

Ants of the Klong U-Tapao Basin, Southern Thailand

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บทคัดย่อ. เขตรักษาพันธุ์สัตว์ป่าโตนงาช้างตั้งอยู่บนเทือกเขาบรรทัด ภาคใต้ของประเทศไทย เป็นแหล่งต้นน้ำไหลลงสู่ลุ่มน้ำคลองอุตะเกาะซึ่งรองรับน้ำจากลำธารหลายสาย ลำธารเหล่านี้ไหลผ่านย่านธุรกิจของเมืองหาดใหญ่ แล้วมารวมกับคลองวาด สูดท้ายไหลลงสู่ทะเลสาบสงขลา ทำให้ความหลากหลายพืชและสัตว์ที่อยู่ตามแนวลุ่มน้ำแตกต่างกันออกไป เช่นเดียวกับมดอาจมีการเปลี่ยนแปลงตามสภาพแวดล้อมไปด้วย เมื่อมดมีความสำคัญในระบบนิเวศ ดังนั้นวัตถุประสงค์ในการศึกษาค้นคว้าครั้งนี้คือดูความการกระจายตัวและความหลากหลายของมดตามลุ่มน้ำของคลองอุตะเกาะ โดยสุ่มเลือกพื้นที่ศึกษา 5 บริเวณได้แก่ 3 แห่งอยู่เขตรักษาพันธุ์สัตว์ป่าโตนงาช้าง และอีก 2 แห่งอยู่บริเวณปลายน้ำของลุ่มน้ำที่เป็นพื้นที่การเกษตร แต่ละพื้นที่ศึกษาวางแปลงถาวรขนาด 20 x 20 ม จำนวน 3 แปลงสำหรับใช้เก็บตัวอย่างมด ส่วนวิธีการเก็บตัวอย่างใช้ 2 วิธีคือ การเก็บด้วยมือ และการเก็บจากซากใบไม้ ซึ่งแต่ละวิธีใช้เวลาในการเก็บตัวอย่างมดแปลงละ 30 นาที ในการเก็บตัวอย่างทุกๆ 2 เดือนระหว่างมกราคม 2547 ถึงมกราคม 2548 พบมดทั้งสิ้น 248 ชนิด 50 สกุล ใน 7 วงศ์ย่อย ของ Aenictinae, Cerapachyinae, Dolichoderinae, Formicinae, Myrmicinae, Ponerinae และ Pseudomyrmecinae ชนิดของมดที่พบมีพบมากที่สุดอยู่ในวงศ์ย่อย Myrmicinae 42.7% และ Formicinae 31% เมื่อวิเคราะห์ข้อมูลแบบ DCA พบว่าพื้นที่ศึกษาสามารถแบ่งมดออกเป็น 2 กลุ่มคือพวกที่อาศัยอยู่ตามต้นน้ำและปลายน้ำ และวิธีการเก็บตัวอย่างก็สามารถแบ่งมดออกเป็น 2 กลุ่มเช่นกันคือมดที่สามารถเก็บด้วยมือและเก็บจากซากใบไม้

จากการศึกษานี้สรุปได้ว่าชนิดของมดมีการกระจายตัวแตกต่างกันไปตามความเปลี่ยนแปลงของลุ่มน้ำคลองอุตะเกาะ และพื้นที่ป่าธรรมชาติมีชนิดของมดแตกต่างกับพื้นที่การเกษตรอย่างชัดเจน

Abstract. Ton Nga Chang Wildlife Sanctuary is located in the Khao Ban Thad Mountain Range, in the southern part of Thailand. It serves as a watershed for the Klong U-Tapao Basin that collects water from many streams, draining via Hat Yai City into Songkhla Lake. It might be expected that the diversity of habitat types along the streams from the watershed to the lake should be reflected in the diversity of fauna and flora. Ants play important roles in the ecosystem, and the aim of this study was to examine the distribution of ants in different habitats along the stream of the Klong U-Tapao Basin. Five study sites were chosen within the following categories: three from the forest watershed area of the Wildlife Sanctuary and two from agricultural landscapes downstream. At each study site, three permanent plots of 20 x 20 m were selected for sampling. Two sampling methods, hand collecting (HC) and leaf litter sampling (LL), were used to collect ants within a time limit of 30 minutes for each method in each permanent plot; sampling took place every two months from January 2003 to January 2004. We collected 248 species of ants in 50 genera and seven subfamilies: Aenictinae, Cerapachyinae, Dolichoderinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae. The majority of species were in the Myrmicinae (43%) and Formicinae (31%). Detrended Correspondence Analysis (DCA) distinguished between the two groups of sites (forested watershed area and downstream agricultural landscape) and the different sampling methods (HC and LL). In conclusion, this study indicates that the distribution of ant species does vary along the Klong U-Tapao Basin, and that natural forest areas differ substantially from agricultural habitats.

