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Short Communication

Species Diversity and Functional Groups of Ants (Hymenoptera: Formicidae) in selected areas of Mt. Kalatungan Range Natural Park, Bukidnon, Philippines

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ABSTRACT

Ant diversity provides useful information for conservation and environmental management planning. The study aimed to determine the species diversity of ants and functional groups in three habitat types of Mt. Kalatungan Range Natural Park on Pangantucan, Bukidnon, Philippines. Two sampling sites were chosen, with three subsites in each site classified according to habitat types. An opportunistic sampling was used to sample ants in different microhabitats. A total of 29 species were documented, with four Philippine endemics and six invasive species from the two sampling sites. Overall species diversity index was moderate, H'= 2.81. The most abundant functional groups were Specialists Predator (44%) in the buffer zone, Subordinate Camponotini (37%) in secondary forest, and General Myrmicinae (GM), Opportunists (O), and Tropical-Climate Specialists (TCS) in the agro-ecosystem, each with 21% abundance. Also, functional group composition showed a significant difference (p=0.04) between habitat types. *The presence of invasive species indicates* that the area is disturbed, and possibly due to the existing anthropogenic activities of the sampling sites.

Key words: Anthropogenic, Buffer zone, Endemic, Invasive species, Pangantucan.

INTRODUCTION

The Philippine Formicidae currently has 582 species, including subspecies, belonging to 100 genera in 10 subfamilies. Two hundred seven species are endemic, and eighteen are introduced species in the country. The most species-rich subfamilies are Myrmicinae (40%), Formicinae (26%), and Ponerinae (17%) (Antweb, 2021).

Ant diversity study in Mindanao is very scarce with at least 18% of species known to be distributed on the islands of Mindanao. The study of Gabisay et al (2021) documented 23 species of ants in Mt. Agad-agad in Iligan City; 14 species of ants in the caves of Siargao Island Protected Landscape and Seascape (SIPLAS), Surigao del Norte (Batucan and Nuñeza, 2013); 23 species in karst limestone habitats in selected areas of the provinces of Davao Oriental and Bukidnon (Figueras and Nuñeza, 2013); and 122 species were documented in Mt. Hamiguitan Range, Davao del Oriental (General and Buenavente, 2017). In the Philippines, slash-and-burn farming (kaingin) is still commonly observed in upland areas of Mindanao Island. Fire has been observed to influence ant diversity. In burned areas, less diverse plant communities and structurally simple vegetation result in the reduction of available ant nesting sites. Consequently, species richness decreases while species abundance increases due to the greater availability of food resources (Fagundes *et al*., 2015).

Furthermore, the impact of anthropogenic activities on ant community structure varies according to species foraging behavior and level of tolerance to environmental stress. Ant species richness decreases with increasing intensity of disturbances and reduction of functional group in slash-and-burn communities (Ruiz *et al*., 2009). Ant functional group composition varies with vegetation types (Andersen, 1995). Some species of specialized functional groups are more frequent in the primary forest whereas generalist and opportunistic groups are more frequent in an active pasture (García-Martínez *et al*., 2015). Understanding how different ant functional groups respond to disturbances can be used in conservation measures. The study of Andersen (1997) found that ant functional group composition provides more reliable information of changes in disturbed sites. Also, ant functional groups play a vital role in using ants as bioindicators of ecological changes (King et al., 1998).

Moreover, the species distribution of ants has been associated with the interactions of ant species between colony (Human *et al.,* 1998), ant-plant, ant-fungi, and ant-endosymbionts (Huxley and Cutler, 1991; Barbosa *et al*., 2015; Chomicki and Renner, 2017). Also, the distribution of food resources and microhabitat availability affects ant dispersal (Lanan, 2014; de Souza-Campana et al., 2017) and the species potential impact on the environment. For instance, the Argentine ants

