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Habitat wise distribution of ants with special reference to their host plants in Kholahat Reserve Forest, Assam, India

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Abstract
Ants play a major role in the terrestrial ecosystem by conducting many key ecological functions. The present study was undertaken to investigate the habitatwise distribution of ants in Kholahat Reserve Forest, Assam. The ants were collected from forest habitat, grassland habitat and human habitat from September 2017 to August 2020. A total of 30 ant species belonging to 22 genera and 6 Subfamilies were recorded. The Shannon diversity indices indicated that the diversity was highest in forest habitat (3.32), followed by grassland habitat (3.29) and lowest in human habitat (3.04). The Sorenson's similarity index was highest between forest and grassland habitat while lowest between forest and human habitat. Six ant species were observed in teak and sal trees, while nine ant species were observed exclusively foraging on the soil during the daytime.

Keywords: Ants, Assam, Habitatwise distribution, Kholahat reserve forest

Introduction
Ants, the minute and often negligible little creature performed an interesting model system for ecological studies due to the role they played in the ecosystem. They are the bioindicators to determine the forest quality as they are associated with biogeochemical cycles of nature such as the nitrogen and carbon cycles. The soil ants are known as ecosystem engineers or soil engineers. They act as seed dispersal agents and help in pollination. Ants are very sensitive to the microclimatic conditions and habitat structure therefore, they are quickly responded to any environmental changes including land use disturbances, as well as their restoration efforts [1, 2]. The ant diversity is associated with the availability of shelter, nesting sites, and foraging territory for food sources [3, 4]. Changes in vegetation can effect on the availability of food resources and nesting sites for ants [5]. Apart from this, the plant community plays a vital role in ant diversity [6]. The mutualistic relationship between ants and plants is a widespread phenomenon as plants provide shelter and food for ants on the other hand ants provide protection to the plants from other herbivores [7].
Assam is a biodiversity hotspot area, but very scanty work has been done on the habitatwise distribution of ants in Assam. In the present study Kholahat Reserve forest is chosen as the ideal study site due to the presence of various habitats such as forest habitat, grassland habitat and human habitat. Except for the diversity of avian species no record of studying any floral and faunal diversity. Therefore the present study was conducted to gather some knowledge about the habitatwise distribution of ants as well as their host plants.

Materials and Methods
Study Site: Kholahat Reserve Forest is located at a geographical location of $92^{0}0'$-$93^{0}30'$E longitude and $25^{0}30'$-$26^{0}30'$N latitude. This reserve forest is a tropical semi evergreen forest. The forest is mainly composed of three types of forest such as teak forest, sal forest and natural forest. Based on the visual observations the survey was carried out in three different habitats- (a) forest habitat, (b) grassland habitat and (c) human habitat.

Survey Time: The survey was carried out twice in a month from 8 am to 2 pm in each study site from September 2017 to August 2020.

A sampling of Ants: For a collection of ants the standard protocol given by Agosti *et al*. [8] and Bharti *et al*. [9] was followed with modifications. Various sampling techniques such as beating vegetation, sugar baiting and hand collection were carried out for a sampling of ants. At each study site, one transect (200m length and 5m wide) was selected along which the samples were collected. Twenty sugar baits were placed in each transect with 10m spacing between the baits. Hand collection was carried out within an area of 2.5m on either side of the transect by searching for ants tree trunks, leaves, under the rocks. Ants foraging on the vegetation were collected by beating the vegetation of within an area of 2.5m left and right of the transect.

Preservation of Ants: The collected ants were washed properly and preserved in 70% alcohol.

Identification of Ants: The collected ants were further taken to the laboratory, observed under a Leica stereo zoom microscope and identified based on identification keys [10, 11].

