the ephemeral, annual cropping systems where the primary nests are constructed at the bases of trees or shrubs located at the field boundaries (pers. obs.) and the satellite nests are located in the irrigations channels and the crop-growing central field zone (Agarwal *et al.,* 2008 a). *Camponotus compressus* colonies construct two types of nests: the primary nests, usually at the base of a tree (within which they make galleries) and the associated satellite nests (Orr *et al*., 1996; Kumari *et al.*, 2016). A recent study indicates that *C. compressus* colonies modify soil pH and also soil nutrients (Kumari *et al.,* 2016). It is also well known that these ants visits extra floral nectary-bearing plants (Agarwal and Rastogi, 2008b; 2010) and tend homopterans for honeydew (Way, 1963). No information is available on its nest architecture till date. This is the first study providing a description of the architecture and demography of the satellite nests of *C. compressus*.

The study was carried out in the Botanical Garden of Banaras Hindu University, Varanasi, India, during the winter season (October, 2016 to February, 2017).Following the method of Tschinkel (2010) a thin slurry of dental stone plaster in water (in 1:1 ratio) was poured into the nest entrance hole of actively used (Shukla *et al.,* 2013) satellite nests (n = 5) and this was allowed to set overnight. The hardened cast was gently and systematically excavated after a 24 hr period with the help of a small spade. Since dental plaster casts are only moderately hard, the casts very often broke during the excavation process so the pieces were carefully and systematically labeled numerically (the labels were kept in position with the help of an adhesive tape), while digging and were sequentially assembled later. The dental stone plaster casting method offers an advantage because the casting material flows downward and fills all the nooks and cavities of a nest and occupies the entire inner space, something that is difficult to achieve during direct excavation of an uncast ant nest. For descriptive purposes, the shaft is defined as a more or less vertical length while a chamber is defined as a horizontal feature of the nest (Tschinkel, 2005). The nest dental plaster cast (along with its broken segments) was carefully transferred to a tray and brought to the laboratory where each nest was reassembled and the dimensions of each were carefully measured (in cm). The nest's volume was estimated by dividing the nests' cast weight by the density of dental stone plaster (Mikheyev and Tschinkel, 2004). The demography of the actively used satellite nests was examined by carefully excavating another set of satellite nests (n = 5) and sorting out the brood (larvae and pupae) and worker ants present within each nest.

Satellite nests were located in soft, slightly moist ground, covered with *Cynodon dactylon* grass. Casts of the 5 satellite nests of *C. compressus,* shown in the photograph (Fig. 1) reveal that the nests are mainly vertically oriented. Each nest is found to contain well-demarcated chambers and a single shaft. The chambers (Mean ± SEM; 4 ± 1.09; range: 2-8) were present predominantly in the upper part of each nest, just beneath the nest hole. The lower part of each nest consisted of a single, long, shaft.The satellite nests were moderately deep (51.2 ± 8.17 cm) and the nest volume was 246.56 ± 66.76 cm^3. The variations in nest depth (32 to 78 cm) and volume (115.20 to 425.60 cm^3) are suggested to be due to the variation in the satellite

Fig.1. Representative dental plaster casts (n =5) of the satellite nests of *Camponotus compressus*

nest life span (from 15 days to 4 months; Kumari *et al*., 2016). Only worker ants (29.2 ± 8.94) and brood (42.8 ± 21.12) were recorded within the satellite nests. The brood comprised of only late instar larvae (24.2 ± 12.18) and pupae (18.6 ± 9.80) and were recorded only in the top 1 to 2 chambers. The worker ants were however found throughout the nest including the shaft region.