Keywords: diversity, ants, sampling methods, site, Klong U-Tapao Basin, Songkhla Lake, Southern Thailand

INTRODUCTION

The Klong U-Tapao Basin in southern Thailand has many canals, with U-Tapao and Waad Canals being the two most important ones in Songkhla Province. Both of them collect natural and discharged water from rural areas and from Hat Yai City and drain into Songkhla Lake. U-Tapao Canal originates from the Sankarakiri Mountain Range and Ton Nga Chang Canal while Waad Canal starts in the Khao Ban Thad Mountain Range at Ton Nga Chang Wildlife Sanctuary. U-Tapao Canal is 90 km long, while Waad Canal is only 37 km in length (Royal Thai Survey Department 1997a, b, c). The flora and fauna are very rich in the watershed area of Ton Nga Change Wildlife Sanctuary, but there are few reports on species diversity, aside from studies of ant diversity (Watanasit *et al.* 2000; Watanasit & Noon-anant 2005; Watanasit *et al.* 2005b).

Ants are important, not only because of their diversity (Alonso & Agosti 2000), but also because of their functions in ecosystems, such as turning

forest soil, dispersing seeds and helping with decomposition (Maryati 1996). Moreover, ants have been used as biological control agents for insect pests in agriculture in many countries such as Malaysia (Khoo & Chung 1989), Thailand (Kritsaneepaiboon & Saiboon 2000) and Papua New Guinea (Way 1954).

The spatial distribution of ant species depends on many factors, such as elevation (Samson *et al.* 1997), vegetation type and composition (Wilson 1958; Bestelmeyer & Wiens 2001), predation (Kaspari 1996b; Soares & Schoereder 2001), topography (Vasconcelos *et al.* 2003), temperature (Bestelmeyer 2000), humidity (Kaspari 1996a) and habitat preferences of the ants (Watanasit *et al.* 2005a). There are also many studies showing that sampling methods can influence the results of ant diversity studies, such as Watanasit *et al.* (2003). The use of a combination of ant sampling methods yields better results for evaluating ant species diversity than does any one sampling method (Watanasit 2003; Noon-anant *et al.* 2005). In this study we have investigated the distribution and

abundance of ant species along the Klong U-Tapao Basin and also the relationships of the ant species detected to the study sites and sampling methods.

MATERIALS AND METHODS

Study sites

The study was carried out along the Klong U-Tapao Basin located in Songkhla Province, southern Thailand (Fig. 1). Five study sites were selected. Three “upstream” sites (Ton Boon, Ton Klang, Ton Lung) are situated within a few kilometres of each other, separated by mountain slopes. Two “downstream” sites (Klong Waad, Leam Pho) are in the flatter lowlands to the east.

1) Station 1 is called Ton Boon (Ton Samet Chun), located at 5°44' 18" N, 101° 24' 56" E. This study site is at 470-550 m above mean sea level and serves as a watershed area. It represents intact primary forest which includes gaps and has very high humidity year-round. It is dense-canopy and the vegetation is composed of *Syzygium lineatum* (DC.) Merr. & Perry, *Cynometra malaccensis* Meeuwen, *Dipterocarpus crinitus* Dyer, and *Podocarpus wallichianus* Presl. The understorey includes *Goniothalamus giganteus* Hook.f. & Thomson, *Cryptocarya nitens* (Blume) Koord. & Valeton, *Orophea cuneiformis* King and *Bouea oppositifolia* Adelb, whereas the ground cover is dense with shrubs, herbs, palms, ginger and pteridophytes.