Data Analysis: Various diversity indices such as Shannon Diversity Index (H'), Simpson Index (D), Evenness Index were calculated using PAST software.
Sorenson's Similarity index was calculated by as follows-
Sorensen's Similarity Index, β = 2C/(S1+S2)
Where,
S1= Number of species present in the first habitat
S2= Number of species present in the second habitat
C= Number of common species present in both habitat

Results

In the present study 30 ant species belonging to 22 genera and 6 Subfamilies were recorded from Kholahat Reserve Forest. 30 ant species were collected from forest habitat, 28 species were collected from grassland habitat and 22 species were collected from human habitat (Table 1). Various diversity indices were analyzed for the ant species collected from different habitats. The species diversity indices were different among the three different habitats. The Shannon Diversity Index was highest in forest habitat (3.32) followed by grassland habitat (3.29) and the lowest in human habitat (3.04) (Table 2). While evenness index was similar in grassland habitat and human habitat (0.95) and lowest in forest habitat (0.92) (Table 2). The ant abundance was highest in forest habitat followed by grassland habitat and lowest in human habitat (Fig. 1).
The Sorenson's Similarity Index was highest in Forest habitat and Grassland habitat (0.97) while Forest habitat and Human Habitat show the lowest (0.85) (Table 3). The Table 4 represents the collected ant species with some of their common host plants and collecting sites.

Table 1: Distribution of ants in different habitats of Kholahat Reserve Forest (+= Present, - = Absent)

Subfamilies	Species	Habitats		
		F	G	H
Dolichoderinae	*Dolichoderus moggridgei* (Forel, 1886)	+	+	+
	Dolichoderus thoracicus (Smith, 1860)	+	+	+
	Tapinoma melanocephalum (Fabricius, 1793)	+	+	+
	Technomyrmex albipes (Smith, 1861)	+	+	+
Dorylinae	*Aenictus brevicornis* (Mayr, 1879)	+	_	_
Formicinae	*Anoplolepis gracilipes* (Smith, 1857)	+	+	+
	Camponotus compressus (Fabricius, 1787)	+	+	+
	Camponotus mitis (Smith, 1858)	+	+	+
	Camponotus sp	+	+	+
	Oecophylla smaragdina (Fabricius, 1775)	+	+	+
	Paratrechina longicornis (Latreille, 1802)	+	+	+
	Polyrhachis dives (Smith, 1857)	+	+	+
	Polyrhachis laevissima (Smith, 1858)	+	+	_
Myrmicinae	*Aphaenogaster feae* (Emery, 1889)	+	+	+
	Cataulacus granulatus (Latreille, 1802)	+	+	_
	Crematogaster anthracina (Smith, 1857)	+	+	_
	Crematogaster rogenhoferi (Mayr, 1879)	+	+	+
	Meranoplus bicolor (Guerin-Meneville, 1844)	+	+	+
	Monomorium indicum (Forel, 1902)	+	+	+
	Monomorium pharaonis (Linnaeus, 1758)	+	+	+
	Pheidologeton diversus (Jerdon, 1851)	+	+	+
	Tetramorium bicarinatum (Nylander, 1846)	+	+	+
Ponerinae	*Brachyponera luteipes* (Mayr, 1862)	+	+	+
	Diacamma rugosum (Le Guillou, 1842)	+	+	+
	Diacamma scalpratum (Smith, 1858)	+	+	_
	Leptogenys kitteli (Mayr, 1870)	+	+	_
	Odontoponera denticulata (Smith, 1858)	+	+	+
	Pachycondyla sp	+	+	+
Pseudomyrmicinae	*Tetraponera rufonigra* (Jerdon, 1851)	+	+	_
	Tetraponera sp	+	_	_

(F= Forest Habitat, G= Grassland Habitat, H= Human Habitat)

Table 2: Different diversity indices of ant species at different habitats of Kholahat Reserve Forest

Diversity Indices	F	G	H
Shannon Diversity Index (H')	3.32	3.29	3.04
Simpson Index (D)	0.96	0.96	0.95
Evenness Index	0.92	0.95	0.95
Species Richness	30	28	22

(F= Forest Habitat, G= Grassland Habitat, H= Human Habitat)