Each satellite nest of *C. compressus* was characterized by a single vertical shaft connecting simple horizontal chambers. This is a widespread architectural unit among the subterranean ant nests. Chambers were typically in the upper part of the nest, near the surface and the lower part of the nest shaft was tunnel-like without any distinguishable chambers. In contrast, the nests of *P. badius*, *C. socius* and *O. brunneus* ant colonies have chambers along the entire nest depth (Tschinkel, 2004, 2005; Cerquera and Tschinkel, 2010). Examination of the nest demography and the volume of the nest cast reveals that the satellite ant colony of *C. compressus* is small as compared to the nest of *C. socius* (Tschinkel, 2005). Population size of an ant nest is suggested to be directly correlated with the complexity of the colony architecture (Franks and Deneubourg, 1997). Since larger colonies excavate larger nests as a result of nest deepening, chamber enlargement and the addition of new vertical series of chambers (Tschinkel, 2004). The presence of late larval and pupal stages and the complete absence of the eggs and early larval stages in the satellite nests indicate that the early stages remain confined to the wooden, tree-based galleries of the primary nests (Bristow *et al.,* 1992). Our study reveals a well-defined demographic structure and a simple nest architecture of *C. compressus* satellite nests. This appears to be similar to the simple nests built by *Leptothorax* ants, whose colony size ranges between 50 and 500 individuals (Franks and Deneubourg, 1997).

Being sugar-loving *C. compressus* worker ants visit a diverse assemblage of plants and forage mainly on extrafloral nectar and homopteran honeydew (Agarwal and Rastogi, 2008 a; Nettimi and Ayer, 2015). The availability of both of these is expected to undergo periodical changes depending on the season, homopteran density fluctuations and plant phenology. The satellite nest architecture of *C. compressus* reveals that a minimum number of two chambers are usually located just beneath the nest hole. The presence of the brood in the topmost chambers may be conducive towards their exposure to more favourable temperature conditions, during the winter season. The positioning of chambers very close to the exit/entrance hole may influence the foraging performance and thus the speed at which information about a new food source spreads across the colony as the recruitment speed is found to be positively correlated with the connectivity of all chambers. Recent studies indicate that the structure of the top part of a nest, and not the number of ants the chambers can hold, determines the dynamics of collective foraging (Pinter-Wollman, 2015). The upper chambers of satellite nests may therefore facilitate rapid communication among the *C. compressus* worker ants on discovery of extra floral nectary-bearing or homopteran-harbouring plant(s) by a scout ant, although further field-based experiments are required to study this aspect. Thus, ant nest architectural design can contribute not only to our understanding of nest construction mechanisms (Perna and Theraulaz, 2017), but also reveal how nest structure affects the foraging behaviour and the organization of activities within an ant colony.

ACKNOWLEDGEMENTS

The first author thanks the Council of Scientific & Industrial Research, Human Resource Development Group for providing the JRF and SRF. We thank Prof. N.K. Dubey for kindly permitting the ant nest excavations in the Botanical Garden of Banaras Hindu University.

REFERENCES

Agarwal V.M. and Rastogi N. (2008 a) Deterrent effect of a guild of extrafloral nectary-visiting ant species on *Raphidopalpa foveicollis*, a major insect pest of sponge gourd, *Luffa cylindrica*. Entomologia Experimentaliset Applicata 128: 303-311.

Agarwal V.M. and Rastogi N. (2008 b) Role of floral repellents in the regulation of flowervisits ofextrafloral nectary-visiting ants in an Indian crop plant. Ecological Entomology 33: 59-65.

Agarwal V.M. and Rastogi N. (2010) Ants as dominant insect visitors of the extrafloral nectaries of sponge gourd plant, *Luffacylindrica* (L.) (Cucurbitaceae). Asian Myrmecology 3: 45-54.

Bharti H., Guenard B.S., Bharti M. and Economo E.P. (2016) An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). Zookeys 551: 1-83.

Bolton B., Alpert G., Ward P.S., Naskrecki P. (2007) Bolton's Catalogue of Ants of the World. Harvard University Press, Cambridge, Massachusetts 1758-2005.

Bristow C.M., Cappaert D., Campbell N.J. and Heise A. (1992) Nest structure and colony cycle of the Allegheny mound ant, *Formica exsectoides* Forel (Hymenoptera: Formicidae). Insectes Sociaux 39: 385-402.

Buczkowski G. (2011) Suburban sprawl: environmental features affect colony social and spatial structure in the black carpenter ant, *Camponotus pennsylvanicus*. Ecological Entomology 36: 62-71.

Cerquera L.M. and Tschinkel W.R. (2010) The nest architecture of the ant *Odontomachus brunneus*. Journal of Insect Science 10: 64.

Franks N.R. and Deneubourg J.L. (1997) Self-organizing nest construction in ants: individual worker behaviour and the nest's dynamics. Animal Behaviour 54: 779-796.

