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Diversity and Distribution of Ants (Hymenoptera: Formicidae) in Sunderbans, West Bengal, India

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Abstract: The present study deals with the biodiversity of ants in Indian Sunderbans. Study locations were selected from reclaimed area of eastern, central and western sector of Indian Sunderbans. Ants were collected randomly during pre-monsoon and post-monsoon period from different habitats of selected locations likely homestead orchard, paddy field, sandy beach, mangrove patch and waste land by using honey bait and hand picking method. Altogether 62 species of ants under 30 genera and 5 subfamilies were identified from the inhabited areas of Sunderbans. The present study revealed that the predominant subfamily was the Myrmicinae with 12 genera and 28 species followed by Formicinae, Ponerinae and Dolichoderinae. The genus *Camponotus* was found to be the most speciose genus in all the studied locations. Total 4 genera namely *Camponotus*, *Pheidole*, *Lepisiota* and *Crematogaster* were common in all the six habitats. The species richness of ant communities in the mangrove habitat was found relatively poor than agricultural land and homestead orchard. The ant genera *Monomorium*, *Camponotus*, *Pheidole*, *Crematogaster*, *Paratrechina*, *Lepisiota*, *Tapinoma*, *Diacamma*, *Nylanderia*, *Tetramorium*, *Pseudoneoponera*, *Trichomyrmex*, *Iridomyrmex*, *Solenopsis*, *Carebara*, *Dolichoderus*, *Dilobocondyla*, *Leptogenys*, *Oecophylla*, *Cataulacus* and *Tetraoponera* were found in both pre- and post-monsoon seasons. Shannon diversity index and Simpson diversity index values indicated that the ant community is mature and stable in studied locations of Sunderbans.

Keywords: Ants, Mangrove, Biodiversity, Reclaimed area, Sunderbans, Myrmicinae, Formicinae, Ponerinae, Dolichoderinae

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Introduction

Sunderbans is one of the most vulnerable coastal habitats which constitute a unique mangrove forest ecosystem, located in the tropical and

subtropical region of the world. The ecosystem is extremely prone to several natural calamities which directly affects integrity of biodiversity and

changes the tropic structure of the biological communities. Sunderbans is characterized by luxuriant mangrove vegetation. There are 64 species of mangrove plants and mangrove associates in the Sunderbans which include Kaora (*Sonneratia apetala*), Baen (*Avicennia* spp.), Gewa (*Exoecaria agallocha*), Kankra (*Bruguiera gymnorrhiza*) etc. Not only mangroves but also various plants like *Salmelia malabaricum*, *Thespesia populnea*, *Erythrina indica*, *Acacia* sp, *Azadirachta indica* and *Suaeda* sp. are commonly found in Sunderbans. The seasonal climate may be categorized as pre-monsoon or summer, monsoon and post-monsoon. The pre-monsoon period is predominantly dry starting from March to June, occasionally accompanied by rains and thunder storms. Monsoon starts from July and prolongs upto October with excess of humidity. The post-monsoon period is characterized by cold weather from November to February.

Ants are most fascinating group of social insect and ecologically diverse because they act as seed dispersers (Wilson, 1992), leaf and seed predators, and in some cases as pollinators. They also play an important role in soil turn over and nutrient recycling (Lal, 1988). Ants are symbiotic of ant-plant relationships (Davidson, 1993). They are very sensitive to habitat transformation and disturbances so they are used as indicator species (Hoffmann and Andersen, 2002). They are relatively easy to collect in a standardized way as most ant species are stationary and have a perennial nest with a restricted foraging range. Globally there are about 16,546 valid species (<https://www.antweb.org>). As per the recent classification, all ants are grouped into 290 genera and 21 subfamilies (Bolton, 2003). India representing 828 valid species and subspecies of ants belonging to 100 genera grouped in 10 subfamilies (Bharti *et al.*, 2016)

All the members of ant fall into the single family Formicidae. This family is included in the Superfamily Vespoidea of the order Hymenoptera. They are differentiated from other such groups by elbowed antennae on the head and a constricted

area between the thorax and abdomen called the petiole. The petiole has either one or two nodes. Most of the ants found in a colony are workers and do not have wings while a sting is present in many ants whereas it is absent in several common groups (e.g. Dolichoderinae, Formicinae).

Many research works are published on ant diversity from different region of India. But studies on ant diversity in Sunderbans are limited. Tiwari *et al.* (1999) reported 128 ant species, 45 genera under 7 subfamilies from different districts of West Bengal but does not cover Sunderbans. Therefore a significant scope emerges to study on the above mentioned title. The present study deals with the biodiversity of ants in Indian Sunderbans.

