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Population and Nesting Behaviour of Weaver Ants, *Oecophylla smaragdina* from Meghalaya, India

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Abstract

Weaver ants are known for their unique nest-building skills using leaves and larval-silk as a binding agent. The weaver ants, *Oecophylla smaragdina,* are present in large numbers in the Ri-Bhoi district, Meghalaya. This study is the first from this region on the nesting behavior and the population dynamics of these ants. It was noted that *Oecophylla smaragdina* build nests more abundantly in needlewood trees (*Schima wallichi*), locally known as 'diengngan'. The nests of *O. smaragdina* are somewhat round-oval using the leaves of different sizes ranging from 8-32 cm^2, and the average nest size is about 9,483 cm^3. The nearest distance of the nest from the central tree trunk of *S. wallichi* is about 0.7 m, and the farthest is up to 3.4 m. The nests are made at a height ranging from 4-25m. They utilize about twenty leaves with a specific number of chambers to keep their broods, the queen, and food. The number of worker ants, pupae, and larvae are variable in nests of different sizes. The study shows that the active period for foraging and nest building of *O. smaragdina* is at 20-25 °C and significantly declines with the rise in temperature at 30 °C and above. This finding on the presence of an enormous population and familiarity with the nesting behavior of weaver ants *O. smaragdina* could be useful as an alternative source of nutrition and traditional medicine for the people in this region.

Introduction

Weaver ants (*Oecophylla* sp.) are arboreal, eusocial insects (Family: Formicidae; Order: Hymenoptera). They play a significant role in pest management, food, and medicines (Itterbeeck et al., 2014). *Oecophylla* sp., also known as the red weaver ants and green tree ants, comprises only two extant species, *O. smaragdina* (Fabricius), distributed in tropical Asia to Northern Australia and *O. longinoda* (Latreille) distributed in Africa (Cole & Jones, 1948). Weaver ants exhibit a unique strategy of nest building on the tree using the leaves for nest construction. The mated *O. smaragdina* queen starts its colony by laying the first batch of about 35 eggs underneath tree leaves and taking care of the eggs until they hatch into worker ants (Lokkers, 1990). The worker ants exhibit a bimodal size distribution in which the major workers are approximately 8-10 mm in length, and the minors are roughly half the length of the majors (Weber, 1946; Wilson & Taylor, 1964). The function of the minor workers is mostly to feed the queen and primary workers in attending the broods, rearing, and milking honeydew from the scale insects. The significant workers function as soldiers, hunters, and nest builders (Holldobler, 1983).

While building the nest, the worker ants pull the leaves and glue them using their larvae silk. In the case of leaves that are far, a group of worker ants move towards the target leaves and form the ants chain to pull towards the nest site by shortening the chain by one ant at a time until the leaves are

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close enough to be glued together. When the nest leaves die, these weaver ants abandon the nest and construct a new one (Bharti & Silla, 2011). They also clean the nest by applying venom gland secretions (formic acid) to avoid bacterial and fungal infections (Tragust, 2016).

In Southeast Asia, Australia, and Africa, *O. smaragdina* is consumed as food, used in traditional medicines, and pest management (Offenberg et al., 2013; Wetterer, 2017). They are used as natural bio-control agents against agricultural pests by indigenous farmers in Southeast Asia (Peng & Christian, 2005; Crozier et al., 2010). In Australia, *O. smaragdina* is used to treat cold, flu, and headache (Crozier et al., 2010; Bharti & Silla, 2011). *O. smaragdina* has also been used for treating severe cough, cold, and flu in Myanmar, Africa, and India (Rastogi, 2011).

North-eastern India constitutes eight states with various ethnic groups showing unique cultural diversity (Teron, 2019). Different ethnic groups in Assam have unique traditions and cultures distinct from each other and utilize weaver ants for food, medicine, and livelihood. (Langthasa et al., 2017). The Nyishi and the Galo tribes of Arunachal Pradesh, India, use weaver ants to treat fever (Chakravorty et al., 2011).

A prominent state in northeast India, Meghalaya comprises thirteen districts and three indigenous ethnic groups, the Khasis, Garos, and the Jaintias. It has a rich diversity of flora and fauna, which are endemic to the region. In the Garo tradition of Meghalaya, *O. smaragdina*, locally known as 'ketchra,' is consumed as food (Dey, 2013). There is no population dynamics study of these weaver ants from Meghalaya. Our preliminary survey showed that these weaver ants are present in large numbers in the Ri-Bhoi district, Meghalaya. Therefore, the present study was undertaken to examine the population dynamics of the weaver ants concerning the variation in leaves utilized for nest construction and the nest size. Further, the study also evaluated the pattern of the weaver ants at different time intervals concerning the temperature for foraging and building a nest.

Considering that nesting biology of this species is poorly understood, the present study was carried out to test the hypothesis that: 1) the size of weaver ant nests is shaped by the multidimensionality of habitat hypervolume and population traits and 2) the foraging and nest building activity is influenced by temperature

Materials and methods

Study area

The study was carried out during April 2019-February 2020 in Umran-Dairy village (25.78° N latitude and 91.88° E longitude) of the Ri-Bhoi district of Meghalaya, India (Fig 1).

