ORIGINAL ARTICLE

The ant nest of *Crematogaster rogenhoferi* (Mayr, 1879) (Hymenoptera: Formicidae) at Tarutao National Park, Satun Province, Southern Thailand

Suparoek Watanasit[1] and Sopark Jantarit[2]

Abstract

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The ant nest of *Crematogaster rogenhoferi* (Mayr, 1879) (Hymenoptera: Formicidae) at Tarutao National Park, Satun Province, Southern Thailand
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Nests of the ant *Crematogaster rogenhoferi* (Mayr, 1879) were investigated at Tarutao National Park, Satun Province. Fifteen ant nests were selected at random along Phante Malacca Bay between the 2-7 March 2004. They built their nests from leaf and stick debris on branches of trees, at between 248-469 cm above the ground level. The vegetation on which nests were built was composed of 5 species: *Vitex pinnata* L., *Olea salicifolia* Wall, *Syzygium gratum* (Wight), *Ardisia elliptica* Thum and one unknown species. The physical features of each nest were recorded. The average dimensions of the nest width and length were 10.65±2.57 cm and 22.10±1.22 cm, respectively.

Each nest was cut into small pieces for counting the numbers of each caste and developing stages. The results showed that the average number of queens, winged females, males and workers in each nest were 1.53±0.38, 1,753.33±506.55, 4,970.67±2,227.00, 15,577.93±2,637.84 respectively, while the developing stages of pupae, larvae, eggs were 1,589.93±480.37, 4,113.20±1,469.49 and 1,942.80±741.67 respectively. Thus the total number of ants in the population in each nest was 29,949.40±5,358.31.

The relationships between the number of castes, developing stages and physical features of the nests were explored. The Spearman Rank Correlation indicated that the width of nest positively correlated with the number of queens (r_s = 0.862, p = . 000), winged females (r_s = 0.691, p = 0.004) and workers (r_s = 0.667, p = 0.007). A comparison of the effects of vegetation types on the number of castes and development stages,

[1]M.Sc.(Zoology), Assoc.Prof., [2]Master student in Ecology, Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, 90112 Thailand
Corresponding e-mail: suparoek.w@psu.ac.th
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showed that vegetation type did have an influence but only on the number of the worker caste (F = 7.712, P = 0.011, one-way ANOVA). Most workers were associated with nests from *Vitex pinnata*. No nests were found on the dominant tree species of the area probably due to its ability to produce an insect repellant oil.

Key words : *Crematogaster rogenhoferi*, Tarutao National Park, nest, castes, vegetation, physical features

บทคัดย่อ

ศุภฤกษ์ วัฒนสิทธิ์ และ โสภาค จันทฤทธิ์

รังของมดก้นรูปหัวใจ *Crematogaster rogenhoferi* (Mayr, 1879) (Hymenoptera: Formicidae) ณ อุทยานแห่งชาติตะรุเตา จังหวัดสตูล ภาคใต้ของประเทศไทย

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สุ่มเก็บตัวอย่างรังของมดก้นรูปหัวใจ *Crematogaster rogenhoferi* (Mayr, 1879) ที่ทำรังอยู่ตามกิ่งไม้ของป่าชายหาดของอ่าวพันเตมะลากา อุทยานแห่งชาติตะรุเตา จังหวัดสตูล ระหว่างวันที่ 2-7 มีนาคม 2547 จำนวน 15 รัง รังของมดจะเอาวัสดุใบไม้ และกิ่งไม้มาทำเป็นรัง ที่อยู่สูงจากพื้นดิน 248-469 ซม. พืชที่มดทำรังประกอบด้วย 5 ชนิด ได้แก่ ต้นตีนนก (*Vitex pinnata* L.) ต้นมวกกอ (*Olea salicifolia* Wall) ต้นเสม็ดแดง (*Syzygium gratum* (Wight)) ต้นราม (*Ardisia elliptica* Thum) และไม่ทราบชื่อ 1 ชนิด ซึ่งขนาดของรังมีความกว้างและความยาว 10.65±0.81 ซม. และ 22.10±1.22 ซม. ตามลำดับ