2) Station 2 is called Ton Klang and located at 5°45' 12" N, 101°24' 59" E. This study site is 300-400 m above sea level. It represents semi-primary forest because the forest is partially degraded. The canopy cover is also dense. The area is mainly shaded including a few gaps. The dominant vegetation comprises *Parashorea stellata* Kurz, *Vatica odorata* (Griff.) Symington, *Dipterocarpus costatus* Gaertn.f. and *Hopea ferrea* Pierre. The understorey includes *Polyalthia motleyana* (Hook.f.) Airy Shaw, *Diospyros transitoria* Bakh. and *Scolopia spinosa* (Roxb.) Warb. The ground cover is dense with seedlings and shrubs (*Croton*

cascarilloides Raeusch. and *Ixora javanica* (Blume) DC.), with occasional herbs and pteridophytes.

3) Station 3 is called Ton Lung, located at 5° 45' 37" N, 101°24' 37" E. This study site is 138-180 m above sea level and represents logged semi-primary forest, partially cleared in the past for rubber plantation (now disused) but not entirely clear-felled. The canopy cover is also dense and the ground mainly shaded. The dominant vegetation in this area is *Pometia pinnata* Forst., *Callerya atropurpurea* (Wall.) A.M.Schot., *Artocarpus elasticus* Reinw.ex Blume and *Pterocymbium javanicum* R.Br. The understorey includes *Orophea cuneiformis* King, *Barringtonia macrostachya* (Jack) Kurz and *Mallotus floribunda* (Blume) Müll.Arg. The ground cover is dense with climbers, seedlings and shrubs (*Chassalia curvifloran* Thw. and *Ixora javanica* (Blume) DC.) with occasional herbs and pteridophytes.

4) Station 4 is called Klong Waad, located at 5° 56' 10" N, 101°28' 16" E. This study site is at a downstream area (altitude is 40 m above mean sea level). It is in an agricultural area for rubber (*Hevea brasiliensis* (Willd.ex A.Juss.) Müll.Arg.) and neem (*Azadirachta indica* A. Juss.) plantations. The ground cover is sparse with native plants including grass, shrubs (*Chassalia curvifloran* Thw. and *Ixora javanica* (Blume) DC.) and exotic species. The area is mown every year to clear weeds.

5) Station 5 is called Leam Po, located at 5°58' 12" N, 101°37' 02" E. It is a flat plain, swampy (freshwater) and with muddy soil, including some abandoned paddy. It is rather dry in the dry season. The area connects to Songkhla Lake and the altitude is near sea level. The vegetation comprises facultative halophytes with mangrove species, such as *Sonneratia* sp., *Acrostichum aureum* L. and *Acanthus* sp., and exotic species such as *Acacia auriculiformis* Cunn. and *Typha angustifolia* L.