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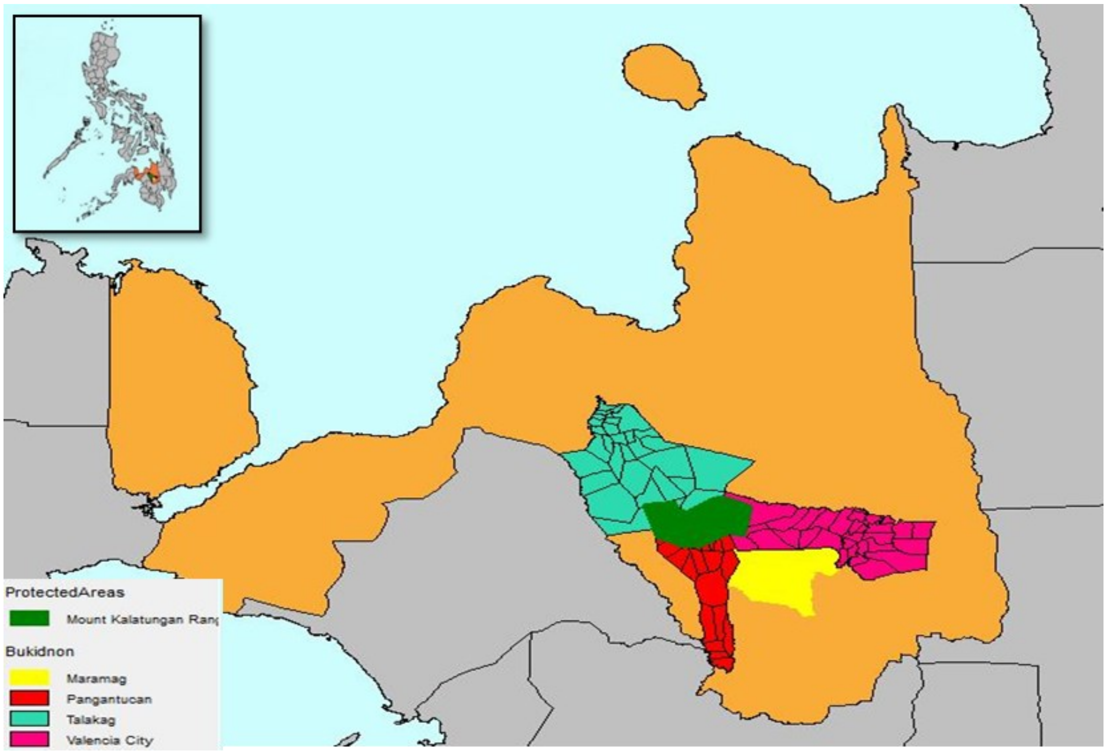

Figure 1. Map of Northern Mindanao showing Mt. Kalatungan Range Natural Park in the Province of Bukidnon.

(*Linepithema humile*) significantly reduce the foraging success of native ant species due to their efficient way of exploiting food sources, and they forage longer (Human and Gordon, 1996). Abiotic factors such as microclimate also influence the distribution of some ant species like *Solenopsis geminata.* Forest ant species have a lower tolerance to higher temperatures than ants from non-forested areas (Torres, 1984).

Ants are involved in various ecological functions that stabilize ecosystems, such as maintaining a low population of leaf miners in coffee plants (De la Mora et al., 2008; Sanford et al., 2008) and control of sugarcane borers (De Oliveira *et al*., 2012).

This study was conducted to assess ant species diversity and functional group composition in selected sites of Mt. Kalatungan Range Natural Park, Bukidnon.

MATERIALS AND METHODS

Sampling sites

There were two study sites chosen on Mt. Kalatungan Range Natural Park (MKRNP), located in barangay Portulin, Municipality of Pangantucan, Bukidnon (Fig.1). One sampling site is located within the Kilakiron range from 1400-1800masl and in the coordinates of 7° 55'9.4794" N latitude, 124°52'1.2" E longitude. The other sampling site is located within an altitude of 1300-1700masl towards the Century tree and in the coordinates of 7°54'47.8794" N latitude, 124°51'29.1594" E longitude. The study was conducted on January 11-12, 2017, March 18, 2017, and February 8, 2018, for a total of 56 person-hours.