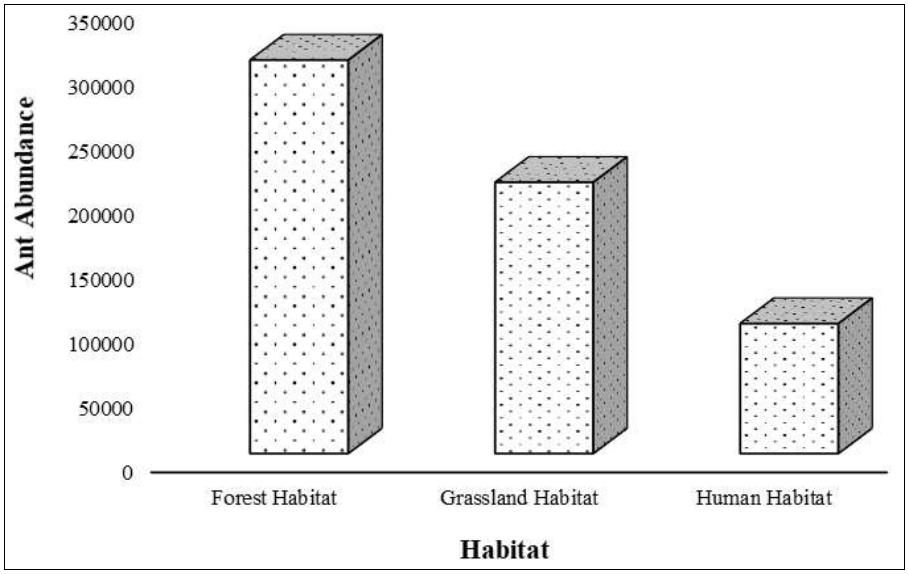

Fig 1: Ant Abundance across different habitats of Kholahat Reserve Forest

Table 3: Sorenson's Similarity index of ant species in different habitats

Habitat Pairs	Shared Species	Sorensons's Similarity Index
Forest-Grassland	28	0.97
Forest-Human Habitat	22	0.85
Grassland- Human Habitat	22	0.88

Table 4: Name of the ant species with collection sites

Species	Observed sites (Plants and Soil)	
	Plants	Soil
Dolichoderus moggridgei	*Hibiscus rosasinensis*	-
Dolichoderus thoracicus	*Hibiscus rosasinensis*	Present
Tapinoma melanocephalum	*Hibiscus rosasinensis, Jasminum grandiflorum, Zizyphus jejuba*	Present
Technomyrmex albipes	*Jasminum grandiflorum, Moringa oleifera, Terminalia Bellirica*	-
Aenictus brevicornis	-	Present
Anoplolepis gracilipes	*Gmelina arborea, Moringa oleifera*	Present
Camponotus compressus	*Hibiscus rosasinensis, Magnifera indica, Moringa oleifera, Zizyphus jejuba, Jasminum grandiflorum, Clerodendrum infortunatum*	Present
Camponotus mitis	*Hibiscus rosasinensis, Jasminum grandiflorum*	Present
Camponotus sp	*Hibiscus rosasinensis, Magnifera indica, Moringa oleifera, Zizyphus jejuba, Jasminum grandiflorum*	Present
Oecophylla smaragdina	*Tectona grandis, Shorea robusta, Magnifera indica, Moringa oleifera, Tinospora cordifolia, Aegel marmelo, Gmelina arborea*	Present
Paratrechina longicornis	*Hibiscus rosasinensis, Jasminum grandiflorum, Ricinus communis, Tectona grandis, Shorea robusta, Magnifera indica, Moringa oleifera, Tinospora cordifolia, Aegel marmelos*	Present
Polyrhachis dives	*Ageratum conyzoides, Ricinus communis, Ipomoea* sp	Present
Polyrhachis laevissima	-	Present
Aphaenogaster feae	*Tectona grandis, Shorea robusta, Jasminum grandiflorum*	Present
Cataulacus granulatus	-	Present
Crematogaster anthracina	*Tectona grandis, Shorea robusta*	Present
Crematogaster rogenhoferi	*Tectona grandis, Shorea robusta, Magnifera indica*	Present
Meranoplus bicolor	*Jasminum grandiflorum, Clerodendrum infortunatum*	Present
Monomorium indicum	*Hibiscus rosasinensis, Jasminum grandiflorum, Ricinus communis, Clerodendrum infortunatum*	-
Monomorium pharaonis	*Clerodendrum infortunatum*	Present
Pheidologeton diversus	-	Present
Tetramorium	*Hibiscus rosasinensis, Jasminum grandiflorum, Ricinus communis*	Present