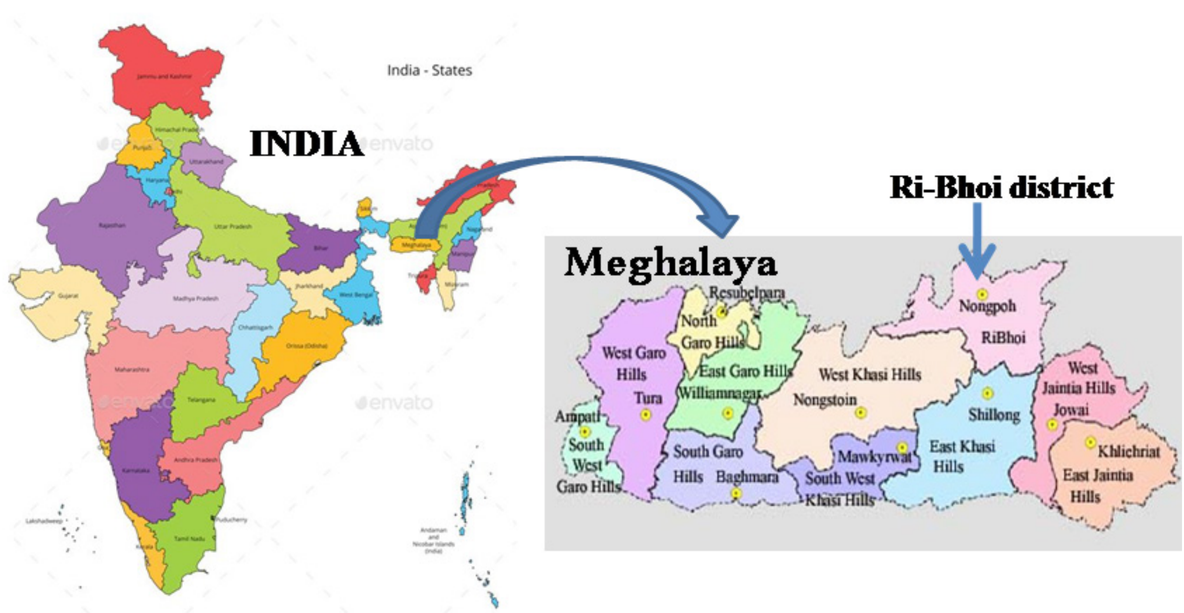

Fig 1. Maps showing the location of Ri-Bhoi district (collection/study site) of Meghalaya, India (maps not at scale).

Ri-Bhoi district is on the national highway-40 in between Shillong and Guwahati of Assam. It is a hot and humid place with an ranging from 18 – 32 °C tand an average annual rainfall of 1267 mm. *O. smaragdina* nests were located in the study area and examined for the type and height of trees, the nests from the ground, and the nests' distance from the central trunk (Santos & Del-Claro, 2009). A behavioral observation like nest building, foraging, protecting the nest, and rearing scale insects was done in the field. The interaction between the ants and other organisms present in the tree was also studied. The study plan has been approved by the Institutional ethics committee (animal models), North-Eastern Hill University, Shillong, India vide reference No. IEC/MS/Misc./21, 3-12-20.

Nest structure and population study

A total of 15 nests of these weaver ants were collected for further study. The nest size was calculated, taking the average length and breadth of the nests from three locations, as shown in Fig 2. The height was also measured, and the area/size (cm^3) of the nest was calculated as length x breadth x height (l x b x h) (Fig 2). The number of queens, worker ants, larvae, and pupae were recorded to know the population in a nest. The number of chambers in the nest and leaves utilized for nest construction was also recorded.

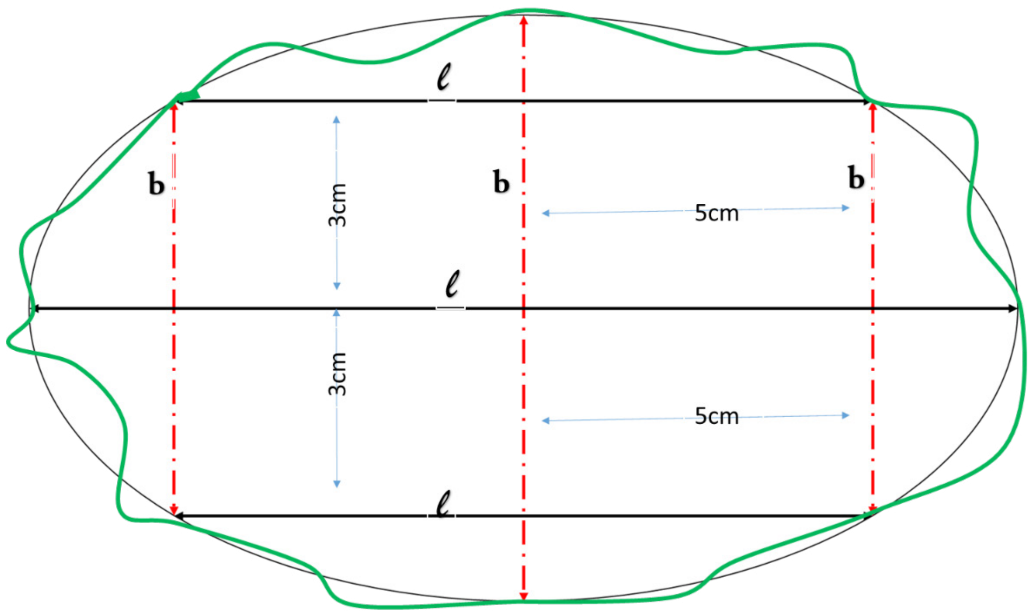

Fig 2. Diagrammatic representation of a nest and the location of the measurement taken for nest area.

Nesting and foraging activity

Nest building behavior was observed four times a day, i.e., morning at 8.0 a.m., afternoon at 1.0 p.m., evening at 6.0 p.m., and at night at 9.0 p.m.in the field for ten days. Related activity such as hunting or foraging and interactions with scale insects was also observed during that time.

Statistical analysis

Pearson correlation, Analysis of Variance (ANOVA), and Principal Component Analysis (PCA) were used as statistical tools to analyse the data and establish a correlation between different variables.