Materials and Methods

Study Area:

Field research was carried out in the reclaimed areas of Sunderbans which lies between 21°31'00" N - 22°30'00" N latitude and 88°10'00" E - 89°51'00" E longitude and is the largest mangrove delta of the world. The present study spreads over the districts of North and South 24-Parganas of the state of West Bengal facing the Bay of Bengal. Total 5 locations were selected from different regions.

Site 1- Sagar: Specimens were collected from different habitats of Sagar Island which is situated in the western sector of Sunderbans at the confluence of river Hugli and the Bay of Bengal.

Site 2- Bakkhali (21°34'59"N/88°16'16"E): This is a small village of western sector of Sunderbans situated into the vast expanse of the Bay of Bengal.

Site 3- Patharpratima (21°47'15"N/88°21'46"E): This is another small village situated in the riverine stretch of Saptamukhi at the western part of Sunderbans.

Site 4- Gosaba (22°7'51"N/88°50'10"E): This is located in the riverine stretch of Matla in the central sector of Sundarbans.

Site 5- Hingalganj (22°21'1"N/88°59'8"E): This is situated at the confluence of two rivers Kalindi

and Raimangal in the eastern sector of Sundarbans.

Sampling protocols:

The studies were conducted during pre-monsoon and post-monsoon periods from different habitats viz. homestead orchard, paddy field, sandy beach, road edge, mangrove patches and waste land, in the year 2019-2020. Ants were collected randomly with the help of honey bait and hand picking method using forceps and brush soaked in 70% alcohol from the dead and live branches, twigs, low vegetation and under stem. Sub-soil and litter dwelling ants were collected by collection of soil from field and extracting those soil in laboratory by using Berlese-Tullgren apparatus. Dry specimens were sorted and mounted on triangular cards for identification.

Identification of ant specimen was done under Leica EZ4 stereo zoom microscope, based on taxonomic keys-- Bingham (1903), Bolton (1994), Tiwari (1999) and various keys available on antwiki.org.

Statistical analysis:

For the analysis of the ant community, the following parameters were estimated in Microsoft Excel 2010:

Species richness (S): Total number of species/Genus recorded at a selected location

Species abundance: Total Number of Individual species ($\sum I_i$) divided by Total Number of Species Population ($\sum N_i$)

The Shannon Diversity Index (sometimes called the Shannon-Wiener Index, 1949) is a way to measure the diversity of species in a community.

Denoted as H , this index is calculated as:

$$H = -\sum p_i \cdot \ln(p_i)$$

Where Σ : A Greek symbol that means "sum"; \ln : Natural log; p_i : The proportion of the entire community made up of species i .

Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

$$D = \frac{1}{\sum (n_i / N)^2}$$

Where n = Total number of organisms of a particular species; N = Total number of organisms of all species; Another way of calculating Simpson's Index of Diversity is $(1 - D)$.

Evenness Index: For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966).

$$e = H / \ln S$$

Where H = Shannon Diversity Index; S = Total number of species in the sample

Margalef's Index was used as a simple measure of species richness (Margalef, 1958).

$$\text{Margalef's Index} = (S - 1) / \ln N$$

Where S = Total number of species; N = Total number of individuals in the sample; \ln = Natural logarithm

Results and Discussion

Species richness and Abundance:

During the present study, 634 samples yielded total 2800 worker ants from 5 subfamilies, 30 genera and 62 species (Table 1). Over the entire collection, the predominant subfamily was the Myrmicinae with 12 genera (40%) and 28 species (45.16%), followed by Formicinae with 7 genera (23.3%) and 17 species (27.4%), Ponerinae with 6 genera (20%) and 8 species (12.9%), Dolichoderinae with 4 genera (13.3%) and 5 species (8.06%), Pseudomyrmicinae with 1 genera (3.33%) and 4 species (6.45%) (Table 2).

The genus *Camponotus* was found to be the most speciose genus in all the studied locations with 7 species followed by *Monomorium* (6 species) and *Pheidole* (6 species). Other diverse genera include *Crematogaster* (4 species), *Tetraponera* (4 species) and *Lepisiota* (4 species), *Nylanderia* (2 species), *Tapinoma* (2 species), *Pseudoneoponera* (2 species), *Leptogenys* (2 species), *Tetramorium* (2 species), *Trichomyrmex* (2 species) and *Cardiocondyla* (2 species). Apart from these 13 genera other 17 were monospecific genera inclusive of two monotypic exotic genera *Anoplolepis* and *Paratrechina* (Table 2).

