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STUDIES ON ABUNDANCE OF *OECOPHYLLA SMARAGDINA* FABRICIUS (HYMENOPTERA: FORMICIDAE) AND THEIR NEST FORMATION IN *MANGIFERA INDICA* AND *MANILKARA SAPOTA*

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Abstract

Weaver ants are potential predators which prey on most of the arthropods entering their territory. A study was conducted to know the abundance of *Oecophylla smaragdina* nests in the plant hosts at Annamalainagar, Tamil Nadu. From the study, it is evident that the highest percentage of nests were recorded in March, April of 2017 and February 2018. Least percentage of nests found during July, November and December 2017. Offenberg index of *Oecophylla smaragdina* on *Mangifera indica* was recorded highest during April, March, Feburary and May as 58.93, 52.45, 41.83 and 40.57 respectively. In nest formation process of *Mangifera indica* and *Manilkara zapota*, maximum workers were involved in chain formation; minimum numbers of workers were involved in walk and move behaviours. Comparatively more workers were involved in *Manilkara zapota* (2413) than *Mangifera indica* (240) nest formation.

Key words : *Oecophylla smaragdina*, abundance, offenberg index, nest formation, *Mangifera indica*, *Manilkara sapota*.

Introduction

Weaver ants are utilized for human applications as they perform many valuable ecosystem services. They are used as biological control agents against a number of pests in several tropical perennial crops (Way and Khoo, 1992; Peng and Christian, 2006), where they, in many cases, are as efficient in insect pest control as conventional chemical pesticides, and in sometimes, are even more efficient (Offenberg, 2015).

The weaver ant is effective in controlling more than 50 species of insect pests (e.g., sap-sucking bugs, beetles, caterpillars, thrips and fruit flies) on tropical tree crops (e.g., cashew, citrus, cocoa, coconut, lychee, mango, and oil palm) and forest trees (e.g., African mahogany, eucalyptus, and hoop pine) (Way and Khoo, 1992; Peng *et al.*, 2004, 2010; Peng and Christian, 2005; Van Mele, 2008). It is a tropical species, and has been used for controlling various pestsin Australia, China, Papua New Guinea, the Solomon Islands, Thailand, and Vietnam (Peng *et al.*, 2004). The weaver ant present in leaf nests in the tree canopy, and it feeds sugary liquids (e.g., extrafloral nectar and honeydew) and different kinds of arthropods by foraging on flushing parts of trees. In Australia, the weaver ant present naturally and abundantly in unsprayed mango orchards (Majer and Camer Pesci 1991).

Oecophylla spp. make fashion homes from living leaves by sowing them into envelopes, using their larvae as living shuttles and the silken thread they produce as glue (Franks, 2009). The weaver ants are exceptional in being the only group that precedes the deposition of larval silk by actively manipulating the leaf substrate to form a nest. Substrate manipulation involves individual ants selecting, grasping and attempting to pull the edge of the leaf substrate (Bochynek *et al.*, 2014). Keeping in mind the importance of management of major pests of fruit crops and the successful use of *Oecophylla smaragdina* as a potential biocontrol agent worldwide present investigation on studies on abundance and nest formation of *Oecophylla smaragdina* was initiated.

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Materials and Methods

Abundance of *Oecophylla smaragdina*

Oecophylla smaragdina abundance was calculated indirectly by two methods *viz.,* counting of nests and offenberg index were detailed here under.

Weaver ant abundances were assessed by counting the number of weaver ant nests in each of the seventeen identified and one unidentified plant hosts at Annamalainagar once at fortnightly intervals during March 2017- February 2018. Counting the number of weaver ant nests takes approximately 3 min 30 sec per tree. Percentage of nests at Annamalainagar was calculated for the study period mentioned above (Peng *et al.,* 1995; 1997b).

The Offenberg index was calculated for five mango trees in the orchard of Faculty of Agriculture, Annamalai University, Annamalainagar once at fortnightly intervals during January 2017-December 2017 by dividing ant trails into trails with 1-9 ants m^{-1} (low density trail), trails with 10-50 ants m^{-1} (medium density trail) and trails with more than 50 ants m^{-1} (high density trail). The low density trail was assigned 1/3 trail score, the medium density trail 2/3 trail score and the high density a full trail score. The sum of trail scores on a tree then divided by the number of main trunks on the tree and multiplied by 100 to produce the index value. Assessing the branch index on a tree takes approximately 1 min 30 sec (Offenberg and Wiwatwitaya, 2010).

Nest formation

The largest accessible five nests in *Mangifera indica* and *Manilkara zapota* trees were selected and observed in the orchard of Faculty of Agriculture, Annamalai University, Annamalainagar. Nest construction was initiated by pulling apart the existing nest. Once construction of the new nest began, number of major workers involved in seven predetermined behavioural categories *viz*., chain, weave, hold, brood, stay, walk and move were noted (Chen *et al.,* 2018).

