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Diversity of Ants (Hymenoptera: Formicidae) from Ton Nga Chang Wildlife Sanctuary, Songkhla, Thailand

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ABSTRACT The diversity of ants was investigated at Ton Nga Chang Wildlife Sanctuary, Songkhla, Thailand, during May 1997 to March 1999. Pitfall traps were used to collect ants at 3 randomly placed small quadrats of 5 x 5 m^2 in a permanent plot of 100 x100 m^2. Seven subfamilies of ants, including 59 genera, were found. Species richness and Shannon -Weiner diversity index were higher in the wet season than in the dry season. Seasonal change also influenced the numbers of individuals in subfamily Myrmicinae and in species *Tapinoma* 1, *Phcidologclol1* 1, *Pheidologclon* 4 and *Paralopula* 1. The relationships between physical factors (temperature, rainfall and humidity) and the numbers in subfamilies and species were examined. Temperature was negatively correlated with *Pheidole 3* ($P < 0.05$). Rainfall was positively correlated with *Phcidole* 2, *Parawpula2* and *Pararopula* 3 ($P < 0.05$). Humidity was also positively correlated with *Camponotus* 6. ($P < 0.05$).

KEYWORDS: formicidae, ant, seasonal change, physical factors, diversity.

INTRODUCTION

The extinction rates of the fauna and flora of Thailand are increasing. One of the main causes of this is deforestation. Although commerial logging has been banned for many years, the rate of deforestation is still high, resulting in changing in faunal communities. Some groups of insects can be used as bioindicators in tropical forest.[4,11] These groups include ants,[4,17] dung beetles,[15,27] and moths of Sphingidae[27] and Geometridae.[10] To manage and conserve tropical forest, we urgently need more information on the communities of those insects, particularly their diversity. In this study we concentrate on ant diversity (Hymenoptera: Formicidae).

Ants are social insects.[3] Maryati[19] reported that ants play an important role in the forest ecosystem, for example, by improving the forest soil, by assisting in the decomposition process, by serving as food sources for insect-eating animals, and by exerting a positive effect in the regeneration processes of forest trees.

Formicidae is a dominant group of insects in the forest. Stork[25] studied the composition of the arthropod fauna of Bornean lowland rainforest by fogging the canopy and showed that Formicidae was not a species-rich group. It was the most abundant family in terms of individuals, and had the commonest species.

Environmental changes have an impact on macroarthropod abundance[1,21,30] and behaviour.[28,29] The majority of studies examining the effects of physical factors on diversity and abundance of ants have been done along elevational gradients in different parts of the world such as Venezuela,[14] Costa Rica,[13] North America[20] and the Philippines.[23] None of the reports, however, has examined the effects of temperature, humidity or rainfall on the diversity and abundance of ants. The few studies of temperature have been concerned with foraging behaviour of ants[9,31] and ant brood care.[22] The aim of this study is to determine the effects of environmental factors on ant diversity and abundance.

MATERIALS AND METHODS

a. The study site

This study was conducted at Ton Nga Chang Wildlife Sanctuary, which is located in a mountainous section of Songkhla and Satun provinces (longtitude 15° 33' - 16° 23' N; latitude 99° 33' - 99° 7' E) (Fig 1.). The average annual rainfall is over 2,000 mm.