bicarinatum		
Brachyponera luteipes	-	Present
Diacamma rugosum	-	Present
Diacamma scalpratum	-	Present
Leptogenys kitteli	*Gmelina arborea*	-
Odontoponera denticulata	-	Present
Pachycondyla sp	-	Present
Tetraponera rufonigra	*Tectona grandis, Shorea robusta, Terminalia arjuna*	-
Tetraponera sp	*Tectona grandis, Shorea robusta*	-

Discussion

The findings of the present study showed that the distribution of ant species is influenced by their habitats. The highest ant diversity was recorded from forest habitat, followed by grassland habitat and the lowest in the human habitat. This finding was supported as well as contradicted by Chahvan and Pawar [12] and Chanda [13]. They reported that forest habitat exhibit the highest ant diversity and grassland habitat exhibit the lowest ant diversity. Forest habitat shows the highest ant diversity as it comprises many trees that provide food and shelter to the ants. Sunil Kumar *et al*. [14] reported that ant diversity increases with increasing number of trees and canopy cover. On the other hand, in the human habitat area lowest ant diversity was recorded. Human activities as well as man-made disturbance possess negative effect on the ant diversity. Anthropogenic disturbance causes elimination of less disturbance-adapted species and allowed the more tolerant species to survive [15]. The vegetation structure and rate of disturbance determine the ant diversity [16].