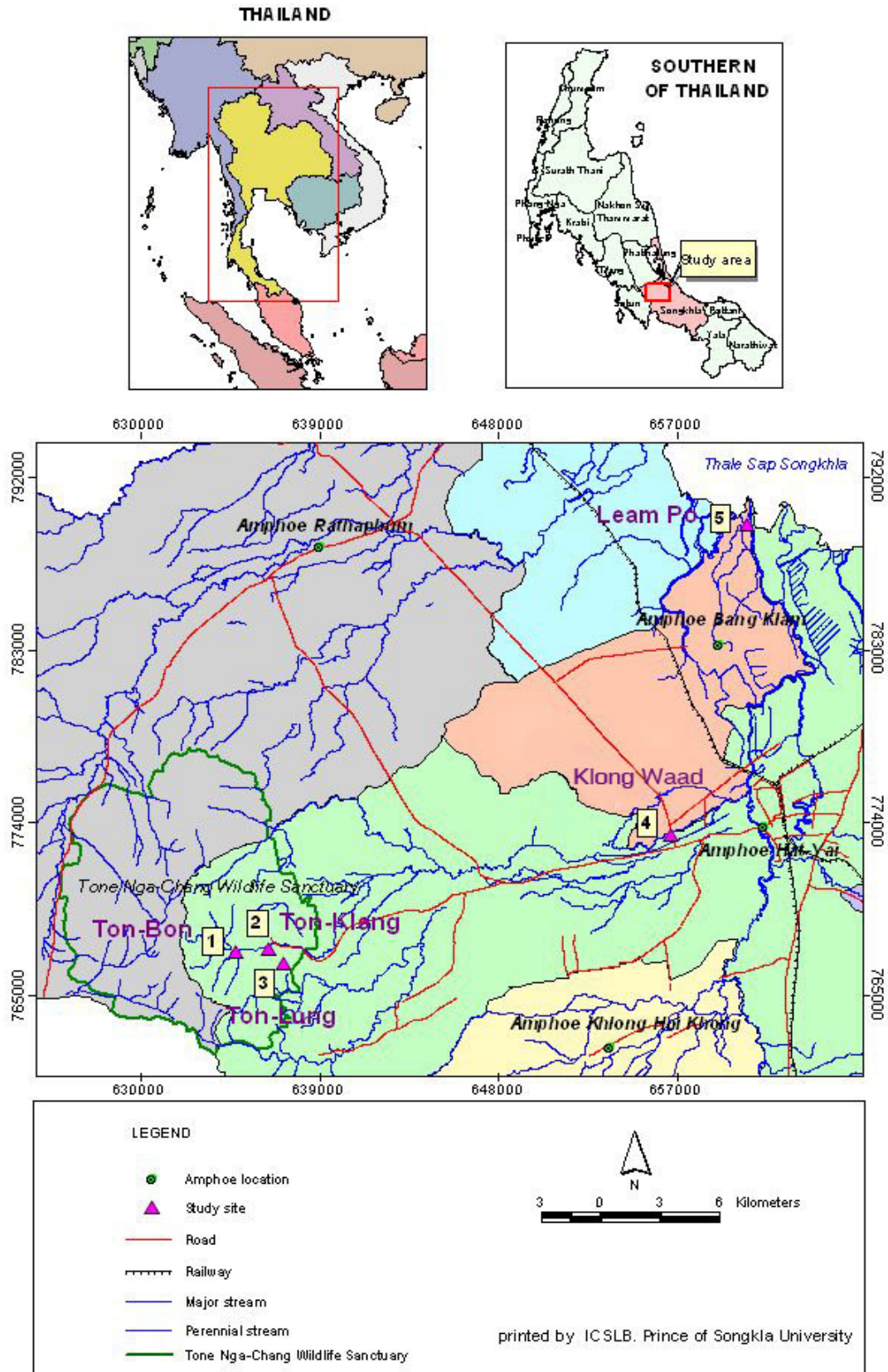


Fig. 1. Map of Klong U-Tapao Basin showing five study sites (1, 2, 3 =upstream and 4, 5 = downstream). Note: 1 = Ton Boon, 2 = Ton Klang, 3 = Ton Lung, 4 = Klong Waad, 5 = Leam Po.

Sampling procedures

Three permanent plots of 20 x 20 m were established 100 m apart in all five study sites, providing 15 permanent plots. Ant sampling collections were made every two months between January 2003 to January 2004 for a total of seven sampling events. Two different sampling methods were used, as follows.

1. Hand collection (HC)

All ants found in the permanent plots were collected using forceps and an aspirator. After spending 30 minutes collecting at each permanent plot ant samples were transferred to plastic containers (7.5 x 15 cm) for transport to our lab. This method could be used for ants living on the ground and low on trees.

2. Leaf litter sample (LL)

Leaf litter was collected in the permanent plots and placed in a sifter directly above a white pan (27 x 16 x 6 cm). Forceps and an aspirator were used to collect ants in the white pan. The time limit was also 30 minutes at each permanent site. This method was used to collect ants living on the ground and in the litter.

Preservation and identification

The collected ant specimens were brought back to the Department of Biology, Faculty of Science, Prince of Songkla University, for preserving in 70% ethanol and pinning for further identification.

