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Study of Nesting behavior adaptability in Asian weaver ant *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae) with respect to reproductive cycle and floral diversity

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Abstract
Oecophylla smaragdina also known as Asian weaver ants is an arboreal ant found in Southeast Asian nations. The ant selects evergreen types of trees for nesting. In Indian subcontinent weaver ants are found majorly on Mango trees, but during the present study we observed diverse types of trees selected by weaver ants for nest making. It was observed that the weaver ants are synchronizing their reproductive behavior with the period of year and the size and shape of nest. Leaf structure and size of various plant types were not found to be a problem for weaver ant workers to construct nest and propagate colony. The floral diversity shown by the weaver ant colony for nesting behavior shows adaptability of weaver ant with availability of resources and ability to modify behavior as required in various ecosystems.

Keywords: Weaver ants, arboreal insects, nesting, bio control agent

Introduction
Oecophylla smaragdina is a social Hymenopteran ant also known as Asian Weaver ant. Greenslade (1972) [3], 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. Lokkers (1990) [7], studied the construction and structure of nest in *O. smaragdina.* Nesting habit of weaver ant is studied by Crozier *et al*., (2009) [15], stating that colony can be extremely large consisting more than hundred nests spanning dozens of trees and contain more than million workers. Peeters (2012) [13], titled weaver ants and marvelous architect of nature recognizing their well-coordinated ability of nest construction. Weaver ants are reported by various workers on diverse type of plants, suggesting nesting behavior of *O.smaragdina* also include selection of plants.
So the present work was carried out to study the nesting behavior of O.smaragdina with relation to Breeding season and Monsoon.

Materials and Methods
Behaviour Study
Social organization, nest construction and role of various caste of *Oecophylla smaragdina* in colony propagation were observed during present work. Different types of trees were observed for weaver ant nest. To study the behavior of various polymorphs in-situ, the numbers of events were recorded and photographs were captured frame by frame with a digital camera.

Results
During construction of hive at new location the workers were showing a well co-ordination among them. Initially the major workers formed a live chain and folded a tender leaf with their bodies holding each other's appendages in their mouth and brought the edges of the leaf close (Fig.1). The minor workers hold the worker larvae with their mouthparts to join the edges with the help of silky secretion of the worker larvae (Fig.2). The minor workers press the body of worker larvae gently. The larva secretes salivary sticky secretion which, solidifies when it comes in contact with the air. Sometimes branches of two different trees were joined together forming a single bridge like nest connecting two trees in the fruit orchard for easy movement

of the workers (Fig. 3). *O. smaragdina* shows variation in shape, size as well as height of nest from the ground with respect to the time of year and type of brood present in it. By the end of month of May, small cigar shaped nest with few leaves were observed around 5-6 feet from the ground surface at the tender branches of the tree (Fig. 4). These nests were witnessed with few larval stages of queen and drone of *O. smaragdina*. The shape of the nest in the later month of July-August was found to be more oval and globular with increased number of leaves used to construct nest and increased number of larval and pupal stages of fertile caste. (Fig.5 & Fig.6). During the month of June-July and August the number of fertile caste stages increased rapidly. The emergence of adult occurs during this period for mating and colony propagation (Fig.8). The nests were found on more height and bigger in size in the month of October- December. A single colony was found to be spread in an area of around 5000 sq mt. comprising dozens of fruit trees and each tree were having 10-15 nests and showed a typical pattern in orientation of the nests. (Fig.7). All the nests constructed during monsoon were found in North-East direction opposite to the direction of South-East monsoon wind (Fig.9a & Fig.9b).

Table 1: No. of nest found on a single tree and population dynamic of polymorphs.

Sr. No.	Month Year 2012-2018	Number of nest	Height from ground surface (ft)	Number of fertile caste stages	Number of worker caste members/nest	Size of nest (cm)
1.	May	3-4±1	5±1	10-12±2	100-150±25	10-15 2
2.	June	5-6±1	5±1	25-30± 5	200-250±50	20-25 5
3.	July	5-6±1	7±2	200-250± 50	250-300±50	20-35±5
4.	August	7-8± 1	7±2	35-40± 5	250-300±50	20-45±10
5.	September	7-9±1	10±3	-	300-450±50	20-45±10
6.	October	7-9±1	10±3	-	300-450±50	20-45±10
7.	November	9-10±1	10±3	-	500-700±50	20-45±10
8.	December	9-10±1	12±1	-	600-700±100	20-45±10

Table 2: Use of leaves for construction of nest

Sr. No.	Month	Number of leaves used
1.	May	8-9±1
2.	June	15-16±1
3.	July	30-35±1
4.	August	50-60±5
5.	September	60-70±5
6.	October	60-75±5
7.	November	60-75±5
8.	December	60-75±5

Table 3: Variation in size, shape and height of nest in relation to broods present *in O. smaragdina*.