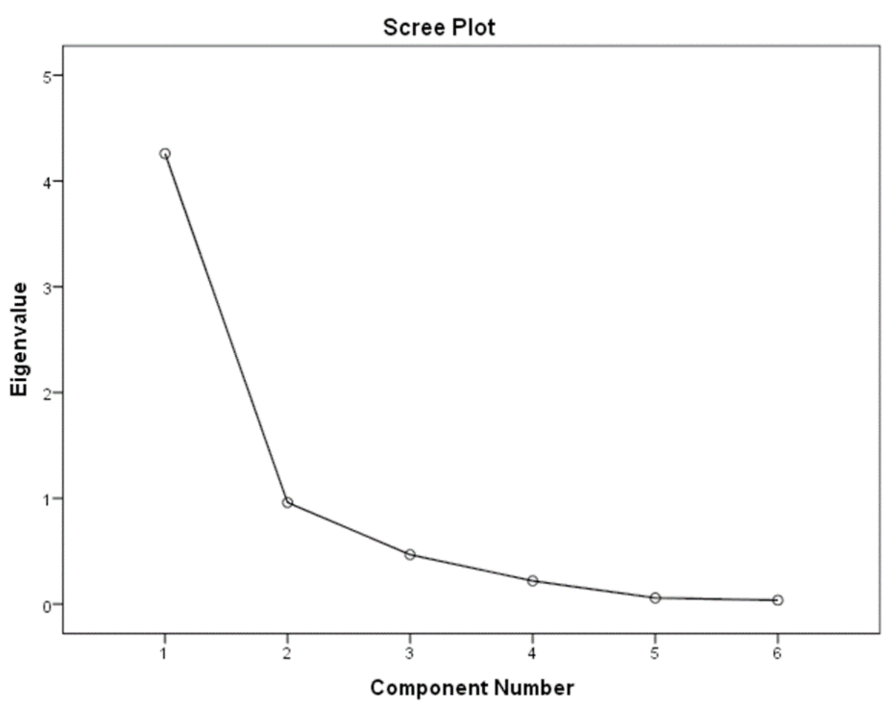

Fig 3. Scree plot showing all components. The first principal component explains about 71% of nest size, the second and the third principal components explain about 16% and 8% respectively, accounting for 95% of the cumulative variation.

Results

Nesting trees and nest spatial location

The *O. smaragdina* nests were found on mango trees (*Mangifera indica*), litchi tree (*Litchi chinensis*), jackfruit tree (*Artocarpus heterophyllus*), needlewood trees (*Schima wallichi*), and a few in other trees. Compared to other trees, the nests of these weaver ants were found abundantly in *Schima wallichi* or the needlewood trees locally known as 'diengngan'. The approximate height of the trees where the nests were found ranged from 4-25 m. Regarding the location of nests in the multidimensional spatial hypervolume, we found that the average nest height from the ground was about 6 m. We found the distance of the nest from the needlewood trees central trunk ranging from 0.7-3.4 m (Table 1).

Table 1. Demographic details of *O. smaragdina* nests on needlewood trees in Ri-Bhoi district of Meghalaya.

Sample nest	Nest size Dimensions (cm) (l × b × h)	Area/size of the nest (cm^3)	Height of the nest from the ground (m)	Distance of the nest from the central trunk (m)	No. of leaves utilized for nest construction	No. of chambers	Population of *Oecophylla smaragdina*
1	25×15×15	5625	4.6	2.5	19	17	2850
2	10×5×8	400	4.5	0.7	7	5	979
3	30×15×17	7650	5.5	3	25	21	3321
4	15×14×10	2,100	3.7	2.3	10	6	1866
5	15×20×10	3,000	4.3	1	13	7	2031
6	20×17×11	3,740	4.9	2.6	15	13	4429
7	10×12×6	720	4.3	1.7	6	16	1896
8	20×18×16	5,760	4.3	2.5	14	15	4164
9	60×31×30	55800	4.4	3.1	53	45	8563
10	50×25×19	23750	10.7	3.4	48	38	9211
11	40×25×15	15000	8.5	2.9	41	32	8712
12	18×15×14	3780	9.1	2.6	12	12	3742
13	20×15×16	4800	3.6	1.1	16	13	6348
14	21×16×18	6048	9.4	1.8	18	15	4006
15	17×15×16	4080	9.8	1.6	15	11	2627
	Mean	9483.53	6.11	2.19	20.80	17.73	4316.33

Nest structure and its population

The nest size was statistically analysed, showing a wide variation, with the smallest of 400 cm^3 and the largest being 55,800 cm^3 (Table 1). Pearson correlation coefficient analysis established that the total population, number of leaves utilized for nest construction, and the number of chambers to be positively correlated with the nest size ($r^2 = 0.731$, 0.878, and 0.885, $p \leq 0.01$, respectively) (Table 2). Data analysis using PCA (Fig 3) showed that three variables explain 95% of the cumulative variation in nest size. Thus, *O. smaragdina* population cum nest size in the first principal component, explains about 71% of the total variance. The second and third components include the number of leaves utilized and the number of chambers explaining 16% and 8% of the total variance respectively. The analysis shows that the population of *O. smaragdina*, the number of leaves utilized, and the number of chambers contribute as essential factors for nest building (Fig 4).

The nests were divided into three groups, i.e., small nests ranging from 400-4,000 cm^3, medium nests from 4,001–10,000 cm^3, and large nests ranging from 10,000 cm^3 and above. The average number of leaves used for the construction of small, medium, and large nests was 10.5 ± 3.50, 17.83 ± 3.9, and 47.33 ± 6.02 having 9.83 ± 4.44, 15.33 ± 3.44, and 38.33 ± 6.5 chambers, respectively. Similarly, the average population of the ants in these nests was 2491± 1,308.7, 386 ± 1,351.3, and 8,829 ± 339.4, respectively (Table 3).

The number of different castes of *O. smaragdina* varied in different nests (Table 4). One or more queens may be present in a single nest, and the nest without the queen is probably the satellite nest, while more queens were observed in nest 9. The highest number of worker ants, pupae, and larvae were recorded in nest 10, nest 11 and nest 9, respectively and the least number of all the castes were recorded in nest 2. Pearson correlation analysis was done to establish a relationship between the presence of a queen and the presence

Table 2. Pearson correlation (one-tailed), n = 15, showing significance at $**p \leq 0.01$ and $*p \leq 0.05$ comparing the multidimensionality of different variables.