Bolton (1994) was used to identify ants to the genus level. Provisional species-level identifications were confirmed by Prof. Seiki Yamane, Kagoshima University, Japan and Dr. Decha Wiwatwitaya at the Ant Museum at Kasetsart University. The voucher collection of ants is maintained at the National History Museum of Prince of Songkla University, Hat Yai, Thailand.

Analysis

The multivariate technique of Detrended Correspondence Analysis (DCA) was used to discriminate among study sites and sampling methods on the basis of ant species presence-absence data, with the PC-ORD program. We included in our analysis only those ant species that were found in more than four of the seven sampling events (see list of ant species and frequency in electronic Appendix 1). Data were entered separately for each species at each site and with each sampling method.

RESULTS

Composition and distribution of ant species

COMPOSITION AND ABUNDANCE

Seven subfamilies and 248 species of ants were collected from Klong U-Tapao Basin between January 2003 and January 2004. The number of ants per subfamily is given in Table 1. There were 50 genera, with *Camponotus* having the highest number of species (26), followed by *Pheidole* (25) and *Polyrhachis* (24).

STUDY SITES AND SAMPLING METHODS

The number of ant species in each subfamily found at each study site, and the number of ant species collected by HC and LL methods, are shown in Table 2. Using the combination of the two methods, the number of ant species collected in each of the upstream sites (Ton Boon, Ton Klang, Ton Lung) was higher than in each of the downstream sites (Klong Waad, Leam Po).

The study sites and sampling methods could be grouped according to the species of ants found. We included in our analysis 124 species that occurred at higher frequency (see Methods). Of these 68 species were found only in the upstream sites (Ton Boon, Ton Klang and Ton Lung), 32 only the downstream sites (Klong Waad and Leam Po), and 24 at both. Species richness was higher at the upstream sites, with 117 species at Ton Boon,

Table 1. The numbers of genera and species of ants collected in each subfamily by hand collection (HC) and leaf litter sampling (LL) at Klong U-Tapao Basin between January 2003 and January 2004.

Subfamily	HC		LL		Total number	
	genera	species	genera	species	genera	species
1. Aenictinae	1	1	1	2	1	2
2. Cerapachyinae	1	1	1	2	1	2
3. Dolichoderinae	4	16	4	12	4	18
4. Formicinae	10	70	10	33	11	77
5. Myrmicinae	13	64	19	81	20	106
6. Ponerinae	8	13	11	31	12	34
7. Pseudomyrmecinae	1	9	1	1	1	9
Total	38	174	47	162	50	248

Table 2. The number of ant species in each subfamily, found in the five study sites by hand collection (HC) and leaf litter sampling (LL) at Klong U-Tapao Basin between January 2003 and January 2004.

Subfamily	Ton Boon		Ton Klang		Ton Lung		Klong Waad		Leam Po		total	
	HC	LL	HC	LL	HC	LL	HC	LL	HC	LL	HC	LL
1. Aenictinae	1	2	1	-	-	1	-	-	-	-	1	2
2. Cerapachyinae	1	1	-	2	-	-	-	-	-	-	1	2
3. Dolichoderinae	5	4	2	3	4	4	2	6	5	9	16	12
4. Formicinae	30	10	23	8	21	11	11	12	11	12	70	33
5. Myrmicinae	26	42	17	36	20	42	12	14	11	20	64	81
6. Ponerinae	5	12	3	15	5	14	3	9	3	4	13	31
7. Pseudomyrmecinae	-	-	2	-	2	-	1	-	4	1	9	1
Total subfamilies	6	6	6	5	5	5	5	4	5	5	7	7
Total subfamilies both methods	6		7		6		5		5		7	
Total species	68	71	48	64	52	72	29	41	34	46	174	162
Total species both methods	117		98		102		52		56		248	

98 at Ton Klang and 102 at Ton Lung, compared with 52 at Klong Waad and 56 at Leam Po (Table 2). The different sampling methods were also biased as 18 species were collected only by HC and 35 species only by LL, the rest being collected by both methods.

The first axis of the DCA based on species composition had an eigenvalue of 0.827, indicating a high ability to discriminate samples. From Figure 2 this dimension of variability is related to site, as the upland sites are clearly separated from the lowland sites. The second axis had an eigenvalue

of 0.446, also indicating quite a high ability to discriminate samples. From Figure 3 this is related to sampling method, distinguishing the hand-collection data from the leaf-litter data.