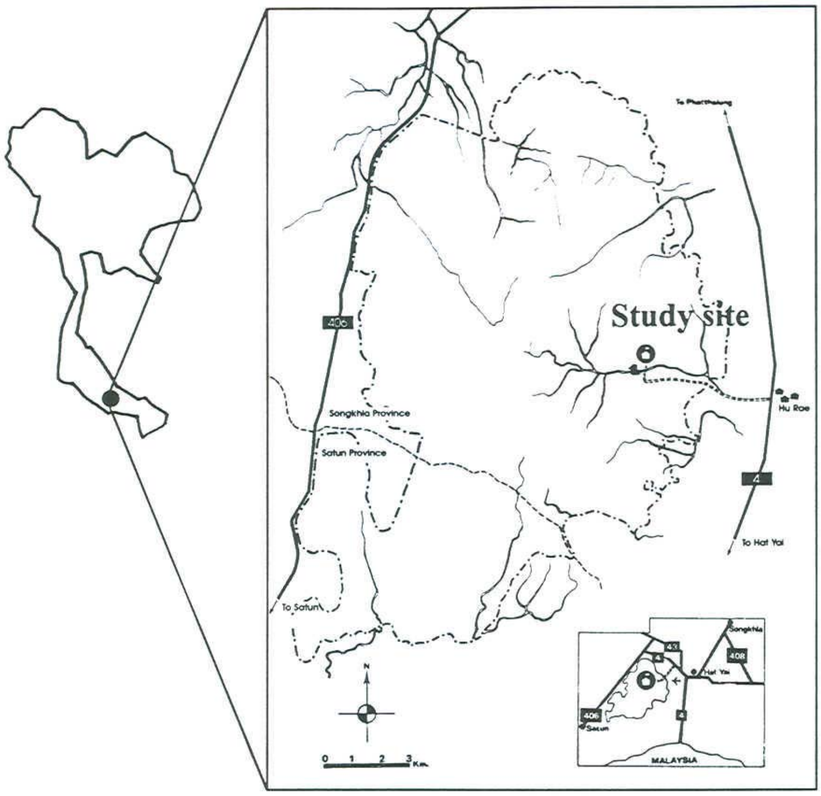

Fig 1. Map of Ton Nga Chang Wildlife Sanctuary and location of study site (Modified from Dobias, 1982)

It serves as an important watershed area. The wettest months of this area are October to December during the northeast monsoon, while the driest months are February to April.[6]

b. Sampling procedures

The study involved the selection of a primary rainforest area and establishment of the permanent plot of 100 X 100 m^2. The area was divided into 100 small quadrats of 10 X 10 m^2 for long term study. Pitfall traps were placed to collect ants in 3 randomly selected small quadrats. Then a square grid of 25 traps spaced 1 m apart was set out in each quadrat site and 450 - ml plastic containers (12.8 cm height, 6.7 cm diameter) were placed within each small quadrat site. The plastic containers were filled to third of their volume with 4 percent formaldehyde mixed with a small amount of detergent. Tuna baits were hung on the tops of the plastic containers and covered with plastic lids to protect against rain. The plastic lids were located about 5 mm above the mounts of the plastic containers. A total of 75 plastic containers were placed in the 3 study sites and were left for 5 days. Then they were collected and brought back to the Department of Biology, Prince of Songkla University, for identification of the trapped ants. This study was carried out between May 1997 - March 1999. Four samplings of ants were done in the wet season and another four in the dry season during the period of study.

c. Physical data

Annual rainfall, average temperature and humidity were kindly supplied by the Haad Yai International Airport.

d. Ant identification

Hōlldobler and Wilson[12] was used for identification of ants to genus.

e. Data analysis

Two way ANOVA was used to compare mean values of total number of species. Calculations were performed on a Macintosh microcomputer using the Superanova program. Spearman rank correlation coefficients between physical factors and individual numbers of ant taxa were computed using the Statview program. Finally, the Shannon-Weiner index was calculated to indicate species diversity.[24]

RESULTS

a. Diversity of ants

Seven subfamilies and 31 genera of ants were collected from Ton Nga Chang Wildlife Sancutary during 2 years of study using pitfall traps. They were further di\;ded into 59 morphological type (putath'e species). The mean individual numbers of subfamilies and genera are shown in Table 1.

The Shannon- Weiner index for total diversity in the first and the second year of study was 1.27 and 0.52, respectively However, the Shannon-Weiner index in the wet season was higher than that in the dry season (5.68 vs 2.29).

b. Effect of seasonal change on individual numbers

The mean individual numbers in subfamilies and genera were compared between dry and wet season and during the two years of study (Table 2). Seasonal change had effects on individual numbers in the subfamily Myrmicinae and individual numbers in species *Tapinoma* 1, *Pheidologeton* 1, *Pheidologeton* 4 and Paratopula 1. There were significant differences between years 1 and 2 for subfamilies Dolichoderinae, Ponerinae and Mynnicinae. Individual numbers of *Camponotus* 6, *Oecophyl!a*, *Tapinoma* 2, *Discothyreal* 1>***Proatta, Pheidologeton* 1** and ***Paratopula*** 1 were also significantly different in the 2 years. The interaction tenn, season X year, was also significantly different for the individual numbers in subfamilies Fonnicinae and Myrmicinae and individual numbers of *Pheidologeton* 1 and *Pheidole* 1.