Time	No. of Nest	Size of nest	No. of leafs used	Height from ground (ft)	No. of queen larvae	No. of Drone larvae
Last week of May	2	10-15 cm	6-7	4.5	2-3	10-12
First week of June	3-4	15-20 cm	15-25	5-6	10-12	35-40
Second week of June	3-4	25-30 cm	20-30	-7-8	15-17	50-65
Mid July	2-3	1.5-2.0 feet	40-50	8-9	20-25	100-140

Fig 1: Workers holding appendages to form live chain and folding the leaves for nest construction

Fig 2: Minor workers hold the worker larvae with their mouthparts to join the edges with the help of silky secretion of the worker larvae

Fig 3: Bridge nest between two trees in fruit orchard for movement of workers

Fig 4: Small cigar shaped nest with few leaves were observed around 5-6 feet from the ground surface at the tender branches of the tree.

Fig 5: Oval and Globular Nest with increased number of larvae and pupae

Fig 6: Oval and Globular Nest with increased number of larvae and pupae

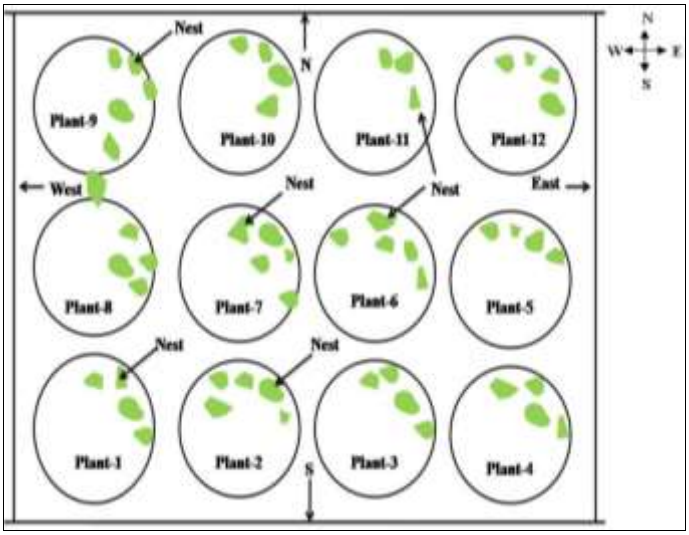
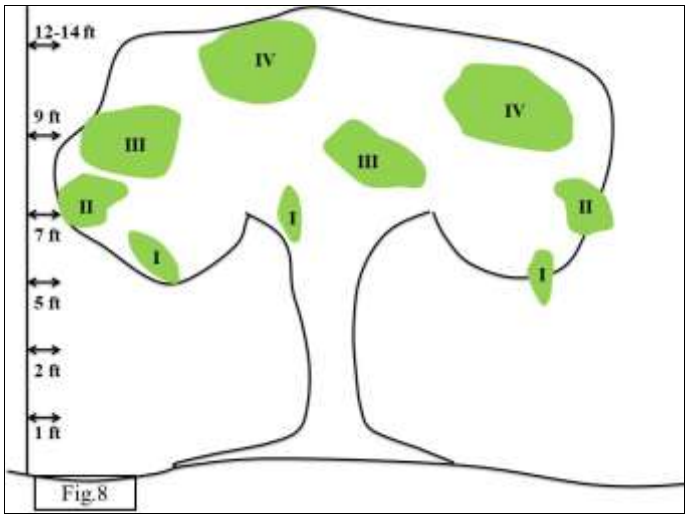


Fig 7: Diagrammatic representation of direction and orientation of O. smaragdina nests in single colony in orchard with respect to southwest monsoon winds.



i) Cigar shaped small nest (June-July)
ii) Oval shaped medium nest (July-August)
iii) Oval shaped large nest (August- September)
iv) Oval shaped large nest (October-December)