เมื่อทำการแยกและนับประชากรของวรรณะต่าง ๆ ของมดในแต่ละรัง พบราชินีมด วรรณะสืบพันธุ์เพศเมีย มดเพศผู้ มดงาน มีค่าเฉลี่ย 1.53±0.38, 1,753.33±506.55, 4,970.67±2,227.00 และ 15,577.93±2,637.84 ตามลำดับ สำหรับดักแด้ ตัวอ่อน และไข่ภายในรังมีจำนวนเฉลี่ย 1,589.93±480.37, 4,113.20±1,469.49 และ 1,942.80±741.67 ตามลำดับ รวมจำนวนเฉลี่ยประชากรของมดก้นหัวใจในแต่ละรัง 29,949.40±5,358.31

เมื่อศึกษาความสัมพันธ์ระหว่างวรรณะต่าง ๆ ของมด และระยะต่าง ๆ ของการเจริญเติบโต กับลักษณะของรัง โดยใช้การวิเคราะห์สัมประสิทธิ์สหสัมพันธ์ พบว่าความกว้างของรังมีความสัมพันธ์ในเชิงบวกกับจำนวนตัวของราชินี (r = 0.862, p = 0.000), วรรณะสืบพันธุ์เพศเมีย (r = 0.691, p = 0.004) และมดงาน (r = 0.667, p = 0.007) นอกจากนั้นได้ทำการเปรียบเทียบผลของพืชอาศัยของมดที่ใช้ทำรังโดยใช้การวิเคราะห์ความแปรปรวนแบบทางเดียว พบว่า พืชอาศัยที่มดใช้ทำรังมีผลต่อจำนวนตัวของมดงานอย่างเดียวอย่างมีนัยสำคัญ (F = 7.712, P = 0.011, one-way ANOVA) โดยมดงานจะทำรังในต้นตีนนกมากกว่าพืชอาศัยอื่น ๆ ไม่พบมดทำรังในต้นไม้ที่เป็นไม้เด่นของป่าชายหาดทั้งนี้อาจเนื่องพืชนั้นได้สร้างสารที่ใช้ไล่แมลง

ภาควิชาชีววิทยา คณะวิทยาศาสตร์ มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่ สงขลา

Ants are eusocial insects. They live in a colony consisting of 4 different castes: queens, reproductive females, males and workers (Hölldobler and Wilson, 1990). Ants can build their nests in soil, rotten logs, under bark and on tree trunks (Shattuck, 1999). Ants are important not only because of their diversity (Alonso *et al*., 2000) but also because of their functions in the earth's ecosystem (Maryati, 1996).

Tarutao National Park was established in 1974 as the first marine park in Thailand. The main area of the park is tropical forest and it is rich in wildlife both flora and fauna (Pate, 1990). The diversity of ants in the park has been previously surveyed (Watanasit *et al*., 2003) and it was established that the ant genus *Crematogaster* was the dominant group, especially *Crematogaster rogenhoferi* (Mayr, 1879). They build their nests

on the tree trunks along Pante Malacca beach of the park headquarters. However, there is some doubt about its biology.

There have been many studies of the populations of ants such as *Myrmecocystus mendax* (Conway, 2003); *Crematogaster* sp. (Nielsen, 2000) and *Crematogaster ashmeadi* Emery (Tschinkel, 2002). These studies indicated that different ant species had different numbers of castes and developing stages in their nests.

The population density of ants depends on many environmental factors both physical and biological. These factors include food, habitat, predator and environmental change (Hölldobler and Wilson, 1990; Kaspari and Majer, 2000). Thus, environmental factors play an important role in the population density of ants.

Ants and plants have coevolved over a long period of time (Speight *et al*., 1999) so ants and their host plant are often species specific. (Tobin, 1995). For example, the *Crematogaster* ant is specific for the *Macaranga* plant (Hölldobler and Wilson, 1990; Fiala *et al*., 1999), pine trees (Tschinkle, 2002) and also the Acacia (Palmer *et al*., 2000). The conclusion from this is that the *Crematogaster* ants can build their nests in different plant species.

The aims of this study were to characterise the population structure of the colonies of *Crematogaster rogenhofer* (Mayr, 1879), to determine any correlation between a nest size and the number of castes and developing stages and also to examine the effect of vegetation on the population density of the ant nests. This will provide a data base for further studies.