c. Correlation with physical factors

Speannan rank correlation coefficients between physical factors (temperature, rainfall and relative humidity) and individual numbers in subfamilies and species types of ants were shown as follows. Indi\;dual numbers of *Pheidole* 3 were negatively correlated with temperature ($r_S = -2.00$, $P < 0.05$). The amount of rainfall was positively correlated with types *Pheidole* 2 ($r_S = 2.08$, $P < 0.05$,), *Paratopula* 2 ($r_S = 2.08$, $P < 0.05$) and *Paratopula* 3 ($r_S = 2.08$, $P < 0.05$,). Humidity, was correlated positively only with *Camponotus*6 ($r_S = 2.02$, $P < 0.05$).

DISCUSSION

a. Affects of seasonal change and physical factors on numbers of ants

1. Subfamily Formicinae

Although the mean numbers of individuals of Fonnicinae did not show a significant difference between seasons, the changes were not consistent over the 2 years, as shown by the interaction tenn of season X year. *Camponotus* spp had the greatest individual numbers (Table 1). We found that Camponotus 2 and Camponotus 6 were present in greater numbers in the first year than in the second year. In this study the indh'idual numbers of Camponotus 6 increased when the relath'e humidity was high.

Humidity may influence nest building of *Camponotus* spp. Sudd and Franks[26] reported that Camponotus spp occupy the soft (issues of trees and live underground. If the humidity is high, it will make the ground soft and enable them to build their nests more easily.

Predators may be an other factor affecting Camponotus populations. Franks and Bossert[8] found that the population of *Camponotus* may be reduced b)' the main predator (the Arm)' ant, *Eciton).* Although we did not collect an)' known predators in this study, predatOrs could have played a role in controlling the *Camponotus* population.

2. **Subfamily Dolichoderinae**

None of the physical factOrs measured had an impact on individual numbers of Dolichoderinae. *Tapinoma* spp were abundant in this group. Both season and the year of study had significant effects on individual numbers in *Tapinoma* 2 (Table 2); there were greater numbers in the wet than in the dry season, and in (he first year than in the second year (Table 1). If individual numbers do not depend on the physical factOrs, food resources may be the main factor. Maryati and Sim reported that *Tapinoma* feed on exudates of Aphis craccivora. (quoted by 18) While searching for food, Tapinoma have a greater chance at falling into the pitfall traps.

3. **Subfamily Dorylinae**

Arnietus was the only genus of Dorylinae in tllls study. Neither season nor physical factors were related to numbers of this group. Sudd and Franks [26] reponed thatAenictus are driverants, hunting prey in subterranean habitat and nesting underground. Thus, only small numbers of *Aenictus* were trapped.

4. **Subfamily Ponerinae**

There were 12 species of Ponerinae in this study. Individual numbers in the first year were significantl)' greater than in the second year (Tables 1 and 2). As no physical factors significantly affected the numbers of ants, food sources may have been

Table 1. Mean (±SE) numbers of individual ants in each subfamily and genus at Ton Nga Chang Wildlife Sancutary. Ants were collected by using pitfall traps in wet (W) and dry (D) seasons in 2 years (1 and 2) of study (May 1997 - March 1999).