Table1: List of ant subfamily, genus and species identified from the studied area of Indian Sunderbans

Subfamily	Genus	Species Name
Dolichoderinae	<i>Iridomyrmex</i>	<i>Iridomyrmex anceps</i> (Roger,1863)
	<i>Tapinoma</i>	<i>Tapinoma melanocephalum</i> (Fabricius, 1793)
		<i>Tapinomaidicum</i> (Forel, 1895)
	<i>Dolichoderus</i>	<i>Dolichoderus taprobanae</i> (Smith, F., 1858)
Formicinae	<i>Technomyrmex</i>	<i>Technomyrmex albipes</i> (Smith,1861)
	<i>Anoplolepis</i>	<i>Anoplolepis gracilipis</i> (Smith,F., 1857)
		<i>Camponotus</i>
		<i>Camponotus sericeus</i> (Fabricius, 1798)
		<i>Camponotus dolendus</i> (Forel, 1892)
		<i>Camponotus parius</i> (Emery, 1889)
		<i>Camponotus basalis</i> (Smith, F., 1878)
		<i>Camponotus binghamii</i> (Forel, 1894)
		<i>Camponotus nicobarensis</i> (Mayr, 1865)
	<i>Oecophylla</i>	<i>Oecophylla smaragdina</i> (Fabricius, 1775)
	<i>Paratrechina</i>	<i>Paratrechina longicornis</i> (Latreille, 1802)
	<i>Nylanderia</i>	<i>Nylanderia indica</i> (Forel, 1894)
		<i>Nylanderia yerburyi</i> (Forel, 1894)
	<i>Lepisiota</i>	<i>Lepisiota frauenfeldi</i> (Mayr, 1855)
<i>Lepisiota opaca</i> (Forel, 1892)		
<i>Lepisiota capensis</i> (Mayr, 1862)		
<i>Lepisiota bipartita</i> (Smith, F., 1861)		
<i>Polyrachis</i>		<i>Polyrachis rastellata</i> (Latreille, 1802)
Myrmicinae	<i>Monomorium</i>	<i>Monomorium floricola</i> (Jerdon,1851)
		<i>Monomorium atomum</i> (Forel, 1902)
		<i>Monomorium monomorium</i> (Bolton, 1987)
		<i>Monomorium orientale</i> (Mayr, 1879)
		<i>Monomorium indicum</i> (Forel, 1902)
		<i>Monomorium latinode</i> (Mayr, 1872)
	<i>Meranoplus</i>	<i>Meranoplus bicolor</i> (Guerin- Meneville, 1844)
	<i>Crematogaster</i>	<i>Crematogaster anthracina</i> (Smith, F., 1857)
		<i>Crematogaster travencorensis</i> (Forel,1902)
		<i>Crematogaster aberrans</i> (Forel, 1892)
<i>Crematogaster rogenhoferi</i> (Mayr, 1879)		
<i>Pheidole</i>	<i>Pheidole parva</i> (Mayr, 1865)	
	<i>Pheidole binghami</i> (Forel, 1902)	
	<i>Pheidole sagei</i> (Forel, 1902)	

		<i>Pheidole multidentis</i> (Forel, 1902)
		<i>Pheidole watsoni</i> (Forel, 1902)
		<i>Pheidole indica</i> (Mayr, 1879)
	<i>Tetramorium</i>	<i>Tetramorium simillinum</i> (Smith, F., 1851)
		<i>Tetramorium lanuginosum</i> (Mayr, 1870)
	<i>Cataulacus</i>	<i>Cataulacus latus</i> (Forel, 1891)
	<i>Trichomyrmex</i>	<i>Trichomyrmex scabriceps</i> (Mayr, 1879)
		<i>Trichomyrmex destructor</i> (Jerdon, 1851)
	<i>Solenopsis</i>	<i>Solenopsis geminate</i> (Fabricius, 1804)
	<i>Carebara</i>	<i>Carebara affinis</i> (Jerdon, 1851)
	<i>Cardiocondyla</i>	<i>Cardiocondyla mauritanica</i> (Forel, 1890)
		<i>Cardiocondyla wroughtoni</i> (Forel, 1890)
	<i>Myrmicaria</i>	<i>Myrmicaria brunnea</i> (Saunders, W.W., 1842)
	<i>Dilobocondyla</i>	<i>Dilobocondyla gastroreticulata</i> (Bharti and Kumar, 2013)
Ponerinae	<i>Pseudoneoponera</i>	<i>Pseudoneoponera rufipes</i> (Jerdon, 1851)
		<i>Pseudoneoponera bispinosa</i> (Smith, F., 1858)
	<i>Diacamma</i>	<i>Diacamma rugosum</i> (Le Guillou, 1842)
	<i>Brachyponera</i>	<i>Brachyponera luteipes</i> (Mayr, 1862)
	<i>Hypoconera</i>	<i>Hypoconera gleadowi</i> (Forel, 1895)
	<i>Leptogenys</i>	<i>Leptogenys hystericus</i> (Forel, 1900)
		<i>Leptogenys peuqueti</i> (Andre, 1887)
	<i>Anochetus</i>	<i>Anochetus madaraszi</i> (Jerdon, 1851)
Pseudomyrmicinae	<i>Tetraoponera</i>	<i>Tetraoponera rufonigra</i> (Jerdon, 1851)
		<i>Tetraoponera nigra</i> (Jerdon, 1851)
		<i>Tetraoponera nitida</i> (Smith, F., 1860)
		<i>Tetraoponera allaborans</i> (Walker, 1859)
Total family: 5	Total Genera: 30	Total species: 62