Collection of Samples

Using direct sampling, both foraging individuals and in colonies were searched in their possible microhabitats, including under logs, rocks, rock crevices, twigs, rotting fruits, and on tree domatia. A mixture of cooked rice and sardines were used as baits to sample both ground-dwelling and arboreal species. Ants were collected using a paintbrush together with one trained field collector. Samples were directly placed in a 5mL plastic container containing 95% ethanol.

Identification of Specimens

Ant specimens were identified based on morphology and using published taxonomic keys. These include the Synoptic Review of the Ant genera (Hymenoptera, Formicidae) of the Philippines (General and Alpert, 2012), *Acanthomyrmex* - Moffett (1986), *Brachyponera, Diacamma, Hypoponera, Leptogenys, Odontomachus, Odontoponera,* and *Ponera* – Schmidt and Shattuck (2014), *Iridomyrmex* and *Technomyrmex* in Heterick and Shattuck (2011), *Myrmicaria* in Zettel *et al*. (2018), *Myrmoteras* in Zettel and Sorger (2011), *Nylanderia* in LaPolla *et al*. (2011). Additional references for species-level identification were: *Leptogenys varicosa in* Stitz (1925c), *Odontomachus scifictus* in Sorger and Zettel (2011), *Diacamma rugosum* in Mayr (1862), *Polyrhachis inermis* in Smith (1858), *Polyrhachis mindanaensis* and *P. bihamata* in Kohout (2014), *Solenopsis geminata* in Trager (1991), and *Monomorium floricola* in Heterick (2006). Moreover, photographs of all specimens were also compared with an online database of ants on Antweb.

Statistical Analysis

The software package Paleontological Statistics ver.2.17c (Hammer *et al*., 2001) was used to calculate diversity indices and one-way ANOVA. Also, the PRIMER software package (Andersen *et al*., 2015) was used to calculate the Bray-Curtis similarity and Similarity Percentage (SIMPER) to examine the relative contribution of ant abundance in ant species assemblages. The species abundance data per sample were log10 (x+1) transformed and standardized for Bray-Curtis and SIMPER. Specimens from this study were deposited in the Natural Science Museum of Mindanao State University – Iligan Institute of Technology.

RESULTS AND DISCUSSION

Species composition and abundance

A combined total of 1004 individuals in 29 species belonging to 24 genera representing four subfamilies were recorded (Table 1). There were four species (13.79%) identified as Philippine endemic, eight functional groups, and six species were classified as a threat to the ecosystem.

The species composition of Mt. Kalatungan Range differs significantly between sampling sites (p=0.037, Table 2). In site 1(Kilakiron), there were 17 species documented with 39% species found only in the agro-ecosystem and 11% common species between buffer zones and in secondary forest. The most abundant species was *Myrmicaria aphidicola*, which was found in the buffer zone (1400-1500masl) and the secondary forest (1500-1800masl). *M. aphidicola* ants forage predominantly on leaf litter and nesting on tree buttress. In contrast, 22 species were recorded in sampling site 2 with 59% species unique in agro-ecosystem and 9% common species between buffer zones and secondary forest. *Solenopsis geminata* and *Dolichoderus thoracicus* were relatively common in this site. Most of *S. geminata* was found in the cornfield and nesting under rocks whereas *D. thoracicus* was mostly found foraging on coffee plants (*Coffea sp.*). The comparison between habitat types found 33% of species exclusive in agro-ecosystem, 8% species in the Buffer zone, and 4% species in the secondary forest. Also, *Solenopsis geminata* was the most abundant and commonly encountered invasive species in the agro-ecosystem.

Table 1. Species composition, distribution status, functional groups, and threat level of ants on Mt. Kalatungan Range Natural Park, Bukidnon.