Dolichoderus moggridgei and *Dolichoderus thoracicus* were common in all three habitats. Both species were observed in the flower, leaves and stems of *Hibiscus rosasinensis* trees. It was reported that they have mutualistic relationship with honeydew producing homopteran insects [17, 18, 19]. *Tapinoma melanocephalum*, was observed in the leaves *Hibiscus rosasinensis, Jasminum grandiflorum, Zizyphus jejuba.* The nest of these ants was difficult to detect [20]. It was reported that *Hibiscus rosasinensis* is host plant of *Tapinoma melanocephalum* [21]. *Technomyrmex albipes* was observed in the flower, leaves and stems of *Jasminum grandiflorum, Moringa oleifera* and *Terminalia Bellirica.* It was reported that they have a mutualistic relationship with aphids [22]. *Aenictus brevicornis* was confined only to the forest habitat. They were observed foraging on the soil. *Anoplolepis gracilipes* were common in all habitats and observed foraging on the *Gmelina arborea*, *Moringa oleifera* and soil. It was reported these invasive ants can survive in any disturbed habitats as well as they are capable of invading any natural habitats by eliminating the native ants [23]. *Camponotus compressus*, *Camponotus mitis* and *Camponotus* sp were reported from all three habitats in the present study. *Camponotus compressus* was observed foraging on the *Hibiscus rosasinensis, Magnifera indica, Moringa oleifera, Zizyphus jejuba, Jasminum grandiflorum, Clerodendrum infortunatum* and soil; *Camponotus mitis* was observed foraging on the *Hibiscus rosasinensis, Jasminum grandiflorum* and soil; *Camponotus* sp was observed foraging on the *Hibiscus rosasinensis, Magnifera indica, Moringa oleifera, Zizyphus jejuba, Jasminum grandiflorum* and soil. It was reported that *Cajanus cajan*, *Lablab purpureus*, *Phaseolus sinensis*, *Vicia faba*, *Vigna mungo* and *Vigna radiata* are common host plants of *Camponotus compressus* [24]. *Oecophylla smaragdina* was observed foraging on the *Tectona grandis, Shorea robusta, Magnifera indica, Moringa oleifera, Tinospora cordifolia, Aegel marmelo, Gmelina arborea* as well as on the soil. It was reported that *Magnifera indica* is one of the common host plant of *Oecophylla smaragdina* [25]. *Paratrechina longicornis* was the most common ant species as they are found in all three habitats and interestingly, it was observed that they are found in almost all the observed trees as well as on the soil. They are associated with aphids [26] and spread by human commerce [27]. *Polyrhachis dives* were reported from all three habitats and observed foraging on the soil, leaves as well as tree trunks. They make their nest between the leaves through the larval silk [28]. On the other hand, *Polyrhachis laevissima* was observed foraging exclusively on the soil in forest habitat and grassland habitat but absent in human habitat. *Brachyponera luteipes, Diacamma rugosum, Odontoponera denticulata, Pachycondyla* sp. were observed during foraging on the soil in all three habitats. While *Diacamma scalpratum and Leptogenys kitteli* were confined to forest habitat and grassland habitat. *Diacamma rugosum* and *Diacamma scalpratum* make their nest under the debris and stones. *Tetraponera* sp was only confined to forest habitat, while *Tetraponera rufonigra* was observed in forest habitats and grassland habitat. They were found foraging on *Shorea robusta* and *Tectona grandis* where they make their nest under the bark. This was in conformity with that of Sriyani and Fernando [29], who reported that *Tectona grandis* is one of the host plants of *Tetraponera rufonigra* and they make their nest under the bark. *Aphaenogaster feae* were observed foraging on the soils, trunk and leaves of the plants of all three habitats. Their nests were observed under the soil and under the stones. *Cataulacus granulatus* was observed foraging on the floor of forest habitat and grassland habitat while absent in human habitats. *Monomorium indicum* was observed foraging on the *Hibiscus rosasinensis, Jasminum grandiflorum, Ricinus communis, Clerodendrum infortunatum* as well as on the soil. While *Monomorium pharaonis* were observed foraging on the *Clerodendrum infortunatum* as well as on the ground. It was reported that *Lablab purpureus*, *Vicia faba* and *Vigna radiata* are common host plants of *Monomorium pharaonis* [24]. They have a mutualistic relationship with aphids [30]. *Pheidologeton diversus* was common in all three habitats and they were observed foraging on the soil as a group. *Meranoplus bicolor* was found during foraging on the *Jasminum grandiflorum, Clerodendrum infortunatum* and soil in all the three habitats. It was reported that *Cajanus cajan*, *Lablab purpureus*, *Phaseolus sinensis*, *Vicia faba*, *Vigna mungo* and *Vigna radiata* are common host plants of *Meranoplus bicolor* [24]. They have a mutualistic relationship with hemipteran insects [31]. *Crematogaster rogenhoferi* was common in all three habitats and observed during foraging on the *Tectona grandis, Shorea robusta, Magnifera indica* and on the soil, while *Crematogaster anthracina* was confined to forest habitat and grassland habitat and observed during foraging on the *Tectona grandis,*

Shorea robusta and soil. *Tetramorium bicarinatum* was observed in all three habitats and observed in *Hibiscus rosasinensis*, *Jasminum grandiflorum*, *Ricinus communis* and soil. It was reported that they are one of the commonest ants associated with coccids [32].

