Plant Archives Vol. 19 No. 2, 2019 pp. 2781-2784 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

NEST COMPOSITION, INWARD AND OUTWARD FLOWS OF *OECOPHYLLA SMARAGDINA* FABRICIUS (HYMENOPTERA: FORMICIDAE) IN SELECTED FRUIT CROPS

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Abstract

Oecophylla smaragdina is a potential biocontrol agent worldwide. A study was conducted to assess the nest composition, inward and outward flows of *O. smaragdina* in *Mangifera indica* and *Manilkara zapota* in the orchard of Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu. In *Mangifera indica,* highest number of eggs, larvae, pupae, workers and female alates were found in colony 3 during February 2018 as 3120.00, 3750.00, 5336.00, 7532.00 and 256.00 respectively which is mature among the colonies. In *Manilkara zapota* highest number of eggs, larvae were found in colony 1 as 157.00 and 543.00 during September 2017 respectively. Highest number of pupae, workers, female alates were found in colony 2 as 693.00, 897.00, 23.00 during January 2018 respectively. Delate queen and alate males were absent in all of the colonies of *Mangifera indica* and *Manilkara zapota*. *O. smaragdina* inward and outward flows in *Mangifera indica* displayed circadian variation in all months with minimum flows during after few hours of dawn (8-9 A.M) and before few hours of dusk (5-6 P.M) but between this period of the day from 11.30 A.M to 3.00 P.M. *O. smaragdina* showed high inward and outward flows.

Key Words : *Oecophylla smaragdina*, nest composition, inward and outward flows, *Mangifera indica* and *Manilkara zapota*.

Introduction

Weaver ants (*Oecophylla* spp.) are conspicuous arboreal ants, well known in the humid tropics and subtropics of Africa, Asia, Australia, and the Western Pacific. Weaver ants build large distinctive nest structures in trees by binding together bunches of leaves using a silk-like substance secreted by the larvae. Groups of *Oecophylla* workers hold the leaves together while other workers move the silk-producing larvae back and forth across the gap, effectively weaving the leaves together. The name *Oecophylla* derives from the Greek: oikos (house) and phyllo (leaf) (Wetterer, 2017).

Oecophylla smaragdina is a dominant canopy ant in tropical India and Australia with colonies of up to 5,00,000 ants housed in nests made of leaves fastened together by larval silk and scattered across dense of trees. Weaver ant silks are produced by final-instars of workers, not adults, for nest construction rather than for cocoon spinning. Silks are produced in the labial or salivary glands of the larval in stars. They have been described as having one of the most highly evolved sets of behaviours among ants in nest construction (Schluns *et al*., 2009). The castes of weaver ant, *O. smaragdina* are easily differentiated into small and large workers, males and females. Major workers (adults) were found to be 8mm in length compared to 5mm in case of minor workers. Pupae of major workers and minor workers measured 4mm and 3mm in length respectively (Bharti and Silla, 2011). *O. smaragdina* queens found colonies either haplo-or pleometrotically (Peeters and Andersen, 1989; Peng *et al*., 1998). Keeping in mind the importance of *O. smaragdina* as a potential biocontrol agent worldwide, present investigation was initiated with the objective to study the nest composition, inward and outward flows of *O. smaragdina* in selected fruit crops.

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Materials and Methods

Nest compositions were determined by randomly selecting four *Mangifera indica* and *Manilkara zapota* nests in the orchard of Faculty of Agriculture, Annamalai University, Annamalainagar during four months *viz.,* September 2017, January 2018, February 2018 and March

2018. Choice of the nest was usually constrained by the length of our ladder to a maximum height of six meters, although some trees were climbed for nests up to ten meters in height. Each nest was put off the tree as quickly as possible, and sealed into a plastic bag containing ethyl acetate in a cotton ball and brought to the laboratory. The ants anaesthetized were removed from the dissected nest. The different forms of ants and their numbers in each colony were recorded *viz.,* dealate queens, eggs, larvae, pupae, workers, female alates and male alates. The nests were collected during 7-12 a.m.