Table 2: Total number and percentage of Genera and Species per Subfamily

Ant Subfamily	No. of Genera (% of total)	No. of species (% of total)
Dolichoderinae	4 (13.333)	5 (8.06)
Formicinae	7 (23.333)	17 (27.419)
Myrmicinae	12 (40)	28 (45.16)
Ponerinae	6 (20)	8 (12.9)
Pseudomyrmicinae	1 (3.333)	4 (6.45)
Total	30	62

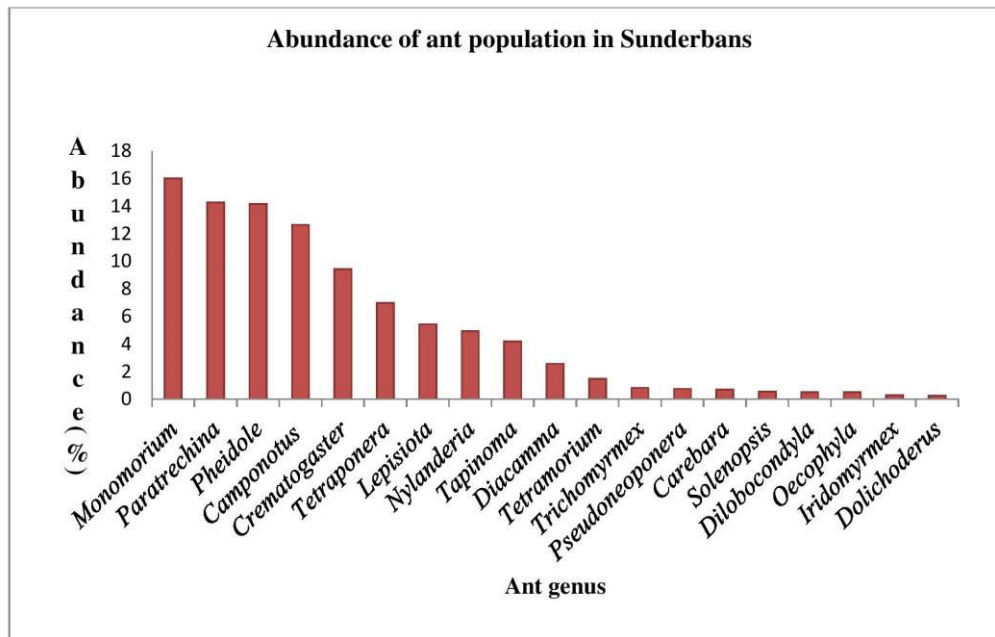


Fig 1: Abundance of ant population in selected locations of Sunderbans.

The most abundant ant genera of all the studied areas was *Monomorium* (Abundance 16%), followed by *Paratrechina*, *Pheidole*, *Camponotus*, *Crematogaster*, *Tetraponera*, *Lepisiota*, *Nylanderia*, *Tapinoma* and *Diacamma* (Fig. 1)

Ant species composition in different habitats:

In this study total 2800 ant species were captured from different habitats. Comparatively lower species richness ($S=5$) and species diversity ($H=1.548$) was observed in waste land whereas higher species richness noticed in agricultural land ($S=24$) where species diversity was ($H=2.568$) (Table 4). The species richness of ant communities in the mangrove habitat was relatively poor with 21 ant genera. It was also found that total 4 genera (*Camponotus*, *Pheidole*, *Lepisiota*, *Crematogaster*) out of 30 genera were common in all the six habitats and make them hyperdiverse genus in that region. *Monomorium* was found most dominant ant genus in both agricultural land and homestead orchard whereas *Pheidole* is dominant genus in both waste land and sea beaches. Predominance of genus *Paratrechina*

is higher than that of the genus *Crematogaster* in all the habitats (Table 3).