		Approximate nest area	Height of the nest from the ground	Distance of the nest from the central trunk	No. of leaves utilized for nest construction	No. of chambers	Population of *Oecophylla smaragdina*
Approximate nest area	Pearson correlation	1	.086	.545*	.878**	.885**	.731**
	Sig. (1-tailed)		.380	.018	.000	.000	.001
	N	15	15	15	15	15	15
Height of the nest from the ground	Pearson correlation		1	.316	.346	.292	.359
	Sig. (1-tailed)			.126	.103	.146	.094
	N		15	15	15	15	15
Distance of the nest from the central trunk	Pearson correlation			1	.689**	.724**	.612**
	Sig. (1-tailed)				.002	.001	.008
	N			15	15	15	15
No. of leaves utilized for nest construction	Pearson correlation				1	.959**	.891**
	Sig. (1-tailed)					.000	.000
	N				15	15	15
No. of chambers	Pearson correlation					1	.869**
	Sig. (1-tailed)						.000
	N					15	15
Population of *Oecophylla smaragdina*	Pearson correlation						1
	Sig. (1-tailed)						
	N						15

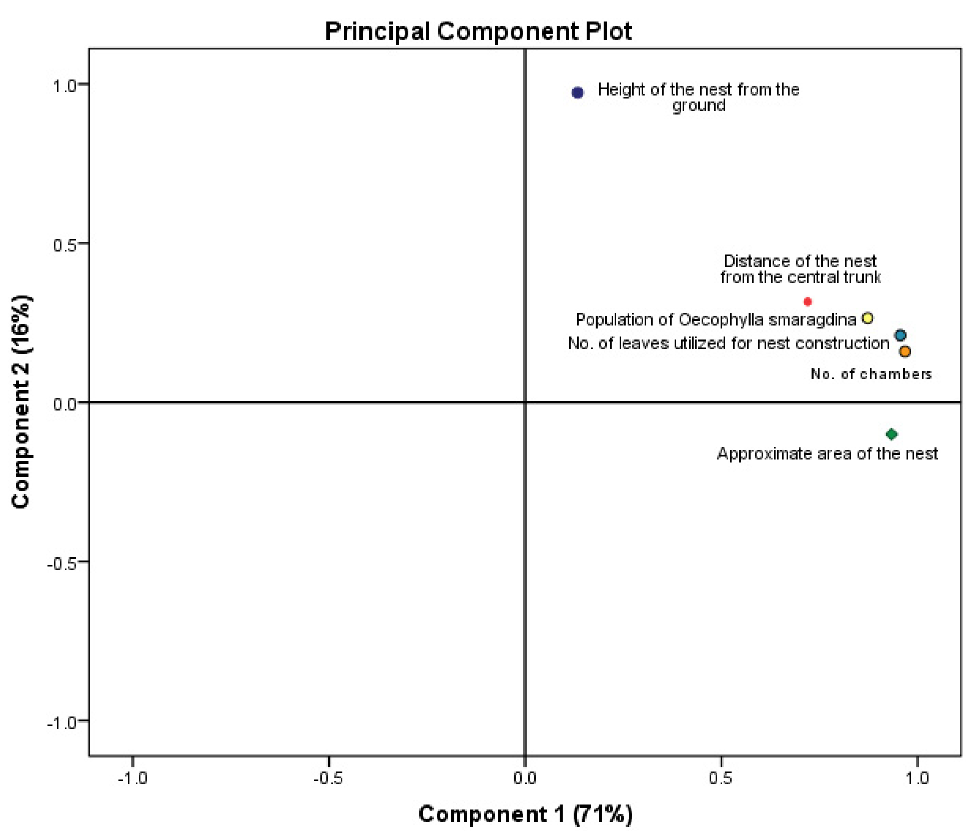

Fig 4. Principal Component plot showing important factors contributing to variations in *O. smaragdina* nest size. Component 1 explaining about 71% variation and component 2 about 16%.

Table 3. Nest size range showing the average number of leaves used, chambers and population of *O. smaragdina*. Mean ± SD, n = 6 for small and medium nest, n = 3 for large nest.

Nest category	Average nest size (cm^3)	Average number of leaves for nest construction	Average number of chambers	Average population of *Oecophylla smaragdina*
Small	400 - 4,000	11 ± 3.5	10 ± 4.4	2,491 ± 1,308.7
Medium	4,001 - 10,000	18 ± 4.0	15 ± 3.4	3,886 ± 1,351.3
Large	10,000 ≤ above	47 ± 6.0	38 ± 6.5	8,829 ± 339.4

of different castes in the nest. Pearson correlation (Table 5) shows a positive correlation between the number of queens and the number of workers ($r^2 = 0.607$), pupae ($r^2 = 0.570$), and larvae ($r^2 = 0.735$). The number of worker ants shows a positive correlation with the number of pupae ($r^2 = 0.805$) and the number of larvae ($r^2 = 0.794$). Also, the number of pupae is positively correlated with the number of larvae ($r^2 = 0.751$). However, a comparison between nests with the queen and without the queen revealed that only the number of pupae shows significant differences between the groups (Table 6).

Table 4. Details of different castes of *O. smaragdina* present per nest. The result is expressed as Mean ± SD, n = 15, *$p \leq 0.05$ and **$p \leq 0.01$ compared to the presence or absence of the queen. (The significance value was taken from Pearson correlation analysis shown in Table 5).

Sample Nest	No. of Queen	No. of worker ants	No. of pupae	No. of larvae
Nest 1	1	1375	963	511
Nest 2	0	545	327	107
Nest 3	2	1506	1498	315
Nest 4	1	788	560	517
Nest 5	0	896	763	372
Nest 6	1	1675	1250	1503
Nest 7	1	678	645	572
Nest 8	1	1540	1298	1325
Nest 9	3	3796	2589	2175
Nest 10	2	4572	2518	2119
Nest 11	1	3563	3716	1432
Nest 12	0	1855	1430	457
Nest 13	2	2536	2049	1761
Nest 14	1	2742	576	687
Nest 15	0	1796	574	257
Mean ± SD	1.07 ± 0.88	1990.87 ± 1215.59**	1383.73 ± 958.91*	940.67± 705.38**

Table 5. Pearson correlation analysis (one-tailed) showing the correlation between the different castes. **$p \leq 0.01$ and *$p \leq 0.05$, n = 15.

		No. of queen	No. of workers	No. of pupae	No. of larvae
No. of queen	Pearson correlation	1	.607**	.570*	.735**
	Sig. (1-tailed)		.008	.013	.001
	N	15	15	15	15
No. of workers	Pearson correlation	.607**	1	.805**	.794**
	Sig. (1-tailed)	.008		.000	.000
	N	15	15	15	15
No. of pupae	Pearson correlation	.570*	.805**	1	.751**
	Sig. (1-tailed)	.013	.000		.001
	N	15	15	15	15
No. of larvae	Pearson correlation	.735**	.794**	.751**	1
	Sig. (1-tailed)	.001	.000	.001	
	N	15	15	15	15

Table 6. Variation in the number of the different caste with respect to the presence or absence of the queen. ANOVA, *p ≤ 0.05, n = 15.