To assess the magnitude of variations between inward and outward flows, the number of ants moving in each direction was visually counted for *O. smaragdina* nest during February 2017- January 2018 in *Mangifera indica* in the orchard of Faculty of Agriculture, Annamalai University, Annamalainagar for each of four nests (one day/ nest). The passage of ants in and out of each nest was monitored and recorded for ten minutes, every one hour, over 8 a.m-18 p.m at weekly intervals.

Results and Discussion

Nest composition

In *Mangifera indica,* highest number of eggs, larvae, pupae, workers and female alates were found in colony 3 during February 2018 as 3120.00, 3750.00, 5336.00, 7532.00 and 256.00 respectively when the maximum, minimum temperature, relative humidity; rainfall were 30.2ºC, 19.60ºC; 70% and 0.00 mm respectively. Lowest number of the same were found in colony 2 for eggs, larvae and workers as 233.00, 428.00, 598.00 in January 2018 respectively. Lowest number of pupae and female alates were recorded in colony 4 as 652.00, 8.00 in March 2018 respectively. While in colony 1 in September 2017 eggs, larvae, pupae, workers and female alates were 553.00, 848.00, 675.00, 826.00 and 48.00 respetively table 1.

In *Manilkara zapota* highest number of eggs, larvae were found in colony 1 as 157.00 and 543.00 during September 2017 respectively when the maximum, minimum temperature, relative humidity; rainfall were 33.10ºC, 25.00ºC; 71% and 1.62mm respectively. Highest number of pupae, workers, female alates were found in colony 2 as 693.00, 897.00, 23.00 during January 2018 respectively when the maximum, minimum temperature, relative humidity; rainfall were 28.50ºC, 26.30ºC; 76% and 0.00mm respectively. Lowest number of eggs, larvae, pupae, workers were found in colony 3 as 84.00, 97.00, 324.00, 647.00 during February 2018 respectively. While female alates recorded the lowest as 12 in colony 1 during September 2017 table 1.

Dealate queen and alate males were absent in all the colonies of *Mangifera indica* and *Manilkara zapota* during the study period.

The eggs were small and ellipse- shaped with a size around 0.5mm×1.0mm. The eyes and mouth of the larvae within the eggs could be seen when they were observed under magnifying glass. The pupae could be differentiated from the mature adults because they were white in colour (Van Mele and Cuc, 2007). This is in accordance with the present observations. According to Marcela *et al*., (2012) only one dealate queen found in the KAFA colony and no dealate queen was found in the TI colony. This may be due to the KAFA colony was established much earlier than TI colony. Therefore, the absence of dealate queens and alate males in the present study reveals that all the colonies of both *Mangifera indica* and *Manilkara zapota* are in earlier period of establishment except colony 3 of *Mangifera indica* which is in completion of maturity.

Lee *et al*., (2003) explained that male ants have only one task, which is to inseminate the queen. They usually possess wings and mating can occur within the nest or outside the (swarming). Similarly Schulnus *et al*., (2009) stated that shortly after mating, the males die and the queens settle and establish new colonies. This supports present study results.

From the present study results it is clear that the colony 3 of *Mangifera indica* was established little earlier than the other colonies which could be understood by the presence of the matured female alates with greenish colour. The number of female alates in colony 3 of *Mangifera indica* was higher than all the other colonies. This in accordance with Lee *et al*., (2003) whom explained that a newly hatched adult which has not yet acquired it's deep coloration is known as a callow. It will undergo green coloration as it grows older. Holldober and Wilson (1990) stated a colony which is large enough to produce new, virgin queens known as "mature colony" and the efficiency of the mature colony is determined by the number of workers in each temporal caste at any given moment.