Species	Distribution Status [1]	Functional Group[2]	Threat Level[3]
Subfamily: Dolichoderinae			
Dolichoderus thoracicus (Smith, 1860)	-	TCS	
Iridomyrmex anceps (Roger, 1863)	-	DD	Low
Technomyrmex vitiensis (Mann, 1921)	-	O	Medium
Subfamily: Formicinae			
Anoplolepis gracilipes (Smith, 1857	-	CS	Medium
Camponotus pilicornis (Roger, 1859)	-	SC	
Camponotus sp.KAL1	-	SC	
Myrmoteras glabrum (Zettel & Sorger, 2011)	Philippine Endemic	SP	
Nylanderia sp.KAL1	-	O	
Oecophylla smaragdina (Fabricius, 1775)	-	TCS	
Paratrechina longicornis (Latreille, 1802)	-	O	High
Polyrhachis mindanaensis (Emery, 1923)	Philippine Endemic	SC	
Polyrhachis bihamata (Fabricius, 1775)	-	SC	
Polyrhachis inermis (Smith, 1858)	-	SC	
Subfamily: Myrmicinae			
Acanthomyrmex mindanao (Moffett, 1986)	Philippine Endemic	TCS	
Aphaenogaster sp.KAL1	-	O	
Crematogaster sp.KAL1	-	GM	
Crematogaster sp.KAL2	-	GM	
Monomorium floricola (Jerdon, 1851)	-	GM	Low
Myrmycaria aphidicola (Calilung, 2000)	-	TCS	
Pheidole sp.KAL1	-	GM	
Solenopsis geminata (Fabricius, 1804)	-	TCS	Medium
Subfamily: Ponerinae			
Brachyponera obscurans (Walker, 1859)	-	SP	
Diacamma rugosum (Le Guillou, 1842)	-	O	
Hypoponera confinis (Roger, 1860)	-	CR	
Leptogenys diminuta (Smith, 1857)	-	SP	
Leptogenys varicosa (Stitz, 1925)	Philippine Endemic	SP	
Odontomachus scifictus (Sorger & Zettel, 2011)	-	SP	
Odontoponera transversa (Smith, 1857)	-	CR	
Ponera sp. KAL1	-	CR	

Legends: [1]Antweb (2020); [2]Brown (2000); [3]Sarnat (2008); **DD**-Dominant Dolichoderinae; **SC**-Subordinate Camponotini; **O**-Opportunists; **TCS**-Tropical Climate Specialists; **CR**-Cryptic Species; **SP**-Specialists Predators; **GM**-General Myrmicinae.

Table 2. Results of ANOVA in ant functional groups composition between the two sampling sites.

	Sum of Sqrs	df	Mean Square	F	*p*
Between groups	835.408	9	92.8231	3.341	0.03692*
Within groups	277.863	10	27.7863		

*significant

Table 3. Ant diversity index in two sampling sites.

Diversity Indices	Kilakiron Range (S1)			towards Century tree (S2)		
	Agro-ecosystem (1300-1400masl)	Buffer zone (1400-1500masl)	Sec. forest (1500-1800masl)	Agro-ecosystem (1300-1400masl)	Buffer zone (1400-1500masl)	Sec. forest (1500-1800masl)
Taxa_S	7	8	5	13	5	6
Evenness	0.75	0.43	0.78	0.65	0.86	0.85
Dominance	0.23	0.38	0.31	0.16	0.27	0.23
Shannon_*H'*	1.66	1.23	1.36	2.13	1.46	1.63
H' index bet. sites	2.22			2.76		
Overall diversity, *H'*	2.81					

The results suggest that the types of habitats and the observed anthropogenic activities in both sampling sites may have influence ant species composition and abundance on Mt. Kalatungan Range. Previous studies found that there are fewer ant species in simpler habitats than in diverse habitats. The presence of disturbances increases the abundance of some species with a generalized diet, resulting in a community dominated by Generalized Myrmicinae, Opportunists, and Subordinate Camponotini (Lenoir, 2009; Kuate *et al*., 2014; Nooten *et al*., 2019). Moreover, Philippine endemic species were documented in the buffer zone and in secondary forest at an elevation between 1500-1600masl. This indicates that despite the observed disturbances, the area hosts a considerable number of different ant species, and this can be associated with habitats where food, nesting sites, and favorable abiotic factors, such as temperature and humidity, regulate resources and species interactions (Cerda *et al.,* 1998; Holway, 1999; Kaspari, 2000; Kwon, 2017).