Materials and Methods

a. Study site

This study was carried out in the Tarutao National Park at Phante Malacca Bay, which is the park headquarters (see Watanasit *et al*., 2003).

b. Sampling procedures

Fifteen nests of *Crematogaster rogenhoferi* were randomly collected at day time between 2-7 March 2004 from the tree trunks. The height above ground of all the ant nests was measured and recorded then the nests were cut from the tree branches with trimming scissors. Each nest was then placed in a plastic bag and brought back to the mobile laboratory at Tarutao National Park. Ethyl acetate was added to kill the ants and the length and width of each nest were also recorded.

The length was measured from end to end of each nest, while the width was measured at 3 points: base, middle and terminal area. The average of these 3 values was calculated and this represents the width. The ant nests were dissected for classifying and counting the different castes and developing stages of each colony. They were preserved in 70% ethyl alcohol. Samples from the host plants from which the nests were collected were brought back to Department of Biology, Faculty of Science, Prince of Songkla University for further identification.

c. Data analysis

The Spearman rank correlation coefficient was applied to find correlations between the physical feature of the nests and the number of castes, and development stages. One-way ANOVA was used to compare the mean values of the numbers of castes and developing stages to the vegetation types. Calculations were performed on SPSS for Windows Version 11.

Results

a. Number of population

The average population number of ants per nest was 29,949.40±5358.31 individuals (table 1). The numbers of ants in each caste (Figure 1 a-d) and in the developing stages was determined (Figure 1 e-g). The results showed that the average number of individual queens, winged females, males and workers in each nest were 1.53±0.38, 1,753.33±506.55, 4,970.67±2,227.00, 15,577.93± 2,637.84 respectively, while the developing stages of pupae, larvae, eggs were 1,589.93±480.37, 4,113.20±1,469.49 and 1,942.80±741.67 respectively.

Table 1. The population number, nest sizes of *Crematogaster rogenhoferi* (Mayr, 1879) and vegetation type that ants built their nests on at Phante Malacca Bay, Tarutao National Park, between 2-7 March 2004.

Nest	Numbers of castes				Numbers of developing stages			Above ground (cm.)	Nest size		Total population	Type of plant for built nest
	Queen	Winged female	Male	Worker	Pupa	larva	egg		Length (cm.)	width (cm.)		
1	0	1,597	0	6,537	575	145	179	285	19	6.83±1.46	9,033	*Ardisia elliptica*
2	0	140	5,253	5,910	1,466	168	195	248	26	6.33±1.53	13,132	*Olea salicifolia*
3	0	8	1,108	1,918	3	0	0	336	18.2	9.63±4.22	3,037	*Olea salicifolia*
4	1	0	245	1,217	6	24	27	431	25.2	10.80±3.37	1,520	*Olea salicifolia*
5	3	4,636	0	35,662	2,242	778	6	291	27.3	18.77±2.43	43,327	*Vitex pinnata*
6	1	50	0	9,263	3,121	8,111	5,757	380	17.6	9.30±2.46	26,303	*Syzygium gratum*
7	1	873	3	20,309	5,634	17,638	8,819	335	18.4	9.77±2.42	53,277	*Syzygium gratum*
8	0	0	1	5,184	1,254	316	7	398	14.2	6.43±1.30	6,762	*Syzygium gratum*
9	3	4,066	3	17,301	453	701	28	358	17.2	12.23±2.67	22,555	*Vitex pinnata*
10	1	841	6,084	27,746	5,433	8,672	4,867	357	24.3	11.10±3.39	53,644	*Vitex pinnata*
11	3	2,099	2,770	21,116	1,447	4,711	2,100	325	22.1	10.60±2.69	34,246	unknown
12	0	0	21,181	19,010	1,988	1,859	0	365	21.6	10.67±3.63	44,038	*Vitex pinnata*
13	4	5,875	9,695	23,743	0	3,931	1,618	398	25.2	14.20±2.82	44,866	*Vitex pinnata*
14	3	3,453	28,212	15,765	218	14,588	5,516	469	23.1	11.57±1.56	67,755	*Olea salicifolia*
15	3	2,662	5	22,988	9	56	23	345	32.2	10.38±2.67	25,746	*Ardisia elliptica*
Total	23	26,300	74,560	233,669	23,849	61,698	29,142	5,348	331.6	159.75±38.55	449,241	
$\overline{X}$ ±se	1.53±0.38	1,753.33± 506.55	4,970.6± 2,227.00	15,577.93± 2,633.89	1,589.93± 480.37	4,113.20± 1,469.44	1,942.80± 741.67	354.7± 14.70	22.10± 1.22	10.65±0.81	29,949.40± 5,358.31	