This suggested that the colony 3 of *Mangifera indica* in the present study was a mature colony of *O. smaragdina* with the presence of higher virgin queens, eggs, larvae, pupae and workers compared to all the other colonies. Greenslade (1971) observed, there was no inactive, resting season of *Oecophylla* colonies. Adults and immature stages of workers and sexual forms were present in nests throughout the year, although the numbers varied. In sexuals this variation is best considered in terms of queens. Males were recorded, but relatively infrequently, though when they occurred they were often very numerous. They were found in 17% of nests compared with queens in 57%, with a total 18,630 individuals (pupae and adults) in contrast to 7,217 queens (late larvae, pupae and winged adults). This coincides

Table 1: Nest composition of *Oecophylla smaragdina* in *Mangifera indica* and *Manilkara zapota.*

Colony	Host	Month	Dealate queens no./nest	Eggs no./nest	Larvae no./nest	Pupae no./nest	Workers no./nest	Female alates no./nest	Male alates no./nest
1	*Mangifera indica*	September - 2017	0.00	553.00	848.00	675.00	826.00	48.00	0.00
2		January -2018	0.00	233.00	428.00	948.00	598.00	40.00	0.00
3		February -2018	0.00	3120.00	3750.00	5336.00	7532.00	256.00	0.00
4		March -2018	0.00	1512.00	2518.00	652.00	1238.00	8.00	0.00
1	*Manilkara zapota*	September -2017	0.00	157.00	543.00	575.00	863.00	12.00	0.00
2		January – 2018	0.00	128.00	326.00	693.00	897.00	23.00	0.00
3		February -2018	0.00	84.00	97.00	324.00	647.00	16.00	0.00
4		March -2018	0.00	102.00	217.00	536.00	873.00	18.00	0.00

with the present study results. According to Lokkers (1990) most nests had no or very few eggs. Only one nest, collected in 1986, contained large numbers of eggs, and a functionally reproductive queen was found in this nest. Presumably, only the queen's nest or a few adjacent nests contain eggs, and most brood are transported after hatching, as larvae, pupae, or young adults. He also added, nests at all sites showed relatively similar patterns of larval proportions, with minimum levels from July to November, and maximum in January and/or March. When mean larval fractions were high, large inter-nest variation was also observed. Interestingly, all nests contained larvae, with 2% the lowest percentage observed. Pupal proportions were lowest from July to November, when nests also had fewest larvae. During July and September, many nests were totally devoid of pupae. This partially coincides with the present study results.

According to Falahudin *et al*., (2015) the dynamics of ant's populations found in the nests at the oil palm plantation were varied. The big nest, there were found few eggs and larvae with the total number with other 8 nests found were about 5494 eggs and 5762 larvae. From those amounts, it can result a high economics value for people in cashew in the society. The nests found were observed ever 10 till 15 days in 4 months. Along that range of time, the young nest has usually been formed. In around 10 days, those nests can be harvested. Each nest's weight is about 1 kg/ nest. The ability of forming the colony is affected by ecology factor. The other supporting factors are the availability of resources and pheromone. Resources are everything consumed by organisms which can be differentiated as materials, energy and spaces. This also supports the present study results.

Inward and outward flows

The number of *O. smaragdina* workers moving inward and outward in *Mangifera indica* are mentioned in table 2. During February; March 20.94, 33.62; 23.78, 31.31 and 2.19, 6.27; 10.39, 20.49 number of ants moved inward; outward flows at 11.30-12.30 P.M and 8.00-9.00 A.M respectively. In April; May 33.07, 45.90; 23.52, 60.22 and 12.31, 21.34; 14.52, 24.12 ants were observed for inward; outward flows at 11.30-12.30 P.M and 8.00-9.00 A.M respectively. During June; July 22.37, 31.52; 9.35, 19.54 and 9.00, 4.94; 2.07, 7.48 ants were noted for inward; outward flow at 11.30-12.30 P.M and 5.00-6.00 P.M; 8.00-9.00 A.M respectively. In August; September 7.82, 24.07; 24.32, 48.35 and 3.21, 7.62; 4.85, 13.59 ants were observed for inward; outward flow at 2.00-3.00 P.M and 8.00-9.00 A.M respectively. In October; November 24.60, 36.15; 17.71, 27.46 and 4.57, 3.62; 9.75, 12.00 ants were observed for inward; outward flow at 11.30-12.30 P.M and 5.00-6.00 P.M

Table 2: Inward and outward flows of *Oecophylla smaragdina* in *Mangifera indica* (February 2017 – January 2018).