On the other hand, six invasive species were documented in this study. *Anoplolepis gracilipes*, *Iridomyrmex anceps, Monomorium floricola*, *Paratrechina longicornis*, *Solenopsis geminata*, and *Technomyrmex vitiensis* were found in both agro-ecosystem site 1 (Mt. Kilakiron range) and agroecosystem site 2 (towards Century tree) of Mt. Kalatungan Range. These species are commonly spread by the movement of infested agricultural products like a banana (*Musa sp.*), corn (*Zea mays*), and even in vegetables that may result in the introduction into new areas. Also, *Iridomyrmex anceps* was found inside the acorn from the ground and the only invasive species documented within the buffer zone. The presence of invasive species indicates a high degree of disturbance in the area (Bharti *et al*., 2013). The potential impact of invasive ant species is inevitable because it may instigate population explosions of some other insect pests such as mealybugs, and it may also increase transmission of plant disease. Despite the susceptibility of invasive species to competitive pressures from some other ant species, invasive species has also the potential to displace native ant populations (Global Invasive Species Database, 2020).

The highest number of species was recorded in the agro-ecosystem (n=13) of sampling site 2 (towards century tree). In table 3, a comparison of diversity index (H') between sampling sites revealed that the sampling site towards Century tree (site 2) had a Shannon index value of 2.76 which indicates moderate diversity based on Fernando biodiversity scale. According to Fernando (1998), a Shannon index value of less than 1.99 indicates very low diversity, values between 2.00-2.49 are of low diversity, between 2.50-2.99 is moderate, between 3.00-3.49 is high, and values greater than 3.50 indicate very high diversity. On the other hand, the overall ant diversity index on Mt. Kalatungan Range at Brgy. Portulin, Pangantucan was moderate. Moreover, species evenness value was very high in almost all habitats, while moderate in the buffer zone of site 1 (Kilakiron range). The habitat of sampling site 1 from 1400-1800 was characterized by a mountainous slope. This might explain the observed difference in diversity indices due to the topography of sampling site 1 that limits the sampling effort and efficiency of the collector.

Results of Bray-Curtis similarity between sampling sites based on species abundance in different habitats suggest that agro-ecosystem and buffer zone have an average similarity in species of 62.54%, while 36.26% in secondary forest (Figure 2). The observed similarity was due to the relative contribution of species abundance to the observed dissimilarity in ant assemblages. This has been revealed in the results of SIMPER analysis that *Dolichoderus thoracicus* and *Solenopsis geminata* are the major contributors to the observed variations in ant species composition in different habitats (Table 4). Moreover, eight functional groups were identified in all sampling sites (Figure 3). The results revealed that in the agro-ecosystem area, 36% of recorded species are invasive and 21% are Opportunists functional group; 11% of species found in the buffer zone are invasive and 44% are Specialists Predator, and 33% of species in the secondary forest are Subordinate Camponotini.

Patterns of functional groups change along the land-use gradient and some ant species were prevalent in highly disturbed areas (Bestelmeyer and Wiens, 1996). *Paratrechina longicornis* is an Opportunist species and commonly encountered in disturbed areas. In this study, *P. longicornis* was found only in the agro-ecosystem. However, due to its ability to invade

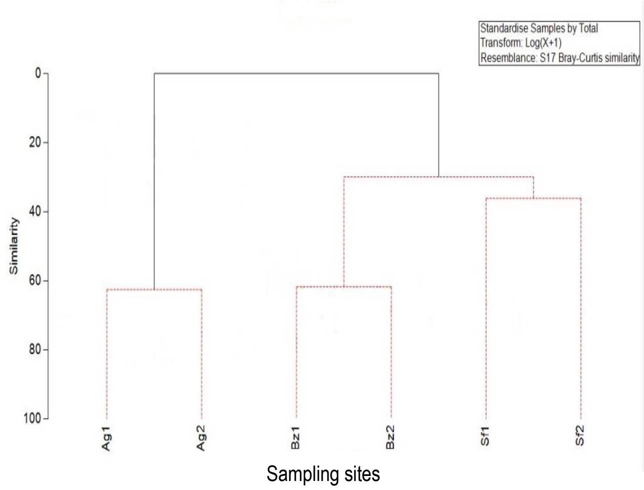

Figure 2. Bray-Curtis similarity matrix of ants in different habitat types.