DISCUSSION

Composition and abundance

A total of seven subfamilies, 50 genera and 248 species of ants were recorded from the Klong U-Tapao Basin. Wiwatwitaya (2003a) has estimated that there are 800-1,000 species of ants in Thailand.

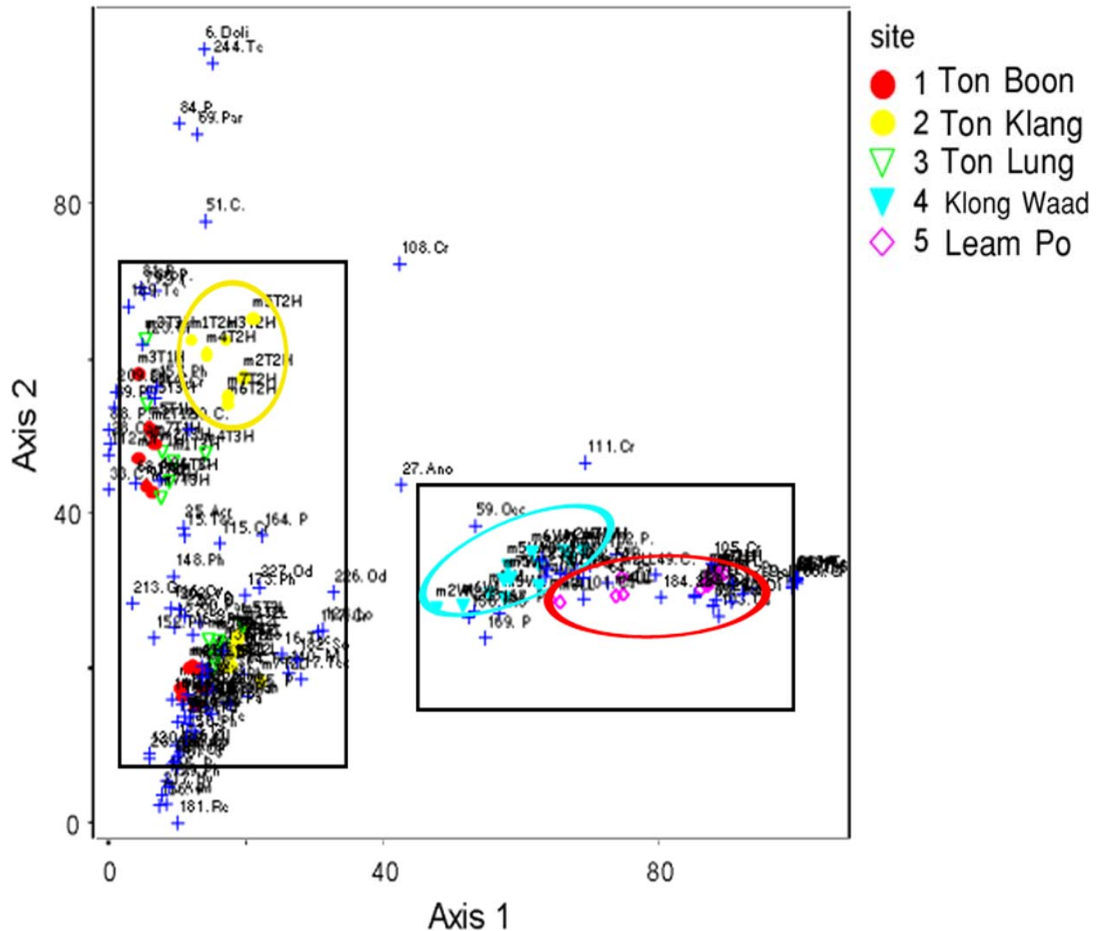


Fig. 2. Species- and site-plot from DCA ordination of 124 ant species from five study sites at Klong U-Tapao Basin between January 2003 and January 2004. Blue crosses depict species positions along each axis; coloured symbols depict site positions (see key). The blue rectangle surrounds ant species collected at the three upland study sites (excluding outliers). The black rectangle encompasses ant species collected from the two lowland study sites (Klong Waad and Leam Po). The pale blue oval groups ant species from Klong Waad, the red oval ant species from Leam Po.