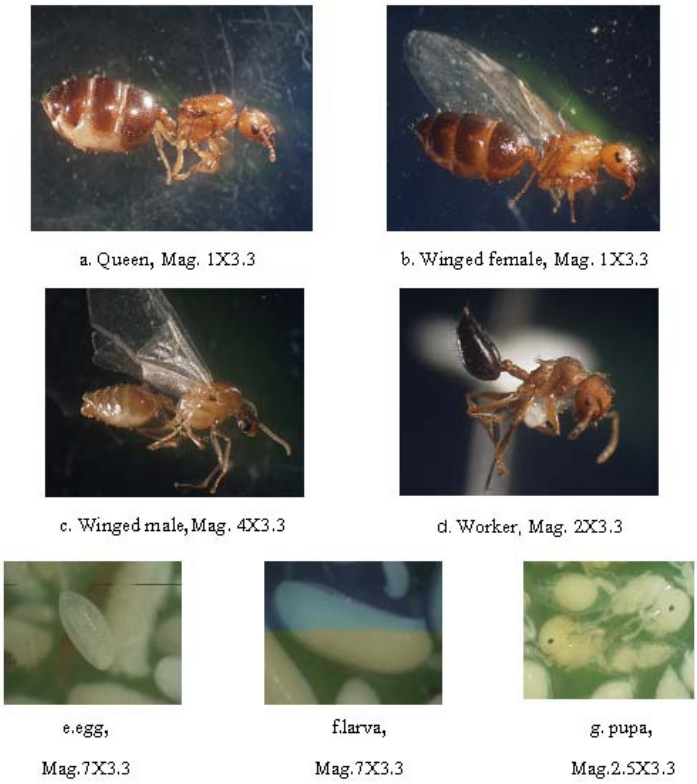

Figure 1. Castes and developmental stages of *Crematogaster rogenhoferi.*

b. Relationship between physical feature of ant nest and the individual numbers of ant castes and developmental stages

The average height of each ant nest above the ground was 354.73±14.70 cm. The dimensions of width, length, and height above ground were termed the physical features used for analysis. The average dimensions of the nest width and length were 10.65±2.57 and 22.10±1.22 cm respectively (Table 1). Spearman rank correlation coefficients between these physical features and the individual numbers of castes and developing stages are shown in Table 2. Only the nest width had a positive correlation with the queens (r_s = 0.862, p = 0.000), winged females (r_s = 0.691, p = 0.004) and workers (r_s = 0.667, p = 0.007).

c. Preference of vegetation types on the individual numbers of each caste and developing stages

Nests were found in 5 species of trees: *Vitex pinnata* L 5/15; *Olea salicifolia* Wall 4/15; *Syzygium gratum* (Wight) 3/15; *Ardisia elliptica* Thum 2/15 and one unknown species (Table 1).

The mean numbers of castes and ant developing stages were compared among vegetation types (Table 3). The results indicated that the vegetation type had a significant influence on only the numbers of the worker caste (F = 7.712, P = 0.011, one-way ANOVA, Table 4).

Discussion

a. Number of population

In this study the ant population numbers of *Crematogaster rogenhoferi* ranged from 1,520 to 67,755 individuals/nest (Table 1) because there were some ants leaving the nests for foraging outside. More than one queen could occupy a colony and the population of workers was always much greater than the rest of the castes. This is not surprising because workers are sterile females

Table 2. Spearman rank correlation (r_s) and p-value between the various physical features of ant nests and the individual numbers of castes and developing stages of *Crematogaster rogenhoferi* (Mayr, 1879) at Tarutao National Park.

Factors	Castes and developing stages	r_s	p
Width	Queen	.826	**.000***
	Winged female	.691	**.004***
	Male	.221	.043
	Worker	.667	**.007***
	Pupa	-.241	.386
	Larva	.198	.478
	Egg	-.070	.805
	Total	.472	.076
Length	Queen	.385	.157
	Winged female	.357	.192
	Male	.312	.257
	Worker	.436	.104
	Pupa	-.136	.629
	Larva	-.122	.666
	Egg	-.063	.825
	Total	.213	.447
Height	Queen	.236	.397
	Winged female	-.160	.570
	Male	.318	.248
	Worker	-.186	.507
	Pupa	-.359	.188
	Larva	.179	.524
	Egg	.068	.810
	Total	.127	.652

*** = significant**

Table 3. The mean value ± se of the individual caste numbers, developmental stages of *Crematogaster rogenhoferi* (Mayr, 1879) on vegetation types at Tarutao National Park.