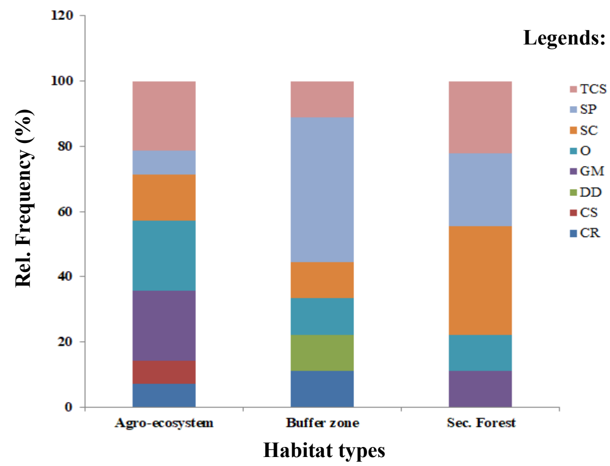

Figure 3. Functional group composition of ants in different habitats of Mt. Kalatungan.

Table 4. Species relative contribution of dissimilarity between sampling sites in SIMPER analyses.

Species	Ave. Dissimi-larity	Dissimilarity/SD	Contribution (%)	Cumulative Contribution (%)
Dolichoderus thoracicus	9.63	7.51	9.63	9.63
Solenopsis geminata	9.63	7.51	9.63	19.25
Myrmicaria aphidicola	8.54	4.85	8.54	27.79
Oecophylla smaragdina	6.39	4.50	6.39	34.18
Polyrhachis mindanaensis	6.31	2.36	6.1	40.48
Paratrechina longicornis	5.97	2.22	5.97	46.45
Leptogenys diminuta	5.43	0.93	5.43	51.88
Anoplolepis gracilipes	5.28	14.87	5.28	57.16
Odontoponera denticulata	3.49	7.83	3.49	60.65
Pheidole sp.KAL1	3.31	0.93	3.31	63.97
Diacamma rugosum	3.17	0.93	3.17	67.14
Brachyponera obscurans	3.14	0.87	3.14	70.28

different habitats and capable of displacing other ants it is considered a serious threat (Global Invasive Species Database, 2020). On the other hand, *Camponotus pilicornis, Camponotus sp. KAL1, Polyrhachis inermis, Polyrhachis mindanaensis,* and *Polyrhachis bihamata* were classified as Subordinate Camponotini (SC) which are co-occurring species and behaviorally submissive to Dominant Dolichoderines (DD) (Hoffman and Andersen, 2003). These observed functional groups exhibit how these species interact with each other according to their resource requirements, environmental conditions, and response to stress and disturbances that may influence their productivity (Bestelmeyer, 2000; Bernadou *et al*., 2013; García-Martínez *et al*., 2015). Furthermore, identified functional groups of ants reflect land-use types on Mt. Kalatungan. The presence of generalist ant species can be used as a bioindicator of the degree of habitat disturbances and in the formulation of conservation measures due to their sensitivity to habitat fragmentation (Bution et al., 2010). Hence, ants are considered a vital tool for land managers to monitor ecosystem conditions because they are part of functioning tropical ecosystem (Underwood and Fischer, 2006).

CONCLUSION

Our study revealed that the ant diversity index in the sampling sites of Mt. Kalatungan Range at Brgy. Portulin, Pangantucan was moderate with very high species evenness in almost all habitats. Ant functional group composition differs between sampling sites. Furthermore, the types of habitats significantly influenced ant species composition and abundance. Also, ant functional groups demonstrate the potential use of ants as bioindicators of disturbances and land-use patterns in different habitats. Hence, data on ant diversity and functional groups provide useful information for the conservation of Mt. Kalatungan Range since the expansion of agricultural activities and human settlements along with the potential introduction of invasive ant species in agricultural products were identified as a potential threat to the protected area.

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