Those in the Klong U-Tapao Basin represent about 24-31% of this estimated total. The richness of ants is higher than recorded by previous studies in the region, in which only 59, 206 and 118 species were found by Watanasit *et al.* (2000), Watanasit & Noon-anant (2005) and Watanasit *et al.* (2005b), respectively. The explanation of the different result could be the expansion of the study area in the present study and the combination of sampling methods used. In this study, the sites investigated ranged from the Ton Nga Chang Wildlife Sanctuary to the agricultural area near Songkhla Lake, while in the previous studies, Ton Boon and Ton Klang were not sampled. With regard to the sampling methods, in this study both HC and LL were used to collect ants. This highlights the limitations of using only pitfall traps as in Watanasit *et al.* (2000). Many studies now support the use of a combination of ant sampling methods as this always produces higher yields than any single method (e.g. Watanasit *et al.* 2005a; Noon-anant 2003; Hashimoto *et al.* 2003).

The most species (126) were in the subfamily Myrmicinae, followed by Formicinae (77 species) (Table 1). These findings are similar to those of Wiwatwitaya (2003a) and Noon-anant (2003). The Myrmicinae is the most abundant and diverse ant subfamily worldwide (Shattuck 1999). In this case they represented 42.7% of the total ant species collected.

At the genus level, *Camponotus*, *Pheidole* and *Polyrhachis* were the most speciose genera in this study with 26, 25 and 24 species respectively. This is not surprising, as the three genera are among the most speciose worldwide (Brown 2000).

Habitat type

Habitat type is known to influence species diversity in many groups of insects, for example geometrid moths (Intachat *et al.* 1999a, 1999b; Beck *et al.* 2002), butterflies (Willott *et al.* 2000), beetles (Watanasit *et al.* 2004) and also ants (Watanasit 2003; Watanasit *et al.* 2005b). In this study using DCA we can distinguish two groups of sites, one upland and the other lowland (Fig. 2).

Shattuck (1999) and Kaspari & Majer (2000) have advocated that ants can be used as bioindicators and are suitable taxa for monitoring environmental change. For example, *Pheidologeton affinis* (Jerdon), *Odontoponera denticulata* (F. Smith) and *Oecophylla smaragdina* (Fabricius) have been found more abundant in open and disturbed areas (Wiwatwitaya, 2003b).

In this study these three species were found in both upstream and downstream areas; at Ton Klang and Ton Lung all these species were detected but at Ton Boon only *Oecophylla smaragdina* was found. Ton Boon represents an undisturbed tropical rain forest, but this site has natural gaps which may be suitable for *Oecophylla smaragdina* to build their nests. Ton Klang and Ton Lung are semi-primary forest areas. Human activity in the Wildlife Sanctuary still exists, and this may impact the study site of Ton Klang while Ton Lung used to be logged for a rubber plantation and the forest is still recovering. The occurrence only in the forest upland area of 68 ant species, such as *Aenictus* spp. and *Cerapachys* spp. and *Camponotus* (*Dinomyrmex*) *gigas* (Latreille), provide incidental support for using ants as bioindicators. *Camponotus gigas* is a particularly promising indicator of forest condition as it is conspicuous and restricted to undisturbed forest. In Thailand, this ant species is found only in the south (Noon-anant 2003). It is more abundant at Ton Boon than at Ton Klang or Ton Lung, indicating that the forest area of the Ton Nga Chang Wildlife Sanctuary is in good condition.