Fig 8: Month wise occurrence of Nest with size and height from the ground

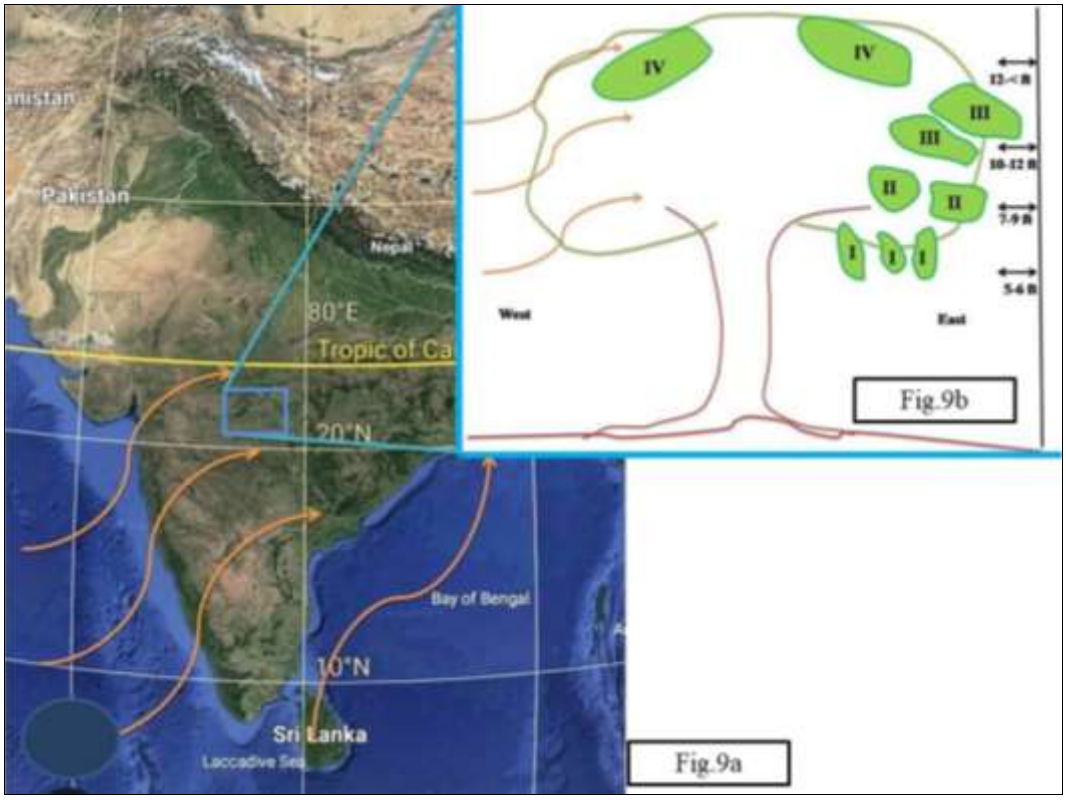


Fig 9ab: Satellite image showing orientation of *O. smaragdina* nest with respect to direction of south-west monsoon winds, Diagrammatic representation of nesting position during southwest monsoon in Maharashtra.