	Year and Season							
Taxa	Y1D1	Y1W1	Y1W2	Y1D2	Y2D1	Y2W1	Y2W2	Y2D2
Subfamily Formicinae	6.33 (3.84)	90.67 (34.72)	55.67 (35.96)	343.67 (154.14)	19.67 (5.04)	40.33 (20.10)	35 (17.39)	8.3 (4.06)
Camponotus 1	0.33 (0.33)	2.33 (1.45)	0	1.33 (0.67)	0.33 (0.33)	0	0.33 (0.33)	0
Camponotus 2	1 (0)	7.67 (3.71)	9 (3.61)	17 (14.05)	2 (2)	5 (3.21)	0.33 (0.33)	0.33 (0.33)
Camponotus 3	0.67 (0.67)	6.67 (6.67)	2 (2)	2.67 (2.67)	0.33 (0.33)	0	0	0
Camponotus 4	0.33 (0.33)	26 (26)	5.33 (5.33)	23.67 (12.81)	1.67 (1.67)	12.33 (12.33)	7.33 (7.33)	2.33 (2.33)
Camponotus 5	0	10.67 (10.67)	1.67 (1.67)	2.33 (1.45)	1.67 (1.20)	1 (1)	1.67 (1.67)	0.67 (0.67)
Camponotus 6	0	0.33 (0.33)	1 (0.58)	0	0	0	0	0
Calamyrmex	2.67 (2.67)	36.33 (36.33)	36.33 (36.33)	296.33 (151.72)	0	0.67 (0.67)	25.33 (20.99)	5 (5)
Euprenolepis 1	0.67 (0.67)	0	0.33 (0.33)	0	0.33 (0.33)	1.33 (1.33)	0	0
Euprenolepis 2	0	0	0	0	0.33 (0.33)	1.33	0	0
Polyrhachis 1	0.33 (0.33)	0	0	0.33 (0.33)	0	0	0	0
Polyrhachis 2	0.33 (0.33)	0.33 (0.33)	0	0	0	0	0	0
Oecophylla	0	0.33 (0.33)	0	0	12.67 (6.33)	20 (17.56)	0	0
Gesomyrmex	0	0	0	0	0.33 (0.33)	0	0	0
Subfamily Dolichoderinae	3.33 (3.33)	51 (39.02)	2 (1)	5 (1.15)	1.67 (0.33)	1.67 (0.88)	5.33 (2.96)	0.67 (0.33)
Tapinoma 1	3 (3)	7.67 (3.18)	0.33 (0.33)	2.33 (1.45)	1.33 (0.67)	1.67 (0.88)	4.67 (2.91)	0.33 (0.33)
Tapinoma 2	0	43 (36.59)	0	2.33 (2.33)	0	0	0.67 (0.33)	0
Hypoclinea 1	0.33 (0.33)	0.33 (0.33)	1.67 (1.20)	0.33 (0.33)	0	0	0	0.33 (0.33)
Hypoclinea 2	0	0	0	0	0.33 (0.33)	0	0	0
Subfamily Dorylinae	0	13.33 (13.33)	1.33 (1.33)	0	0	0	0	0
Aenictus 1	0	13.33 (13.33)	0	0	0	0	0	0
Aenictus 2	0	0	1.33 (1.33)	0	0	0	0	0
Subfamily Ponerinae	33.33 (3.48)	74.33 (36.44)	33.33 (5.36)	31.33 (12.86)	36.67 (8.97)	41.33 (27.64)	24.67 (10.53)	6 (1.53)
Odontomachus	1.67 (0.88)	23 (18.08)	7.33 (2.33)	4.33 (3.38)	8 (5.29)	2 (0.58)	2 (1)	0.33 (0.33)
Pachycondyla 1	16.33 (5.04)	9 (6.03)	4.33 (1.86)	4 (1)	11 (7.09)	2.67 (2.19)	8.33 (5.90)	0.33 (0.33)
Pachycondyla 2	0.67 (0.67)	0	0.33 (0.33)	2 (2)	0	0	0.33 (0.33)	0.33 (0.33)
Pachycondyla 3	0.67 (0.67)	0	0	0	0	0	0	0
Odontoponera	12.33 (3.76)	39.67 (13.04)	21 (7.09)	21 (11.93)	17.33 (7.62)	36.67 (25.06)	13.67 (6.84)	3.67 (2.03)
Discothyreal 1	1 (0.58)	1.67 (0.88)	0.33 (0.33)	0	0.33 (0.33)	0	0	0
Discothyreal 3	0	0	0	0	0	0	0	1 (1)
Diacomma	0	0.67 (0.67)	0	0	0	0	0	0
Hypoponera	0.33 (0.33)	0.33 (0.33)	0	0	0	0	0	0
Myopopone	0.33 (0.33)	0	0	0	0	0	0	0