Sampling methods

In this study, we show that sampling method can influence assessments of ant species composition. DCA separated the data from the two sampling methods (Fig. 3). Eighteen species were collected only by HC and 35 species only by LL. The majority of ants caught exclusively by HC belong to the genera *Camponotus* and *Polyrhachis* in the subfamily Formicinae, *Crematogaster* (Myrmicinae) and *Tetraponera* (Pseudomyrmecinae). These four genera are prevalent on the tree trunks

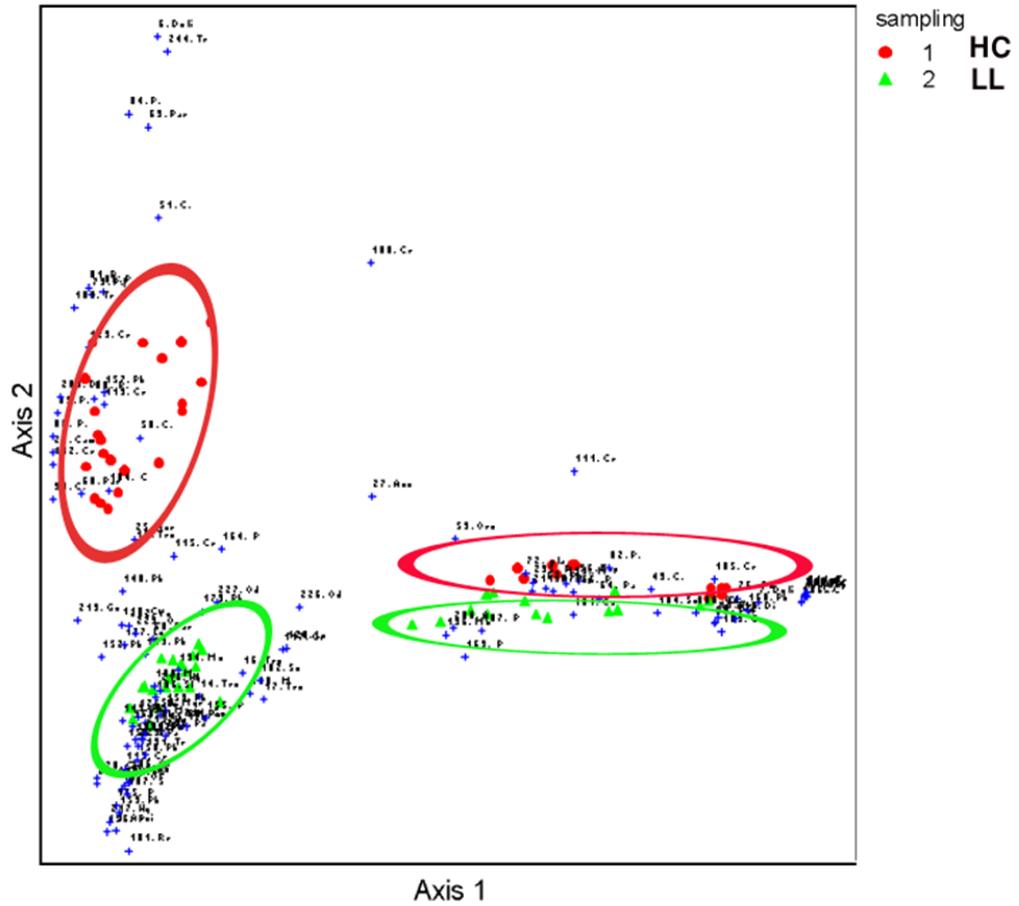


Fig. 3. Species- and sampling methods- plot from DCA ordination of 124 ant species from two sampling methods at Klong U-Tapao Basin between January 2003 and January 2004. Blue crosses depict species positions along each axis; coloured symbols show data points for each sampling method (see key: HC=hand collecting, LL=Leaf litter sampling). Red ovals group species collected by HC; yellow ovals group species collected by LL.

and in the canopy (Watanasit *et al.* 2005b). Although some species of *Camponotus* and *Polyrhachis* can nest on the ground (Brown 2000), in this study both were rarely found at ground level. Thus, HC is more useful than LL for collecting these four ant genera. In contrast, the majority of ants exclusive collected by LL were in the genera *Pheidole* (Myrmicinae) and *Pachycondyla* (Ponerinae). *Pheidole* spp. build their nests on the ground and are omnivorous (Brown 2000) while *Pachycondyla* behave as ground predators. Therefore, they are less associated with vegetation than *Camponotus*, *Polyrhachis*, *Crematogaster* and *Tetraponera*. LL sampling methods are therefore more suitable for collecting the genera *Pheidole* and *Pachycondyla*.

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