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Species diversity and functional groups of ants (Hymenoptera: Formicidae) in Mt. Agad-agad, Iligan City, Philippines

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Abstract

Ants play a vital role in various ecological processes in the ecosystem. They are involved in nutrient cycling, soil aeration, seed dispersal, and indicator of habitat condition. The study was conducted to determine the species diversity and functional group composition of ants near the residential area and agro-ecosystem of Mt. Agad-agad, Brgy. Puga-an, Iligan City, Philippines. Ants were collected using baits and hand collecting to sample ants. A total of 4,047 individuals belonging to four subfamilies, 17 genera, and 23 species were documented in the two sampling sites. Species diversity was recorded highest in agro-ecosystem with *H'*=2.74 and species richness of 3.96. Also, five invasive species, including *Paratrechina longicornis* was recorded in both sampling sites. The most abundant functional group was Generalized Myrmicinae (36%) near the residential area, while Subordinate Camponotini (29%) in Agro-ecosystem. The result suggests that existing land-use influences species and functional group composition of ants, and the presence of invasive species indicates the magnitude of anthropogenic disturbances in the area.

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Introduction

Ants are ecologically important group due to their inherent ecological qualities (Underwood and Fisher, 2006), including their potential use as biological control agent (e.g. *Oecophylla smaragdina*) (Lim *et al.,* 2008; Offenberg and Witwatwitaya, 2010), facilitate seed dispersal (Handel and Beattie, 1990), induced soil modification (Dostal *et al.,* 2005) and nutrient cycling (Verchot, 2003). Ants are highly responsive to anthropogenic impacts on the environment (Folgarait, 1998), and plant abundance (Cardoso and Schoereder 2014) influence ant species diversity and distributions (Human *et al.,* 1998; Fergnani *et al.,* 2008). Hence, ants are recognized as bioindicators in the context of detecting ecological change associated with human land-use (Andersen *et al.,* 2008). At present, there are 577 species of ants in the Philippines with 213 endemic and 7 introduced species (Antweb, 2020). At least 265 species are known to occur on the island of Luzon while 99 species recorded in Mindanao. The current number of known ants in Mindanao indicates that the island needs more inventory studies.

Mount Agad-agad range is located near the center of the highly urbanized City of Iligan. It is bounded on the south by the Pugaan Mountain Range, on the southwest by the Ugdongan mountain range, on the northwest by Luyong Hills, and on the north by Cigaluga Hills. It has an estimated elevation of 490 meters above sea level (masl). Mount Agad-agad has been proposed to be established as a Protected Area. Currently, no faunal inventory studies have been conducted in Mt. Agad-agad, particularly on ants. The present work aimed to determine the species diversity and functional group composition of ants at Mount Agad-Agad in Brgy. Pugaan, Iligan City.

Materials and methods

Sampling Area

The study was conducted in the vicinity of Mt. Agad-agad, Brgy. Puga-an, Iligan City. Two sampling sites were identified according to land-use types (Fig. 1). Sampling site 1 was near the residential area, located at 8°13'25.4"N latitude and 125°16'05.5"E longitude. The area was characterized by dominant plants, including *Gmelina arborea*, *Cocos nucifera*, *Chromolaena odorata*, *Lantana camara,* and *Paspalum conjugatum* (buffalo grass). Sampling site 2 was an agro-ecosystem, located at 8°12'36.3"N latitude and 124°16'15.7"E longitude. *Cocos nucifera*, *Chromolaena odorata*, *Lantana camara, Saccharum sp., Musa acuminata × balbisiana* were common in the area.