	Year and Season							
Taxa	Y1D1	Y1W1	Y1W2	Y1D2	Y2D1	Y2W1	Y2W2	Y2D2
Prionopelta	0	0	0	0	0	0	0.33 (0.33)	0
Mystrium	0	0	0	0	0	0	0	0.33 (0.33)
Subfamily Myrmicinae	120.3 (33.03)	35025 (25023)	4663 (3240)	3142 (642.6)	1251 (345.6)	2884 (1576)	1379 (753)	55.67 (46.37)
Proatta	1 (0.58)	41.67 (32.19)	25.33 (11.35)	8 (8)	10 (5)	0	0.67 (0.33)	0.67 (0.67)
Lophomyrmex	0	0.33 (0.33)	5.67 (5.67)	861 (861)	91.67 (88.68)	76 (45.08)	10.33 (9.35)	3 (3)
Kyidris	0.33 (0.33)	0	0	0	0	0	0	0
Liomyrmex	0.33 (0.33)	0	0	0	0	0	0	0
Pheidologeton 1	34.33 (34.33)	28041 (47366)	280.67 (205.1)	1 (1)	564 (289.7)	0	0	0
Pheidologeton 2	42 (18.19)	6008 (6008)	3613 (3417)	281.7 (248.9)	210.3 (107.6)	1837 (1837)	406 (406)	0.67 (0.67)
Pheidologeton 3	0	194.3 (193.8)	71 (64.61)	467 (4.18)	1 (0.58)	48 (48)	16.67 (16.67)	0
Pheidologeton 4	0	213.3 (114.6)	9 (5.20)	0.67 (0.67)	0	25.67 (25.17)	2 (2)	0
Pheidologeton 5	1 (1)	15.67 (15.67)	0	310.7 (155.4)	0	91.67 (91.67)	0	0
Pheidole 1	0.67 (0.67)	0.33 (0.33)	168.7 (168.7)	1157 (289.6)	114.7 (78.95)	244.67 (214.89)	422 (422)	36 (35.50)
Pheidole 2	1 (1)	5.33 (4.37)	7.67 (4.33)	2.67 (1.76)	2 (2)	15.33 (15.33)	10.67 (10.67)	0
Pheidole 3	0	0	1	0 (1)	0	0	1	0 (1)
Pheidole 4	0	0.67 (0.67)	8 (8)	7 (3.61)	0	3 (1.73)	3.33 (2.85)	0
Pheidole 5	0	2.67 (1.45)	3.67 (3.67)	27.67 (16.80)	5.33 (2.91)	14.67 (14.67)	1.33 (1.33)	0.67 (0.67)
Pheidole 6	1 (0.58)	6.33 (6.33)	0	2.33 (1.33)	10.33 (5.24)	22 (21.50)	6.67 (4.81)	0.67 (0.67)
Paratopula 1	28.33 (8.33)	299.7 (89.60)	107.7 (58.50)	306.3 (105.4)	46.33 (22.24)	153.7 (97.73)	80 (14.64)	11.67 (10.20)
Paratopula 2	6.33 (1.76)	161.7 (93.24)	345 (259.3)	164 (69.29)	169.3 (130.9)	323.7 (315.7)	326 (309.1)	1 (0.58)
Paratopula 3	2.67 (1.33)	24 (24)	15.67 (12.33)	0	9.33 (2.67)	23.33 (16.42)	63.33 (60.84)	0.67 (0.67)
Paratopula 4	0	0	0.33 (0.33)	0	0	2.67 (2.67)	0	0
Monomorium 1	0.33 (0.33)	9.33 (9.33)	0 (5.33)	5.33 (2)	2 (27.01)	0	28	0
Monomorium 2	0	0	0	0	0	2 (2)	0	0
Crematogaster 1	1 (0.58)	0.67 (0.33)	0.67 (0.33)	0.67 (0.33)	1 (0.58)	0.67 (0.33)	0	0.33 (0.33)
Crematogaster 2	0	0	0	0	0.33 (0.33)	0	0	0
Paedalgus	0	0	0	0.67 (0.67)	13 (13)	0	0.67 (0.67)	0
Strumigenys	0	0	0	0	0	0	0	0.33 (0.33)
Subfamily Pseudomyrmecinae	0	0	0	0	0.33 (0.33)	3.67 (3.67)	0	0
Tetraponera 1	0	0	0	0	0.33 (0.33)	0	0	0
Tetraponera 2	0	0	0	0.33 (0.33)	0	0	0	0
Subfamily Leptanillinae	0	0	0	0	0	3.67 (3.67)	0	0
Leptanilla	0	0	0	0	0	3.67 (3.67)	0	0