Discussion

Wheeler (1910) [17], first described the use of larval silk for weaving of nest by weaver ants in India. Way (1954) [16], and Hölldobler (1980) [5], established weaver ants are predominantly arboreal in habitat, constructing nest with leaves of host trees. Although Schremmer (1979) [14], found similar use of larval silk in two species of *Camponotus* for nest building. Hölldobler and Wilson (1983), recorded use of larval silk in number of species of *Polyrhachis*. Hölldobler (1983) [18], confirmed *Oecophylla* sp. is the most complex weaver of all the ant species. During the present study it has been found that the major and minor worker of *Oecophylla smaragdina* holding larval stages for weaving leaves. The construction of new nest starts with the major workers holding the new tender leaves with mandibles and folding it to form a small pocket. Other major workers contribute by holding the leaf together. Large leaves are folded by workers forming a chain holding through the petioles of each other. According to Way (1954) [16], weaver ant colonies are the biggest of all Hymenopteran spanning around 800 sq mt. Itterbeeck *et al.,* (2015) [6], explained *O. smaragdina* colony as Polydomous (Multiple Nest). During the present study it was observed that weaver ant colony was found scattered in an area of around 10000 sq ft of fruit orchards comprising of Mango (*Mangifera indica*), Guava (*Psidium* sp)., Umber (*Ficus* sp)., Chikoo (*Manikera* sp.),Asoka (*Saraca* sp) and Jamun (*Syzygium* sp) plants. The trees were apart from each other by 10-15 ft but the canopy was intermingling, Taylor and Adedoyin (1978) [19], reported that worker ants travel from one tree to other by ground or through the interconnected branches, in the present study workers were found carrying brood stages from one host tree to other either on the ground in distant trees or on the branches in inter-connected trees. Peng *et al*., (2010) [20], explained an experimental work carried out on *O. smaragdina* as a useful pest control agent during 1997-98 involving study of ant trail marking on the tree branches establishing that worker of *O. smaragdina* uses tree branches as route to cross from different trees while moving from one nest to another in a bigger colony expanding in dozens of trees. The presence of large nest constructed by weaver ant worker using leaves from two different trees connecting branches of different tress together observed during the present study supports the study of Peng *et al*., (2010) [20]. Nene *et al*., (2015; 2016) [8-9], reported wide range of food preference by *Oecophylla* sp. And alternative supplementary feeds by African weaver ant.

Offenberg (2014) [10], experimentally explained adaptability of *O. smaragdina* to harsh climatic change by rearing *O. smaragdina* colony in artificial hive constructed using empty plastic bottles and observed the weaver ant preferred plastic bottles with aluminum foils with closed, dark interior. The weaver ants adapted the artificial nest only during rainy season and left the bottle after the rains. During the present study it was observed that the weaver ants tend to construct a small cigar shaped nest away from the direction of South west monsoon wind. It was possible that weaver ants nesting behavior is correlated to the onset of monsoon and to protect itself the ants choose safe side of the canopy. Peng *et al*., (1998) [11], and Devarajan (2016) [1], studied variation of nest size and shape in *O. smaragdina* and reported the two types of nests found in weaver colony a small young nest with green leaves and old oval nest with dried leaves. During the present study, the colony was found with various shape and size nests. The small cigar shaped nest was found made up of green naïve leaves joint linearly and comprises of queen brood. According to Itterbeeck *et al.,* (2015) [6], the use of green leaves are possibly for controlling internal temperature of nest as the nest comprises queen broods. During the present observation it was noticed that month of August or late monsoon the nest size is comparatively bigger and shape of

nest was oval bending the twigs and branches by the worker ants was similar to the observations made by Itterbeeck *et al.*,(2015) [6]. Peng *et al.*, (1998) [11], found queen nest in cashew nut orchard during the month of May-July, during the present study the queen brood was also first found during last week of May till end of August. Devarajan (2016) [1], found a positive correlation between size of the nest and height of the nest from the ground surface. During the present study the smaller nest were found at lower height whereas the large oval nest were found on the top of the canopy. Itterbeeck *et al.*, (2015) [6], reported presence of queen brood at peak during the month of March in Laos when the rains are expected and the queen brood production was found to be sooner in vicinity of a water body. During the present study the highest emergence of fertile brood was found coinciding with the onset of rains as pest insects are easily available. According to Dias and Perera (2016) [2], the highest emergence of fertile caste is correlated with the pest insects in early monsoon. Devarajan (2016) [1], also reported correlation of water with nesting behavior and found the nest were preferably present on one side of the canopy, possibly due to presence of water or direction of sun. During the present study the nests were found located in the north east direction opposite to the direction of south west monsoon winds in Indian peninsula.

Conclusion

- The major workers use their body appendages to hold each other and form a live chain to pull edges of the leaves together, and use silk secretion from the worker larvae to join the leaves by holding and pressing the larval body with their mandibles.
- The queen brood nests of *O. smaragdina* are distinct in shape, size and type of leaves used for nest construction. Its cigar shaped and found about 6± 1 feet from the ground made up of green leaves attached laterally to each other.
- The size of the nest in an *O. smaragdina* colony is directly proportional to height of nest from the ground.
- Two different types of nest are constructed by the worker ants during onset of monsoon.
- The orientation of nest in *O. smaragdina* colony is opposite to the southwest monsoon winds in Indian peninsula during the month of May to October.

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