Results and Discussion

Abundance of *Oecophylla smaragdina*

Studies conducted to assess the abundance of *Oecophylla smaragdina* during March 2017-February 2018 at Annamalainagar are presented in (Table 1). The total number of *Oecophylla smaragdina* nests in eighteen plant hosts Annamalainagar during twelve months were 609.50. The highest percentage of nests were recorded in March, April of 2017 and February 2018 were 20.67, 13.28 and 11.23 respectively. During September 2017, January 2018 and May 2017 percentage of nests recorded were 10.58, 8.44 and 7.46 respectively. Least percentage of nests found during July, November and December 2017 were 3.93, 3.36 and 2.29 respectively.

In the present study maximum percentage of nests in host plants were present during March month because of optimum temperature and favourable rainfall. An increasing number of nests do not necessarily reflect an increase in ant numbers, but more likely reflects the phenology of the host trees.

The present study results are in accordance with Leston (1973) who stated that colonies of weaver ants in cocoa plantations in Ghana can cover over 20 trees, and it is also asserted by Taylor and Adedoy (1978) whom inferred that colonies in Nigeria may occupy over 100 cocoa trees. These differences in colony sizes could be caused by vegetation influences, such as tree density, tree condition, levels of canopy interconnection, amount of under storey growth, and the proximity of native forest vegetation.

Gibbs and Leston (1970) also inferred that trees may influence weaver ants directly by providing clusters of leaves for nest construction, and allowing inter-tree access when canopies interconnect. Indirectly tree condition can affect the abundance of fauna, both homopterans for honeydew, and other arthropod prey.

The number of weaver ant nests per tree has often been used as a measure of ant abundance in plantation - crops (Rapp and Salurn, 1995; Peng *et al.*, 1997a; Peng *et al.*, 1997b; Ayenor *et al.*, 2007; Dwomoh *et al.*, 2009; Olotu *et al.*, 2013a; Olotu *et al.*, 2013b).

Nest numbers increased from October to December on cashew and from November to January on mango. These periods are the time when cashew and mango trees, respectively, produce leaf and flower flush in Benin. During this developmental stage of the host trees, ants produced numerous new small nests not necessarily because of increased ants numbers, but because they prefer to build new nests on young shoots with flexible leaves (Offenberg *et al.*, 2006) and since flushing shoots are often infested with honeydew producing homopterans which the ants shelter by building nests around their colonies (Lokkers, 1986; Joachim Offenberg, unpublished data). In both mango and cashew, nest numbers also increased from May to July, which is the end of the fruiting season in both crops (early varieties; GVN and Ifac 3). During this time fruit petioles are often infested with attended homopterans and these are also sheltered by new small ant nests. Similar observations were made by Lokkers (1990) who showed that the number of weaver ant nests (*Oecophylla smaragdina*) peaked during seasons of maximum physiological activity of the ant's host plants, *i.e.*, during leaf and flower flush. The result is a high number of small nests during the flush and fruiting of host tree. The above studies are supportive to the present findings.

Abundance of *Oecophylla smaragdina* on *Mangifera indica* was assessed by offenberg index are presented in Table 2. Offenberg index during April, March, February and May were 58.93, 52.45, 41.83 and 40.57 respectively on *Mangifera indica*. During July, November, August and December the branch indices percentage were 33.05, 22.31, 22.08 and 14.06 respectively.

The present study results shown that *Oecophylla smaragdina* ant abundance was maximum in April and March because of favorable temperature, flowering and fruiting period which invited more homopterans, that induced ant abundance.

Peng 1 is the fastest way to assess ant trails as only the presence of ants on each trunk needs to be determined. In terms of time investment this measure is therefore preferable. Also, this measure can be used to assess if ant abundance is high enough to attain adequate protection. If the Peng 1 index on average exceeds 50%, effective pest control may be expected (Peng *et al*., 2008). However, if population dynamics need to be tracked, Peng 2 and Offenberg indices should be preferred due to their higher sensitivity to variation. This would be at the cost of spending a few minutes more per tree during the scoring of ant trails (Wargui *et al.,* 2015). This is in a accordance with the present study results.

According to Wargui *et al*., (2015) Peng 2 and the offenberg indices are to be preferred over the Peng 1 index in cases where it is of importance of track seasonal variations in population numbers. Also they added that the range of fluctuations in the number of nests was very high and unlikely to reflect actual ant abundance dynamics. The fluctuation in nest numbers was 2-3 fold on mango and 2 fold on cashew within a year, in contrast to the branch indices that showed much less fluctuations (from 11 to 49%) which partially supports the present study results.