Note: Y1D1 = year 1, dry season 1; Y1W1 = year 1, wet season 1; Y1W2 = year 1, wet season 2; Y1D2 = year 1, dry season 2; Y2D1 = year 2, dry season 1; Y2W1 = year 2, wet season 1; Y2W2 = year 2, wet season 2; Y2D2 = year 2, dry season 2

Table 2. Two way Anova showing F- value and significance level of individual numbers in subfamilies and genera of ants at Ton Nga Chang Wildlife Sancutary. (* = P<0.05, ** = P<0.01, ns = non significant; degrees of freedom in parenthesis)

Taxa	Source of variance		
	year (1)	season (3)	year X season (3)
Subfamily Formicinae	3.99 ns	1.86 ns	**4.45** *
Camponotus 1	3.79 ns	0.72 ns	0.93 ns
Camponotus 2	**9.13** **	1.22 ns	1.61 ns
Camponotus 3	2.95 ns	0.06 ns	0.25 ns
Camponotus 4	0.27 ns	0.49 ns	0.42 ns
Camponotus 5	0.09 ns	0.18 ns	0.63 ns
Camponotus 6	**4.39** *	2.04 ns	2.04 ns
Calamyrmex	1.65 ns	1.18 ns	0.80 ns
Euprenolepis 1	0.06 ns	0.59 ns	0.89 ns
Euprenolepis 2	1.00 ns	1.00 ns	1.00 ns
Polyrhachis 1 @	2.00 ns	0.67 ns	0.67 ns
Polyrhachis 2 @	2.00 ns	0.67 ns	0.67 ns
Oecophylla	**5.71** *	2.41 ns	1.93 ns
Gesomyrmex	1.00 ns	1.00 ns	1.00 ns
Subfamily Dolichoderinae	**4.83** *	2.28 ns	**4.21** *
Tapinoma 1 @	0.91 ns	1.04 ns	2.33 ns
Tapinoma 2	**5.42** *	**3.63** *	**4.91** *
Hypoclinea 1	3.51 ns	0.60 ns	0.98 ns
Hypoclinea 2	1.00 ns	1.00 ns	1.00 ns
Subfamily Dorylinae	1.73 ns	0.76 ns	0.76 ns
Aenictus 1	1.00 ns	1.00 ns	1.00 ns
Aenictus 2	1.00 ns	1.00 ns	1.00 ns
Subfamily Ponerinae	**4.99** *	1.88 ns	0.94 ns
Odontomachus	2.71 ns	1.21 ns	1.51 ns
Pachycondyla 1 @	0.82 ns	2.38 ns	0.56 ns
Pachycondyla 2	0.86 ns	0.73 ns	0.29 ns
Pachycondyla 3	1.00 ns	1.00 ns	1.00 ns
Odontoponera	2.42 ns	0.99 ns	0.45 ns
Discothyreal 1	**5.24** *	1.84 ns	1.26 ns
Discothyreal 3	1.00 ns	1.00 ns	1.00 ns
Diacomma	1.00 ms	1.00 ns	1.00 ns
Hypoponera @	2.00 ns	0.67 ns	0.67 ns
Myopopone	1.00 ns	1.00 ns	1.00 ns
Prionopelta	1.00 ns	1.00 ns	1.00 ns
Mystrium	1.00 ns	1.00 ns	1.00 ns
Subfamily Myrmicinae	**7.78** *	**6.99** **	**7.86** **
Proatta	**5.03** *	0.70 ns	3.14 ns
Lophomyrmex	1.14 ns	0.07 ns	1.30 ns
Kyidris	1.00 ns	1.00 ns	1.00 ns
Liomyrmex	1.00 ns	1.00 ns	1.00 ns
Pheidologeton 1	**8.59** **	**3.23** *	**7.43** **
Pheidologeton 2	1.82 ns	0.48 ns	0.61 ns
Pheidologeton 3	0.56 ns	1.14 ns	0.26 ns
Pheidologeton 4	3.95 ns	**6.89** **	1.35 ns
Pheidologeton 5	1.65 ns	1.68 ns	1.86 ns
Pheidole 1	0.09 ns	1.26 ns	**3.29** *
Pheidole 2	0.32 ns	0.67 ns	0.22 ns
Pheidole 3 @	0 ns	2.00 ns	0 ns
Pheidole 4	0.62 ns	1.52 ns	2.13 ns
Pheidole 5	0.10 ns	0.39 ns	1.68 ns
Pheidole 6	1.57 ns	0.35 ns	0.83 ns
Paratopula 1 @	**6.15** *	**3.25** *	2.37 ns
Paratopula 2 @	0.07 ns	0.84 ns	0.34 ns
Paratopula 3	1.85 ns	2.24 ns	0.13 ns
Paratopula 4	0.43 ns	0.81 ns	1.19 ns
Monomorium 1	0.01 ns	0.18 ns	1.73 ns
Monomorium 2	1.00 ns	1.00 ns	1.00 ns
Crematogaster 1 @	0.82 ns	1.06 ns	0.33 ns
Crematogaster 2	1.00 ns	1.00 ns	1.00 ns
Paedalgus	0.85 ns	0.61 ns	1.05 ns
Strumigenys	1.00 ns	1.00 ns	1.00 ns
Subfamily Pseudomyrmecinae	1.52 ns	0.83 ns	0.83 ns
Tetraponera 1	1.00 ns	1.00 ns	1.00 ns
Tetraponera 2	1.00 ns	1.00 ns	1.00 ns
Subfamily Leptanillinae	1.00 ns	1.00 ns	1.00 ns
Leptanilla	1.00 ns	1.00 ns	1.00 ns