Castes and developmental stages	Vegetation		
	Vitex pinnata L. (n=5)	*Olea salicifolia* (n=4)	*Syzygium gratum* (n=3)
Queen	2.20±0.73	1.00±0.71	0.67±0.33
Winged female	3,083.60±1,133.68	900.25±851.52	307.67±283.03
Male	7,392.60±3,914.01	8,704.50±6,593.72	1.33±0.88
Worker	24,692.40±3,297.58	6,202.50±3,350.86	11,585.33±4,517.98
Pupa	2,023.20±9,54.85	423.25±351.21	3,336.33±1,268.97
Larva	3,188.20±1,489.73	3,695.00±3,631.19	8,688.33±5,008.76
Egg	1,303.80±943.58	1,434.50±13,61.18	4,861.00±2,582.95
Total	41,686.00±5,134.81	21,361.00±15,677.89	28,780.67±13,484.75

Table 4. One way ANOVA showing F-value and significance level of the number of castes and developmental stages of *Crematogaster rogenhoferi* (Mayr, 1879) among the vegetation types at Tarutao National Park.

Castes and developmental stages	F	P
Queen	1.404	.295
Winged female	.852	.458
Male	.798	.480
Worker	7.712	**.011***
Pupa	2.284	.158
Larva	.805	.477
Egg	1.550	.264
Total	.938	.427

Note: All data were transformed to log (1+X). Variances were not homogeneous (P<0.05).
*** = significant**

that have many functions in the colony, e.g, searching for food, building, defending and cleaning the nest (Shattuck, 1999). So it is of benefit for the colony to have more workers than any other castes.

Why is the number of males larger than that of the reproductive females? The only function of both these castes is to reproduce and maintain their genes in the population. They mate in the air. Females fly from their nest and males from other colonies follow the reproductive females. Then males will compete to mate with a female. Reproductive females can mate with one or more than one male (Bourke and Franks, 1995). Hence, there should be more reproductive males than reproductive females.

Social insects have special features of haplodioploidy. Some conflicts occur between queens and workers on whether to invest in either male or female castes (reproductive female and workers) in the colony. The sex ratio of ants may change from 1:1 to 3:1 in favor of females (Hölldobler and Wilson, 1990; Krebs and Davies, 1987). In this study the sex ratio of females to males corresponds to 3:1 (χ^2 = 1,312.08, p<0.01, Chi-square test). Therefore this study indicates that there are not many queens in the colony and the queens mate only once in their life time (Hölldobler and Wilson, 1990; Krebs and Davies, 1987).

b. Physical features of ant nest on the individual numbers of ant castes

Hölldobler and Wilson (1990) said that as the population of ants increases, the ant nest size becomes larger. In this study the width of the ant nest correlates with the number of queens, winged females and workers. All these caste numbers increase with the ant nest width. As mentioned above, workers are the main population numbers in the ant colony as they play such active roles in the ant colony (Shacttuck, 1999). Therefore, it is necessary for the ant population to enlarge their nest size when the population number of ants in the colony increases to provide more space for rearing the new generation.

c. Vegetation types on the individual numbers of ant castes

The vegetation types had an effect only on the number of workers. Nests on *V. pinnata* had greater numbers of workers than nests from *S. gratum* and *O. salicifolia*, respectively (Table 3). The ants mainly feed on the nectar. It is possible

the amount of nectar of *V. pinnata* is higher than the other vegetation type. Thus the ant prefers to build their nest on *V. pinnata*.

The vegetation of the study area is 95% *Melaleuca cajuputi* Powell (personal obervation) yet *C. rogenhoferi* does not build its nest on this species. Why? It is possible that the cajuput oil produced by *M. cajuputi* acts as an insect repellent (Parnell and Chantaranothai, 2000). If the cajuput oil could repellent the ants, the *M. cajuputi* were not suitable for *C. rogenhoferi* to build its nest.

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