Month#	Number of ants *							
	8.00-9.00 A.M		11.30 A.M-12.30 P.M		2-3 P.M		5-6 P.M	
	Inward	outward	Inward	Outward	Inward	Outward	Inward	Outward
February	2.19	6.27	20.94	33.62	17.34	12.19	6.39	4.91
March	10.39	20.49	23.78	31.31	19.89	15.75	11.55	5.32
April	12.31	21.34	33.07	45.90	24.59	23.28	16.14	9.30
May	14.52	24.12	23.52	60.22	24.13	18.74	13.22	7.00
June	9.55	14.08	22.37	31.52	18.68	13.70	9.00	4.94
July	2.07	7.48	9.35	19.54	6.26	8.09	5.65	3.05
August	3.21	7.62	13.45	16.10	7.82	24.07	11.05	3.97
September	4.85	13.59	14.05	16.73	24.32	48.35	4.87	1.48
October	10.43	15.12	24.60	36.15	26.12	33.42	4.57	3.62
November	9.45	15.20	17.71	27.46	16.75	12.75	9.75	12.00
December	3.74	6.91	12.85	35.81	12.83	22.08	12.31	6.09
January	8.62	19.31	24.07	40.82	15.56	13.06	10.52	2.11

Mean of four counts. * Mean of four nests.

respectively. During December; January 12.85, 35.81; 24.07, 40.82 and 3.74, 6.91; 8.62, 19.31 ants were observed for inward; outward flow at 11.30-12.30 P.M and 8.00-9.00 A.M respectively table 2.

In the present study *O. smaragdina* inward and outward flows displayed obvious circadian variation in all months with minimum flows during after few hours of dawn (8-9 A.M) and before few hours of dusk (5-6 P.M) but between this period of the day from 11.30 A.M to 3.00 P.M. *O. smaragdina* showed high inward and outward flows. Nests monitored in February, March, June, September, November- January showed reasonably similar moderate circadian cycles of activity. April, May and October months showed highest circadian activity with high flows but July and August months showed lowest circadian activity with minimum flows.

The seasonal changes in circadian activity patterns probably explained by some authors have reported *O. smaragdina* to be primarily diurnal (Greenslade, 1971, 1972; Holldobler, 1979; Holldobler and Wilson, 1978), while others have observed substantial nocturnal foraging (Leston, 1973; Weber, 1949). The effects of varying climates and levels of inter-specific competition may also influence patterns of activity. For example, *Aphaenogaster rudis*, a generalist ant species, appears to alter its circadian activity cycles from nocturnal to diurnal, when the aggressive nocturnal ant, *Camponotus ferrugineus*, is most abundant (Lynch *et al.,* 1980).

Lokkers (1990) reported that the only climatic variable which was consistently related to variations in ant activity throughout the day was temperature. Activity patterns were most affected by temperature when trials were conducted in the hottest months and the coldest months. *O. smaragdina* activity was markedly reduced by cold temperatures and risen to a maximum level at an optimum temperature of 28 to 33ºC. This is similar to the present study results in which activity was the highest during April and May when the maximum, minimum; relative humidity; rainfall were recorded as 37.10ºC, 33.30ºC; 65.10%, 0.00mm and 37.60ºC, 26.90ºC, 62.00%, 0.01mm respectively. Activity was recorded as the lowest during July and August when the maximum, minimum temperature; relative humidity; rainfall were recorded as 36.10ºC, 25.60ºC; 66.00%, 3.72 mm and 33.90ºC, 25.90ºC, 73.00%, 7.75mm respectively.

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