		Sum of Squares	df	Mean Square	F	Sig.
No. of workers	Between Groups	2810904.824	1	2810904.824	2.044	.176
	Within Groups	17876468.909	13	1375112.993		
	Total	20687373.733	14			
No. of pupae	Between Groups	2031189.388	1	2031189.388	2.436	.143
	Within Groups	10841895.545	13	833991.965		
	Total	12873084.933	14			
No. of larvae	Between Groups	2251086.402	1	2251086.402	6.207	.027*
	Within Groups	4714790.932	13	362676.226		
	Total	6965877.333	14			

Nesting behavior and foraging activity

Temperature plays a significant role in the nesting and foraging behavior of weaver ants. High activity for nesting with about 116 of these ants was observed at 9:00 pm, where the temperature was about 21 °C. Moderate activity with about 55 and 71 ants at 8:00 am and 6 pm with an average temperature of 21 °C and 25 °C respectively was noted. The least activity was observed with only eight ants at 1.00 pm, recording an average temperature at about 30 °C and above (Fig 5). The worker ants scout and locate the best spot for the nest building. Few worker ants start to bite the leaves, pull them closer, and hold them until another worker ant comes along with the larva in its mandible to glue the leaves (Fig 7). The last instar larvae are used for gluing in which the worker ant squeezes the larvae gently, and the silk is produced (Fig 7C).

The nests of *O. smaragdina* in this locality are somewhat irregular round-oval/ellipse in shape (Fig 6A, B). The nest comprises many chambers depending on different castes of the ants, food, and environmental factors. The worker ants add another layer of leaves around the nest to increase the nest size and population. As the nest ages, the leaves turn from green to pale yellow to brown (Fig 6C). Once the nest turns brown, the worker ants constructed new nests, and side by side, the broods (larvae and pupae) were shifted to the new nest. The queen moves first, followed by the broods and, lastly, the eggs. With the increase in the nest population, the worker ants also construct another nest called the satellite nest in another location of the host tree not far from the mother nest, which is a nest without a queen. This satellite nest was constructed to ease the mother nest from over-population and shift some of its broods. Major workers functioned as soldiers, few foragers, and minor workers to attend the broods.

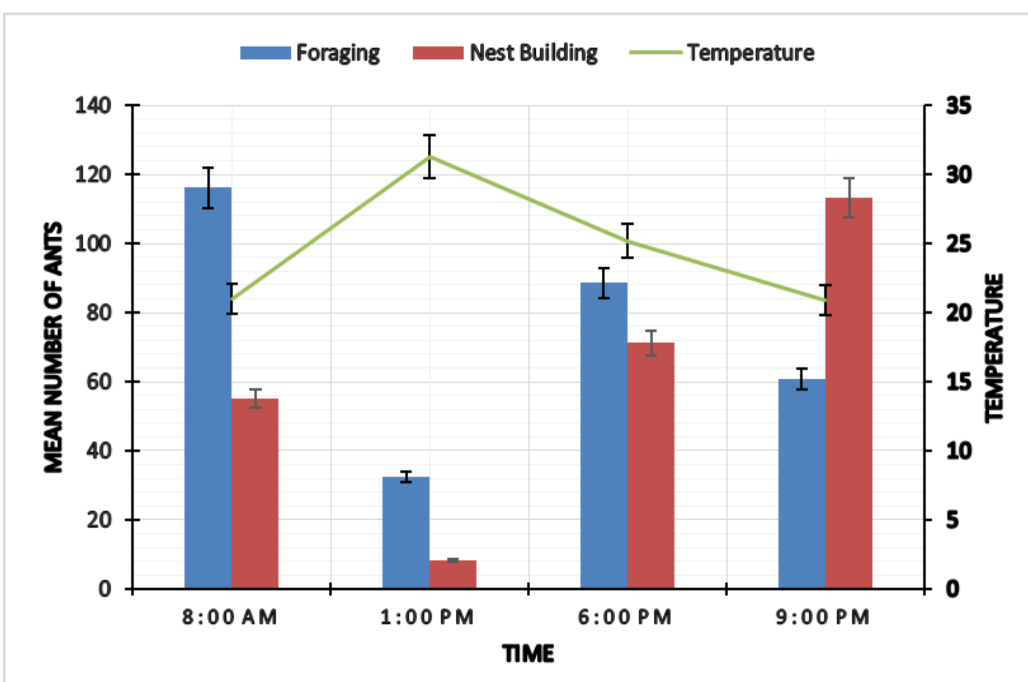

Fig 5. Relationship between temperature and the number of weaver ants performing foraging and nest building activities.