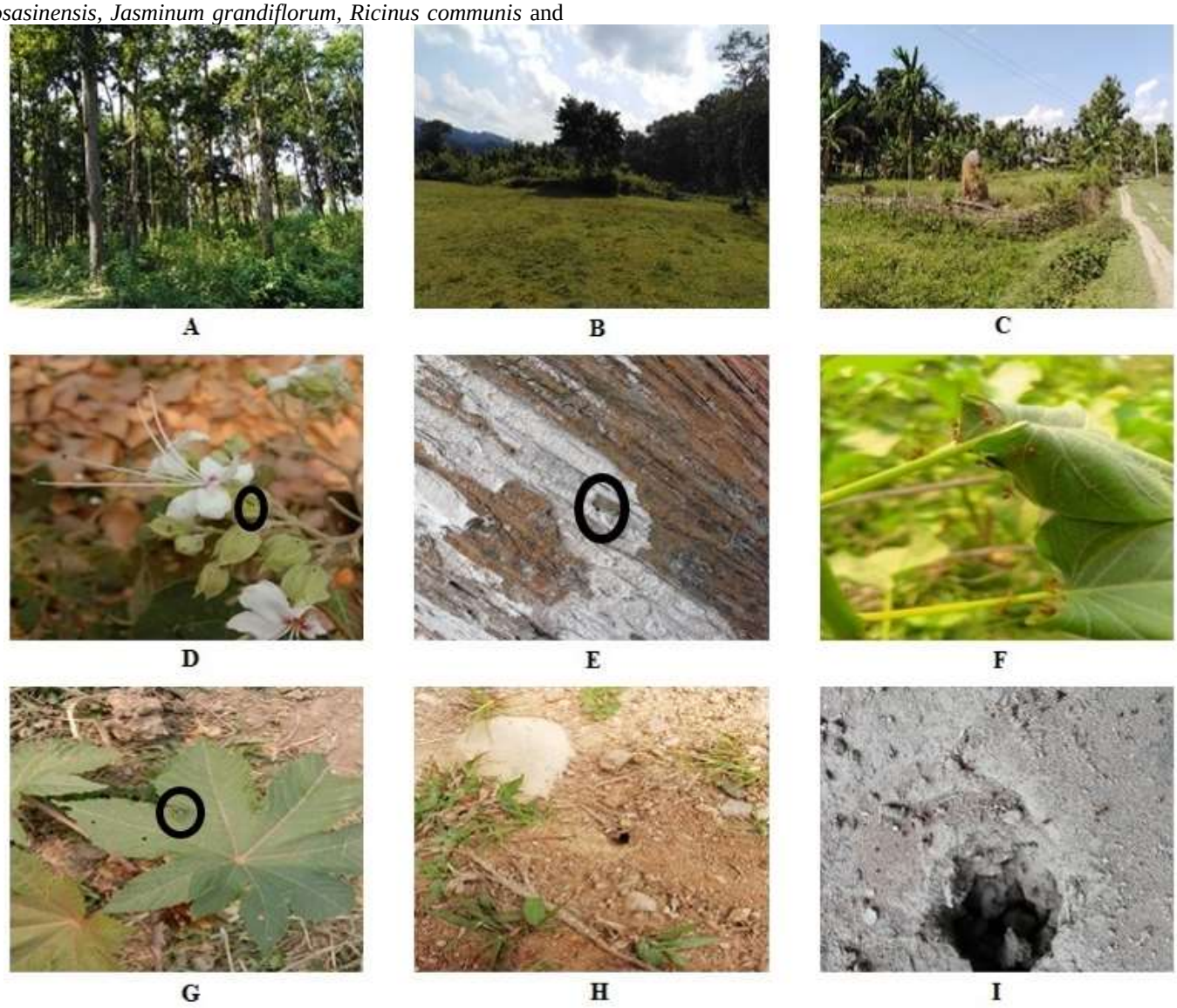

Plate 1: A) Forest Habitat, B) Grassland Habitat, C) Human Habitat, D) *Monomorium indicum* observed in *Clerodendrum infortunatum,* E) *Crematogaster rogenhoferi* observed in *Tectona grandis,* F) *Oecophylla smaragdina* observed in *Tinospora cordifolia,* G) *Polyrhachis dives* observed in *Ricinus communis*, H) Nest of *Odontoponera denticulata*, I) Nest of *Aphaenogaster feae*

Conclusion

From the present study it can concluded that ant diversity vary among various habitats of the Kholahat Reserve Forest. Vegetation as well as host plants are the key factors that determine the variability in ant diversity.

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