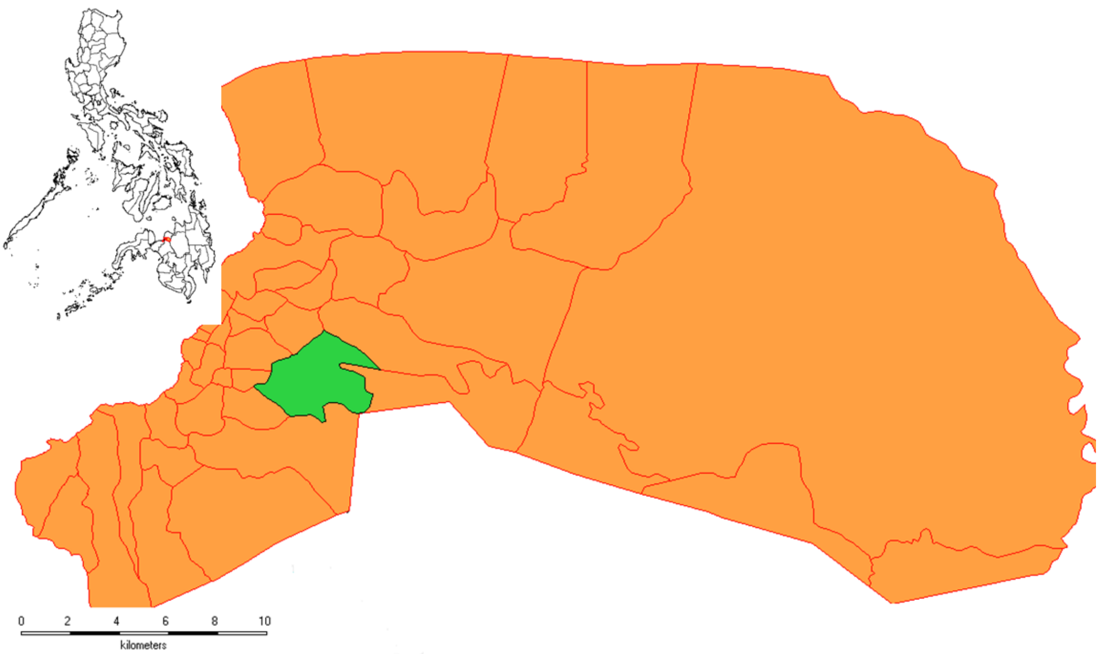

Fig. 1. Map showing the location of Mt. Agad-agad (green) in Brgy. Puga-an, Iligan City (orange).

Collection and Identification of samples

Ants were collected using a combination of techniques: hand sampling method and passive sampling by using hotdog baits. All collected samples were preserved in 95% ethanol and identified using published taxonomic references and online reference database of ants. The collection of samples was conducted on November 9, 16, and 23, 2019 for a total of 72 man-hours.

Statistical Analysis

The software PRIMER v7 (Clarke and Gorley, 2015) was used to calculate diversity indices and similarity percentage (SIMPER) to examine the species contribution to the observed differences in species composition between sampling sites. Abundance data were log10 (n+1) transformed prior to statistical run in order to successfully control the heterogeneity of variance (Zar, 1984).

Results and discussion

Species composition and abundance

A total of 4,047 individuals belonging to 23 species representing four subfamilies of Formicidae were documented in the sampling sites (Table 1). In residential area, *Carebara diversa* was the most abundant species (20%) and commonly found foraging on leaf litter, shrubs, and in disturb habitats. They prey on grasshoppers, crickets, and earthworm and have shown aggressive behavior to colonize available food resources. In agro-ecosystem, *Solenopsis geminata* was the most abundant species (35%) and preferred to nest in the soil and open sunny areas and disturb habitats. The mounds were commonly observed along the trail and near agricultural crops. The spread of *S. geminata* has been associated to disturbances and anthropogenic activites that facilitate colonization and reestablishment (Hill *et al*., 2008). Both *S. geminata* and *C. diversa* demonstrate efficiency in exploitation of available food resources that could lead to the displacement of native species which has an ecological impact on the ecosystem.

Table 1. Species composition and abundance of ants in Mt. Agad-agad.