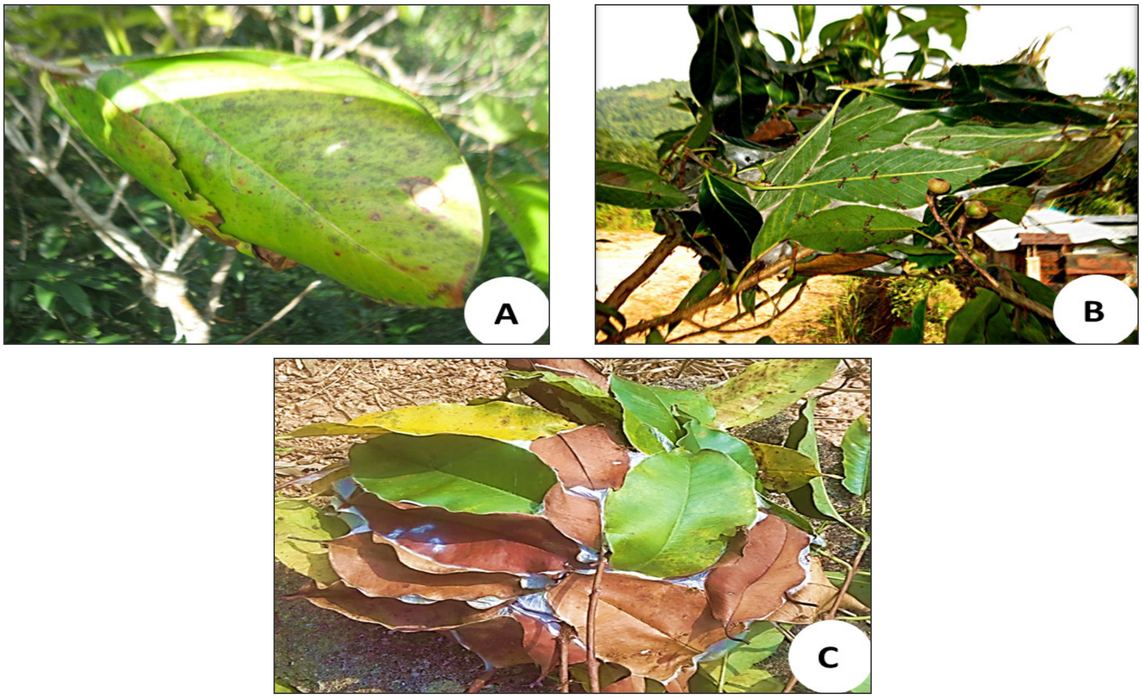

Fig 6. Representative photographs of an irregular oval-ellipse-shaped nests of *O. smaragdina* on needlewood tree (*Schima wallichi*). Smallest nest (A), large nest (B), and a nest containing pale yellow to brown leaves (C).

Apart from nest building, foraging is a critical factor of *O. smaragdina*. Their foraging action becomes very active at around 20 °C, with about 116 ants involved in foraging. As the temperature increases to about 30 °C and above, the number of foraging ants declines as only 32 ants were observed until late afternoon (Fig 5).

It was observed that the ants feed on different types of insects like cricket, grasshoppers, beetles, butterflies, flies, fly larvae, beetle grubs, earthworms, and sometimes dead rodents or birds. Foraging activity for these weaver ants is not restricted only to their host trees, but sometimes they climb down from the tree to find potential prey to feed their colony.

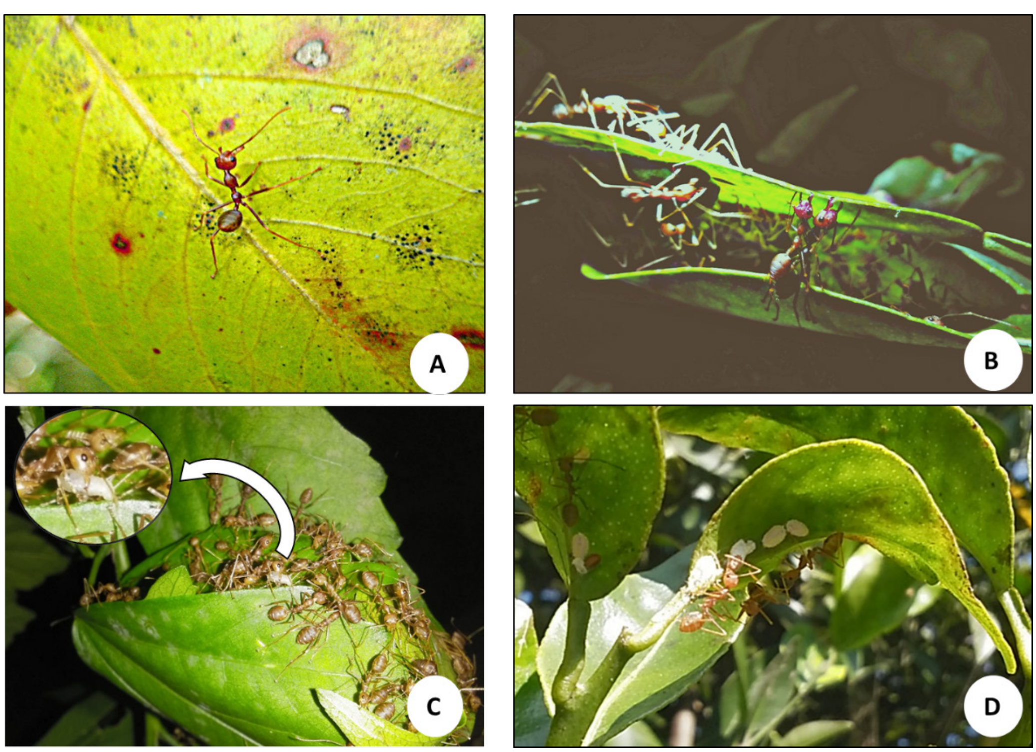

Fig 7. Representative photographs of worker ants and nest construction by *O. smaragdina* in needlewood tree. (A) Individual worker ant, (B) Worker ants pulling the leaves together, (C) worker ants squeezing the larva during nest construction, and (D) weaver ants tending the scale insects (hemipterans).

Discussion

The elucidation of the population dynamics and nesting details of *O. smaragdina* in a particular region should have a direct beneficial impact as these ants have been used as bio-control agents in agricultural pest management (Peng & Christian, 2005; Offenberg et al., 2013), food and traditional medicines (Jena et al., 2020). Weaver ants generally thrive in warm and humid climatic conditions with an average temperature of 20-30 °C (Crozier, 2010; Bharti & Silla, 2011). They are found in almost all kinds of trees with moderate to large-sized leaves, which are easier to pull and provide good shelter for nesting. In the Ri-Bhoi district of Meghalaya, the temperature range of 18-32 °C and an annual rainfall of 1267 mm may be a perfect condition for these weaver ants to flourish.