Note: All data were transformed a log(1+x). Variances were not homogeneous (P<0.5, Cochran's C test, except for data marked @)

important. Ponerines feed on a wide range of food, for example, searching on the surface for prey or carrion and raiding termite nests. They are normally predators.[7, 26] Some species can switch from being predators to seed feeders, depending on season of the year.[26]

5. Subfamily Myrmicinae

Myrmicinae were the most abundant in numbers of ants and the most diverse group (25 species) in this study (Table 1). The mean individual number of Myrmicinae showed a significant difference between seasons, but the change was not consistent across the two years, as indicated by the interaction term of season X year (Table 2). The number of individuals was higher in the wet season and in the first year. *Pheidologeton, Pheidole* and *Paratopula* were the most dominant species (Table 1).

Suud and Franks[26] reported that Myrmicinae behaved as omnivores. They nested in soil humus, in hollow twigs, under bark, inside galls or in nuts of woody plants. It is therefore not surprising that we collected them in great numbers.

Temperature and rainfall had effects on numbers of *Pheidole 2, Pheidole 3, Paratopula* 2 and *Paratopula* 3. The numbers of *Pheidole* 2, *Paratopula* 2 and *Paratopula* 3 increased with high rainfall. Temperature normally drops with increasing rainfall. *Pheidole* 3 increased in numbers with decreasing temperature. None of the physical factors had an impact on individual numbers of *Pheidologeton* spp. As mentioned above, food resources may have played an important role influencing numbers of Formicinae, Dolichoderidae and Poneridae. The same may have been true for *Pheidologeton*.

Concerning physical factors, Pearson and Derr [21] showed that temperature, rainfall, and relative humidity influenced the distribution and abundance of arthropods on the forest floor in Peru. As a result, temperature and rainfall may affect the distribution and abundance of some species of Myrmicinae.

6. Subfamily Pseudomyrmecinae

Tetraponera was the only genus of Pseudomyrmecinae found. Neither seasonal change nor physical factors influenced the numbers of this group. Only low numbers of this genus were collected because of its habitat. Buschinger *et al.* [5] reported that *Tetraponera* nested in internodes of bamboo plants. Thus, it should have little chance of being trapped on the ground.

7. Subfamily Leptanillinae

Only one genus, *Leptanilla* was collected. It is a very tiny ant. Dumpert [7] reported that *Leptanilla* was usually not trapped by the usual methods of ant collecting, and we trapped low numbers of *Leptanilla*. Thus it was not possible to analyze trends in its numbers.

b. Ant diversity

This study showed that diversity of ants was higher in the wet than the dry seasons, and that seasonal changes have impacts on the species richness of ants. Lobry-de-Bruyn [16] found that species richness of ants in native vegetation at Kellerberrin, Western Australia, was lower in winter as compared with spring and summer. Diversity of butterflies at Ton Nga Chang Wildlife Sanctuary also differed among seasons because of food resources.[2] It is likely that food resources play an important role in determining the diversity of ants at Ton Nga Chang Wildlife Sanctuary.

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