Frouz J. (2000) The effect of nest moisture on daily temperature regime in the nests of *Formica polyctena* wood ants. Insectes Sociaux 47: 229-235.

Kumari S., Singh H. and Rastogi N. (2016) Influence of the sugar-loving ant, *Camponotus compressus* (Fabricus, 1787) on soil physico- chemical characteristics. Halteres 7: 163-174.

Moreira A.A., Forti L.C., Andrade A.P.P., Boaretto M.A. and Lopes J. (2004) Nest architecture of *Atta laevigata* (F. Smith, 1858) (Hymenoptera: Formicidae). Studies on Neotropical Fauna and Environment 39: 109-116.

Mikheyev A.S. and Tschinkel W.R. (2004) Nest architecture of the ant *Formica pallidefulva*: structure, costs and rules of excavation. Insectes Sociaux 51: 30-36.

Nettimi P. and Iyer P. (2015) Patch fidelity in *Camponotus compressus* ants foraging on honeydew secreted by treehoppers. Current Science 109 (2): 362-366.

Orr A.G., Charles J.K., Yahya Hj. H.R. and Sharebini Hj. N (1996) Nesting and colony structure in the giant forest ant *Camponotus gigas* (Latreille) (Hymenoptera: Formicinae). Raffles Bulletin of Zoology 44: 247-251.

Perna A. and Theraulaz G. (2017) When social behaviour is moulded in clay: on growth and form of social insect nests. Journal of Experimental Biology 220: 83-91.

Pfeiffer M. and Linsenmair K.E. (1998) Polydomy and the organization of foraging in a colony of the Malaysian giant ant *Camponotus gigas* (Hym./Form.). Oecologia 1170000: 579-590.

Pinter- Wollman N. (2015) Nest architecture shapes the collective behaviour of harvester ants. Biology Letters 11: 20150695.

Rastogi N., Nair P., Kolatkar M. and Gadagkar R. (1997) Foraging strategies in the Ants *Myrmicaria brunnea* and *Diacamma ceylonense* - some preliminary observations. Entomon 22(1): 79-81.

Robinson E.J.H. (2014) Polydomy: the organisation and adaptive function of complex nest system in ants. Current Opinion in Insect Science 5: 37-43.

Shukla R.K., Singh H., Rastogi N., and Agarwal, V.M., (2013) Impact of abundant *Pheidole* ant species on soil nutrients in relation to the food biology of the species. Applied Soil Ecology 71: 15-23.

Sonune B.V. and Chavan R.J. (2016) Distribution and diversity of ants (Hymenoptera: Formicidae) around Gautala Autramghat Sanctuary, Aurangabad Maharashtra, India. Journal of Entomology and Zoology Studies 4 (2): 361-364.

Stickland T.R. and Franks N.R. (1994) Computer image-analysis provides new observations of ant behaviour patterns. Proceedings of the Royal Society of London B 257: 279-286.

Tschinkel W.R. (1987) Seasonal life history and nest architecture of a winter- active ant, *Prenolepis imparis*. Insectes Sociaux 34: 143-164.

Tschinkel W.R. (1999) Sociometry and sociogenesis of colonies of the harvester ant, *Pogonomyrmex badius*: distribution of workers, brood and seeds within the nest in relation to colony size and season. Ecological Entomology 24: 222-237.

Tschinkel W.R. (2003) Subterranean ant nests: trace fossils past and future? Palaeogeography, Palaeoclimatology, Palaeoecology 192: 321-333.

Tschinkel W.R. (2004) The nest architecture of the Florida harvester ant, *Pogonomyrmex badius*. Journal of Insect Science 4(21): 1-19.

Tschinkel W.R. (2005) The nest architecture of the ant, *Camponotus socius*. Journal of Insect Science 5(9): 1-18.

Tschinkel W.R. (2010) Methods for casting subterranean ant nests. Journal of Insect Science 10: 88.

Tschinkel W.R. (2011) The nest architecture of three species of north Florida *Aphaenogaster* ants. Journal of Insect Science 11:105.

Way M.J. (1963) Mutualism between ants and honeydew- producing Homoptera. Annual Review of Entomology 8: 307-344.

(Received 07 March 2017; revised ms accepted 10 August 2017; published 30 September 2017)