The *O. smaragdina* nests were found on mango trees (*Mangifera indica*), litchi tree (*Litchi chinensis*), jackfruit trees (*Artocarpus heterophyllus*), and needlewood trees (*Schima wallichi*). They are more abundant in *S. wallichi* trees due to the leaves that can be easily drawn for nest expansion. Their large number of leaves may provide good camouflage from predators such as birds and an excellent cover from adverse environmental factors like heavy rain, hailstones. The height of these trees should also be suitable to receive accessible sunlight. The suitability for the activity and population of *O. smaragdina* may depend on the geographic location and vegetation. The high abundance of *O. smaragdina* was documented on *Pongamia pinnatta*, *Zizyphys mauritiana*, *Eucalyptus platyphylla*, and *Canarium australianum* in northern Australia. It was suggested that the vegetation depending on the seasonality of rainfall, dry tropical climate, and average temperature, play a significant role in the distribution, colony structure, and activity of the green ant *O. smaragdina* (Lokkers, 1990). Population dynamics of *O. smaragdina* on two trees, *Prunus dulcis* and *Morinda citrifolia,* in Annamalai University, Tamil Nadu, India, showed that in *Prunus dulcis,* the highest number of the green nest, dry nest and leaf pavilion were found in April, May and March, respectively. In *Morinda citrifolia,* most green and dry nests were found in July and October (Nalini & Ambika, 2019). In a study on *Oecophylla longinoda* in Tanzania, more weaver ants were recorded during cashew vegetative and reproductive phases than dormancy. Rainfall and temperature negatively affected the number of nests, while relative humidity was negatively related to shoots with weaver ants (Nene, 2016).

The average nest height from the ground was about 6 m and, from the central trunk, the nearest distance of the nest is about 0.7 m and the farthest up to 3.4 m (Table 1). The approximate height of the tree where the nests were found ranged from 4-25 m. This height and distance of the nests should be suitable for better living of the weaver ants in the climatic condition of the Ri-Bhoi district. The study on the ecology and behavior of the other weaver ant *Camponotus* (*Myrmobrachys*) *senex* in Brazil showed that the weaver larvae have a fundamental function in nest building. The nests were always arboreal (one nest/plant), with a round form, beige in color, and leaves and shoots adhered to the silk nest. The average size and weight of the nests was 34.24 cm and 163.87g respectively. The nests contained up to 50,000 individuals and several queens (Santos & Del-Claro, 2009).

Like other social ants, *O. smaragdina* comprises different castes such as the queen, workers, pupae, larvae, and the eggs (Table 4). These weaver ants are known for their unique ability to construct nests above the ground on the trees. It was noted that the first nest is built with only one or two leaves by the queen by folding the leaves together then glued them using their first batch of larvae, and later when the first batch emerges as adult workers, they take over all the roles from nest building to feeding and hunting (Crozier, 2010). The worker ants are differentiated into major and minor workers based on their sizes (Bharti & Silla, 2011). We also observed that the leaves of the host trees are used for building their nests, and the leaves are pulled by the worker ants and glued together using their larval silk (Fig 6, 7). While gluing, the worker ants hold the larva at a specific place and squeeze the larva to secrete silk (Fig 7). In the case of another weaver ants, *Camponotus (Myrmobrachys) sensex,* Santos and Del-Claro (2009) categorized nests into two groups, small and medium, while Bharti & Silla (2011) categorized these nests into three groups, small, medium, and large. In the present study, based on the nest size, the nests were categorized into three groups to examine the variation in the number of leaves utilized and the number of chambers built in different groups (Table 3). As the population of the weaver ants and nest size increase with time, the leaves die to turn their color from green to pale yellow and finally to brown (Fig 6C).

These weaver ants form long chains to pull the leaves far towards the nest for its expansion (Bharti & Silla, 2011). The number of chambers present in the nest also plays a vital role in increasing the ants' population. It was observed that the average number of chambers built in the nests is about 17 (Table 1). It was noted that these weaver ants utilize a certain number of leaves for nests of different sizes (Table 1). The weaver ants population and number of leaves utilized in nest building are positively correlated since the increase in population is followed by an increase in the number of leaves and chambers in a nest. The study shows that the average number of leaves utilized for nest construction is about 20 (Table 1).

The Scree plot (Fig 3) indicates three components whereby the first principal component explains about 71% variance in nest size. The second and the third principal components explain about 16% and 8%, respectively, leading to a cumulative variance of 95%. These three components are the population of *O. smaragdina*, the number of leaves utilized for nest building and the number of chambers. The study also showed that the approximate area of the nest is influenced by the number of leaves utilized for nest construction, the number of chambers, and the total population (Table 2).

Pearson correlation analysis showed a positive correlation between the number of queens and the number of larvae. In contrast, the number of queens in the nest showed less significance with the number of worker ants and pupae. Moreover, the number of queens influences the number of larvae, which affects the number of pupae and worker ants (Table 5). However, a comparison between nests with and without the queen showed that only the number of larvae has significant differences between the groups (Table 6), confirming the positive correlation between the number of queens with the number of larvae. The nest-building behavior of these weaver ants is greatly affected by the temperature. The present study shows that the number of ants and nest-building activity increases when temperatures are between 20-25 °C (Fig 5).

Along with nest building, foraging activity is an important factor in the living *O. smaragdina*. Their foraging activity becomes elevated at around 20 °C, with about 116 ants involved in foraging. As the temperature increases to about 30 °C and above, the number of foraging ants declines since only 32 ants were observed until late afternoon (Fig 5). It was observed that the weaver ants feed on different types of insects, fly larvae, beetle grubs, earthworms, and sometimes dead birds. The study on *O. smaragdina* in Malaysia revealed that food higher in protein content was highly preferred by *O. smaragdina* than food with lipid and carbohydrate contents. The foraging activity of the *O. smaragdina* was significantly influenced by both temperature and relative humidity. Thus, the weaver ants respond to different food and indirectly, forming a strategic foraging activity to maximize the food supplies for their colony (Pimid et al., 2019). A large number of sensilla supports the workers' role in foraging activity compared to other castes (Barsagade et al., 2020).

When the nest turns brown, the worker ants start building a new nest to transfer the host colony and the queen. It was also observed that these weaver ants build multiple nests when the population increased, expanding their territory and reducing the stress of only one nest (Holldobler, 1983). These nests are called satellite nests, in which weaver ants look after brood till they hatch. Only worker ants live in some of these satellite nests, and when threatened, these worker ants come out in large numbers and defend their colony. The findings from the present study documenting the immense population and specific nesting behavior of the weaver ants *O. smaragdina* in this region could be very useful as an alternative source of food and medicine for human society.