Species	Threat Level	Number of Individuals		Total Count
		Residential Area	Agro-ecosystem	
Subfamily: Dolichoderinae				
Dolichoderus thoracicus Smith, 1860		218	202	420
Tapinoma melanocephalum Fabricius, 1793	Medium	915		915
Iridomyrmex anceps Roger, 1863			6	6
Subfamily: Formicinae				
Anoplolepis gracilipes Smith,1857	Medium	243		243
Camponotus cf. philippinensis Zettel & Zimmermann, 2007			6	6
Oecophylla smaragdina Fabricius,1775		24		24
Paratrechina longicornis Latreille, 1802	High	13	17	30
Polyrhachis armata Le Guillou, 1842			36	36
Polyrhachis follicula Menozzi, 1926			15	15
Polyrhachis chapmani Kohout, 2006			9	9
Polyrhachis sp.1			3	3
Subfamily: Myrmicinae				
Carebara diversa Jerdon, 1851		215	220	435
Crematogaster sp.1		102	150	252
Crematogaster sp.2		71	70	141
Crematogaster sp.3			3	3
Dilobocondyla cf. chapmani			3	3
Pheidole sp.1		108		108
Pheidole sp.2		3		3
Solenopsis geminata Fabricius, 1804	Medium	1029		1029
Subfamily: Ponerinae				
Diacamma rugosum Le Guillou, 1842			69	69
Odontomachus simillimus Smith, 1858	Low		120	120
Odontoponera transversa Smith, 1857			147	147
Tetraponera extenuata Ward, 2001			30	30

Moreover, four invasive species were recorded near the residential area, with three species classified as 'Medium' threat (*Tapinoma melanocephalum, Anoplolepis gracilipes, Solenopsis geminata*) and one 'High' threat level, *Paratrechina longicornis*. In contrast, two invasive species were recorded in the agro-ecosystem, *P. longicornis and Odontomachus simillimus*. Most introductions of these invasive species can be associated to transportation of infested agricultural products in the area. For instance, *P. longicornis* and *T. melanocephalum* were commonly observed on commercial fruits and vegetable crops which could potentially facilitate the dispersal of these species. The economic and ecological consequence of the introduction of invasive species can be considered costly as some destroy seedlings and disrupts pollination (Sinu *et al.*, 2017; Hansen and Muller, 2008).

Species richness and diversity

Table 2 showed the diversity indices of the sampling sites. The highest value for species richness was recorded in the agro-ecosystem and significant variation has been found between sampling sites ($p<0.05$). Reduced species richness in residential area was due to the presence of dominant species, including *T. melanocephalum* and *S. geminata*. The study of Parr and Gibb (2010) found that species richness is reduced where the abundance of dominant ants is high. In addition, the existing land-use might also contribute in low species richness in the area. Mt. Agad-agad and its environs have been undergoing land-use change as human settlement and agricultural expansion has been observed.

Agricultural activities have been associated to contribute in decreased ant diversity and functional groups of native ants (Holway *et al.*, 2002; Kwon *et al.*, 2014; Heuss *et al.*, 2019), and increases invasion of fire ants abundance, which potentially affect native wildlife (Suarez *et al.*, 1998; Todd *et al.*, 2008) as a resuslt of habitat alteration. Furthermore, results of SIMPER analyses revealed 41.17% species similarity and *Carebara diversa, Dolichoderus thoracicus, Crematogaster* sp. 1 and *Crematogaster* sp. 2 were the major contributors to the observed differences in species composition of ants between sampling sites (Table 3). The understory vegetation and land-use types can be attributed in the observed ant species similarity. Understory plants can provide favorable microhabitat and microclimatic conditions and the necessary food resources for ants. The genus *Crematogaster* is a cosmopolitan species that occur in most habitats and efficient in locating food resources; the genus *Carebara* forage mostly on soil and litter; and genus *Dolichoderus* occur in habitats where presence of Dominant Dolichoderine species are generally not abundant (Andersen *et al.*, 1997).