Nest formation

In *Mangifera indica,* for building nests, larger workers draw individual leaves together forming chains of 18.00 to 69.00 workers to bridge the gaps. The chains are formed by each ant by gripping with its mandibles the very long petiole of the ant in front and leaves are gripped by the mandibles and by the well developed tarsal

Table 1: Abundance of *Oecophylla smaragdina* at Annamalainagar (March 2017- February 2018).

S. No.	Observation period	Number of nests #	Percentage of nests #
1.	March	126.00	20.67
2.	April	81.00	13.28
3.	May	45.50	7.46
4.	June	39.50	6.48
5.	July	24.00	3.93
6.	August	35.50	5.82
7.	September	64.50	10.58
8.	October	39.00	6.39
9.	November	20.50	3.36
10.	December	14.00	2.29
11.	January	51.50	8.44
12.	February	68.50	11.23
Total		609.50	99.94

#- Mean of two counts.

Table 2: *Oecophylla smaragdina* index values with the offenberg indices on *Mangifera indica* (January 2017- December 2017).

Observation period #	Offenberg index (%) *
January	36.48
February	41.83
March	52.45
April	58.93
May	40.57
June	38.24
July	33.05
August	22.08
September	39.16
October	30.39
November	22.31
December	14.06

Mean of two counts.

* Mean of five trees.

Table 3: Nest formation of *Oecophylla smaragdina* in *Mangifera indica*.

Building behaviours	Number of workers				
	Nest 1	Nest 2	Nest 3	Nest 4	Nest 5
Chain	53.00	69.00	18.00	25.00	36.00
Weave	36.00	44.00	14.00	19.00	33.00
Hold	20.00	32.00	15.00	16.00	26.00
Brood	23.00	27.00	18.00	19.00	27.00
Stay	25.00	27.00	11.00	15.00	17.00
Walk	15.00	23.00	9.00	11.00	14.00
Move	12.00	18.00	13.00	8.00	8.00
Total	184.00	240.00	98.00	113.00	161.00

Table 4: Nest formation of *Oecophylla smaragdina* in *Manilkara zapota.*

Building behaviours	Number of workers				
	Nest 1	Nest 2	Nest 3	Nest 4	Nest 5
Chain	600.00	45.00	109.00	78.00	226.00
Weave	548.00	25.00	87.00	64.00	138.00
Hold	348.00	18.00	74.00	43.00	117.00
Brood	300.00	16.00	52.00	36.00	94.00
Stay	352.00	23.00	31.00	27.00	85.00
Walk	189.00	12.00	29.00	16.00	72.00
Move	76.00	9.00	25.00	14.00	21.00
Total	2413.00	148.00	407.00	278.00	753.00

claws. About 14.00 to 44.00 workers were observed drawing a pair of leaflets together and manner in which all chains coordinated in pulling together was most striking. After the leaves were drawn together, they were held in position by 15.00 to 32.00 workers. While other 18.00 to 27.00 larger workers carrying larvae in their mandibles, proceeded to secure the edges together with silk secreted by the larvae. Other 11.00 to 27.00 workers hold the leaves stay in correct position after that 11.00 to 23.00 workers move around the nest to take care the extra leaves and twigs. While that time 8.00 to 18.00 workers move front and back to hold the extra leaves to obtain full shape. Totally, 98.00 to 240.00 workers were found to be involved in nest formation (Table 3).

In *Manilkara zapota,* in that chain formation process 45.00 to 600.00 workers were involved. In weave step 25.00 to 548.00 workers were observed in Table 4. In leaf holding process 18.00 to 348.00 workers were involved. In brood carrying process 16.00 to 300.00 workers were involved. The workers of 23.00 to 352.00 numbers were involved in stay process. Twelve to 189.00 and 9.00 to 76.00 workers were involved in walk and move to complete the nest formation. Totally 148.00 to 2143.00 workers were involved to complete the nest formation process.

The present study results indicated that, maximum workers were involved in chain formation process a than other nest formation steps. Minimum number of workers were involved in walk and move behaviours. Comparatively more workers were involved in *Manilkara zapota* than *Mangifera indica* nest formation, because *Manilkara sapota* leaf size is smaller than mango leaves, so more workers were involved in nest forming process.

Similar to the present observations Holldobler and Wilson (1977) also stated that workers of *Oecophylla smaragdina* construct arboreal nests in a process involving co-operating chains of ants pulling leaves together with other ants gluing the leaves together using silk from larvae. A colony may have up to 5,00,000 workers and its territory may include several trees and scores of nests. Worker size is strongly bimodal (Cole and Jones, 1948); Smaller (minor) workers perform tasks within the nest while larger (major) workers carry out a range of tasks both within and outside the nest.

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