The findings from the present study documented that *O. smaragdina* nest structure is more explained by the population size and caste structure than by their location on the spatial hypervolume (height from the ground and distance from main trunk) on trees. Regardless of nest size, the study allowed to verify that *O. smaragdina* can spread their nests over almost all the vertical and horizontal axis of a tree. This is an important information when thinking of using this species as biocontrol agent in tree orchards. There was a direct influence of temperature on the foraging activity of *O. smaragdina*. The ants forage on the coolest hours of the day. This is also an important information for the conservation of this species in agricultural/orchard fields because technical recommendations for spraying insecticides indicate sprayings in the coolest hours. This hazardous recommendation should be carefully employed in cultivated areas with the presence of *O. smaragdina* nests.

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References

Barsagade, D.D., Masram, P.D. & Nagarkar, D.A. (2020). Surface ultra-structural studies on antennae in polymorphs of weaver ant *Oecophylla smaragdina*; *Fabricius* (Hymenoptera: Formicidae) with reference to sensilla. Indian Journal Agricultural Research, 54: 555-562. doi: 10.18805/IJARe.A-5411

Bharti, H. & Silla, S. (2011). Notes on life history of *Oecophylla smaragdina* (Fabricius) and its potential as biological control agent. Halteres, 3: 57-64.

Chakravorty, J., Ghosh, S. & Meyer-Rochow, V.B. (2011). Practices of entomophagy and entomotherapy by members of the Nyishi and Galo tribes, two ethnic groups of Arunachal Pradesh (North-East India). Journal of Ethnobiology and Ethnomedicine, 7: 5-18. doi: 10.1186/1746-4269-7-5

Cole, A.C. & Jones, J.W. (1948). A study of the weaver ant, *Oecophylla smaragdina* (Fab.). American Midland Naturalist, 39: 641-651.

Crozier, R.H., Newey, P.S., Schlüns, E.A. & Robson, S.K.A. (2010). A masterpiece of evolution-*Oecophylla* weaver ants (Hymenoptera: Formicidae). Myrmecological News, 13: 57-71.

Dey, S. (2013). Nutritive value of wild edible insects of Meghalaya. Ph.D. Thesis, North-Eastern Hill University, Shillong. Shodhganga, pp 48-172. http://hdl.handle.net/10603/169754

Holldobler, B. (1983). Territorial behavior in the green tree ant (*Oecophylla smaragdina*). Biotropica, 15: 241-250. doi: 10.2307/2387648

Itterbeeck, J.V., Sivongxay, N., Praxaysombath, B. & Huis, A.V. (2014). Indigenous knowledge of edible weaver ants *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae) from Vientiane Plain, Lao PDR. Ethnobiology Letter, 5: 4-12. doi: 10.14237/ebl.5.2014.125

Jena, S., Das, S.S. & Sahu, H.K. (2020). Traditional value of red weaver ant (*Oecophylla smaragdina*) as food and medicine in Mayurbhanj district of Odisha, India. International Journal for Research in Applied Science & Engineering Technology. 8: 936-946. doi: 10.22214/ijraset.2020.5148

Langthasa, S., Teron, R. & Tamuli, A.K. (2017). Weaver ants (*Oecophylla smaragdina*): a multi-utility natural resource in Dima Hasao district, Assam. International Journal Applied Environmental Sciences, 12: 709-715.

Lokkers, C. (1990). Colony dynamics of green tree ant (*Oecophylla smaragdina* Fab.) in seasonal tropical climate. Ph. D Thesis, James Cook University of North Queensland, Townsville, Queensland, Australia. 301pp, https://researchonline.jcu.edu.au/24114/

Nalini, T. & Ambika, S. (2019). Studies on population dynamics of weaver ant, *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae) nests in *Prunus dulcis* and *Morinda citrifolia*. Plant Archives, 19: 2018-2020.

Nene, W.A. (2016). Aspects of ecology of weaver ants (*Oecophylla longinoda* Latreille) (Hymenoptera: Formicidae) in Tanzania. Ph.D. thesis, Sokoine University of Agriculture. Morogoro, Tanzania. 123 pp.

Offenberg, J., Cuc, N.T.T. & Wiwatwitaya, D. (2013). The effectiveness of weaver ant (*Oecophylla smaragdina*) biocontrol in Southeast Asian citrus and mango. Asian Myrmecology, 5: 139-149.

Peng, R. K. & Christian, K. (2005). Integrated pest management in mango orchards in the Northern Territory Australia, using the weaver ant, *Oecophylla smaragdina*, (Hymenoptera: Formicidae) as a key element. International Journal of Pest Management, 51: 149-155. doi: 10.1080/09670870500131749

Pimid. M, Ahmad, A. H., Krishnan, K. T. & Scian, J. (2019). Food preferences and foraging activity of Asian weaver ants, *Oecophylla smaragdina* (Fabricius) (Hymenoptera: Formicidae). Tropical Life Sciences Research, 30: 167-179. doi: 10.21315/TLSR2019.30.2.12

Rastogi, N. (2011). Provisioning services from ants: food and pharmaceuticals. Asian Myrmecology, 4: 103-120.

Santos, J.C. & Del-Claro, K. (2009). Ecology and behaviour of the weaver ant *Camponotus (Myrmobrachys) sensex*. Journal of Natural History, 43: 1423-1435. doi: 10.1080/00222930902903236

Teron, R. (2019). Cross-cultural ethnobotanical exploration of diversity and utilization of medicinal plants in Karbi-Anglong District, Assam, Northeast India. NeBio, 101: 35-46.

Tragust, S. (2016). External immune defence in ant societies (Hymenoptera: Formicidae): the role of antimicrobial venom and metapleural gland secretion. Myrmecological News, 23: 119-128. doi: 10.25849/myrmecol.news_023:119

Weber, N.A. (1946). Dimorphism in the African *Oecophylla* worker and an anomaly (Hymenoptera: Formicidae). Annals of the Entomological Society of America, 39: 7-10. doi: 10.1093/aesa/39.1.7

Wetterer, J.K. (2017). Geographic distribution of the African weaver ant, *Oecophylla longinoda*. Transactions of the American Entomological Society, 143: 501-510. doi: 10.31 57/061.143.0215

Wilson, E.O. & Taylor, R.W. (1964). A fossil ant colony: new evidence of social antiquity. Psyche, 71: 93-103.

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