Table 2. Diversity indices of ants in two sampling sites of Mt. Agad-agad.

Diversity indices	S	N	d	J'	H'
Residential	11	2941	2.55	0.97	2.33
Agro-ecosystem	17	1106	3.96	0.97	2.74

Legends: S= no. of species; N=Total individuals; d=Species richness; J'=Pielou's evenness; H'=diversity.

Table 3. Results of SIMPER analysis between sampling sites of Mt. Agad-agad.

Species	Ave. Similarity	Species Contribution (%)	Cumulative Contribution (%)
Carebara diversa	9.96	24.19	24.19
Dolichoderus thoracicus	9.84	23.91	48.09
Crematogaster sp.1	8.59	20.85	68.95
Crematogaster sp.2	7.9	19.18	88.13

Functional group across land-use types

Six functional groups were found in two sampling sites (Fig. 2). These include Specialist Predators (SP), Generalized Myrmicinae (GM), Cryptic Species (C), Subordinate Camponotini (SC), Opportunist (O), and Tropical-Climate Specialists (TCS). The highest number of functional group was recorded in Agro-ecosystem.

The sampling site in agro-ecosystem was characterized of various herbaceous plants, vegetable crops, cereals, and fruit trees, which can provide more structurally complex habitat and constrains the types of ants that can support various functional types of ants (Andersen, 2000). Furthermore, the functional groups SC and SP were found exclusively in the Agro-ecosystem. Subordinate camponotini are composed of arboreal species foraging on different herbaceous plants, including *Camponotus cf. philippinensis, Polyrhachis armata, P. follicula, P. chapmani,* and *Polyrhachis sp.4*. This group are large size and often found in shaded habitat (Andersen, 1995; Parui *et al.*, 2015). On the other hand, Specialist predators were composed of *Odontomachus simillimus* and *Odontoponera transversa*, which prefer open areas and specialized nesting sites and prefer specific prey. Moreover, the most abundant were Generalized Myrmicinae (GM) near the residential area, while Subordinate Camponotini in Agro-ecosystem with 36% and 29% relative abundance, respectively.

Both Generalized myrmicines and Subordinate camponotines were behaviorally dominant taxa and exhibit high abundance in lowland open habitats in the tropics where insolation of soil surface is low. Also, the high abundance of GM was associated to their higher tolerance to environmental disturbances and absence of Dominant Dolichoderine functional group (Andersen, 2000).

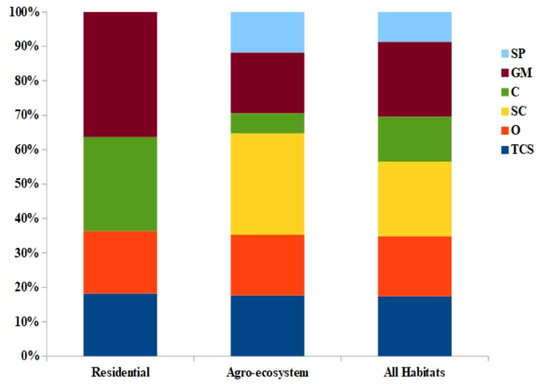

Fig. 2. Functional group composition in different land-use types of Mt. Agad-agad, Iligan City. *Legends:* SP-Specialists Predator, GM- Generalized Myrmicinae, C-Cryptic, SC- Subordinate Camponotini, O-Opportunistic, TCS-Tropical Climate Specialist.

Conclusion

Agro-ecosystem of Mt. Agad-agad demonstrates the highest ant species diversity and functional group composition and is attributed to the existing land-use types in the area. The presence of *Paratrechina longicornis* indicates the magnitude of anthropogenic disturbances in the area. *P. longicornis* species is primarily spread by human activities. Thus, inventory studies on ants in Mindanao will facilitate mapping the occurrence of invasive species, and increasing community awareness will help curb the spread.

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