Seasonality on ant community:

As observed in the present study, species richness was quite different between the dry period (total 27 genera) and the wet season (total 24 genera). The ant genera *Monomorium*, *Camponotus*, *Pheidole*, *Crematogaster*, *Paratrechina*, *Nylanderia*, *Lepisiota*, *Tapinoma*, *Diacamma*, *Tetramorium*, *Pseudoneoponera*, *Trichomyrmex*, *Iridomyrmex*, *Solenopsis*, *Carebara*, *Dolichoderus*, *Dilobocondyla*, *Leptogenys*, *Oecophylla*, *Cataulacus* and *Tetraponera* were found in both pre- and post-monsoon seasons (Fig. 2). *Monomorium* was the most dominant genus in both the seasons. *Cardiocondyla*, *Meranoplus*, *Polyrhachis*, *Brachyponera*, *Myrmecaria* and *Pachycondyla* were found only in pre-monsoon period and *Anoplolepis* and *Anochetus* were found only in post-monsoon.

Comparison of Biodiversity Indices:

Tables 4 and 5 revealed that the Shannon Diversity index (H) ranged between 2.09-2.587 across the five study sites and 1.54-2.568 in

Table 3: Distribution of different ants in various habitats in the studied area of Sunderbans

Ant genus	Agricultural land	Mangrove	Homestead orchard	Road side	Sandy beach	Waste land
<i>Monomorium</i>	+	+	+	+	+	-
<i>Paratrechina</i>	+	+	+	+	+	-
<i>Camponotus</i>	+	+	+	+	+	+
<i>Pheidole</i>	+	+	+	+	+	+
<i>Nylanderia</i>	+	+	+	+	-	+
<i>Technomyrmex</i>	+	-	-	-	-	-
<i>Lepisiota</i>	+	+	+	+	+	+
<i>Crematogaster</i>	+	+	+	+	+	+
<i>Tapinoma</i>	+	+	+	-	+	-
<i>Tetramorium</i>	+	+	+	+	+	-
<i>Diacamma</i>	+	+	+	+	-	+
<i>Tetraponera</i>	+	+	+	+	-	-
<i>Cardiocondyla</i>	+	-	-	-	+	-
<i>Carebara</i>	+	+	+	-	-	-
<i>Leptogenys</i>	+	+	+	+	-	-
<i>Pseudoneoponera</i>	+	+	+	+	-	-
<i>Solenopsis</i>	+	+	+	-	-	-
<i>Trichomyrmex</i>	+	+	+	+	-	-
<i>Dolichoderus</i>	+	-	+	-	-	-
<i>Meranoplus</i>	+	+	-	-	+	-
<i>Oecophylla</i>	+	-	+	-	-	-
<i>Catalaucus</i>	+	+	-	-	-	-
<i>Hypoponera</i>	+	-	-	-	-	-
<i>Polyrachis</i>	+	-	+	-	-	-
<i>Anochetus</i>	-	+	-	-	-	-
<i>Dilobocondyla</i>	-	+	+	+	-	-
<i>Iridomyrmex</i>	-	+	-	+	+	-
<i>Brachyponera</i>	-	-	-	+	-	-
<i>Anoplolepis</i>	-	-	-	+	-	-
<i>Myrmicaria</i>	-	-	-	+	-	-

Table 4: Spatial variation in diversity indices of ant population across the study sites

Diversity Indices	Hingalganj	Gosaba	Sagar	Patharpratima	Bakkhali
Simpson(D)	0.1532	0.1078	0.1124	0.09364	0.1188
Simpson (1-D)	0.8468	0.8922	0.8876	0.9064	0.8812
Shannon (H)	2.09	2.342	2.475	2.587	2.383
Evenness	0.5392	0.6935	0.5398	0.633	0.4924
Margalef	2.183	2.159	3.502	3.323	3.19

Table 5: Spatial variation in diversity indices of ant population in different habitats of Indian Sunderbans

Alpha diversity indices	Agricultural. Field	Mangrove patch	Homestead orchard	Sandy beach	Road edge	Waste land
Simpson (D)	0.09855	0.1164	0.1142	0.1867	0.1581	0.2362
Simpson (1-D)	0.9014	0.8836	0.8858	0.8133	0.8419	0.7638
Shannon (H)	2.568	2.372	2.401	1.921	2.161	1.548
Evenness	0.5436	0.5106	0.5517	0.6204	0.482	0.7838
Margalef	3.537	3.02	2.925	1.88	3.002	1.456

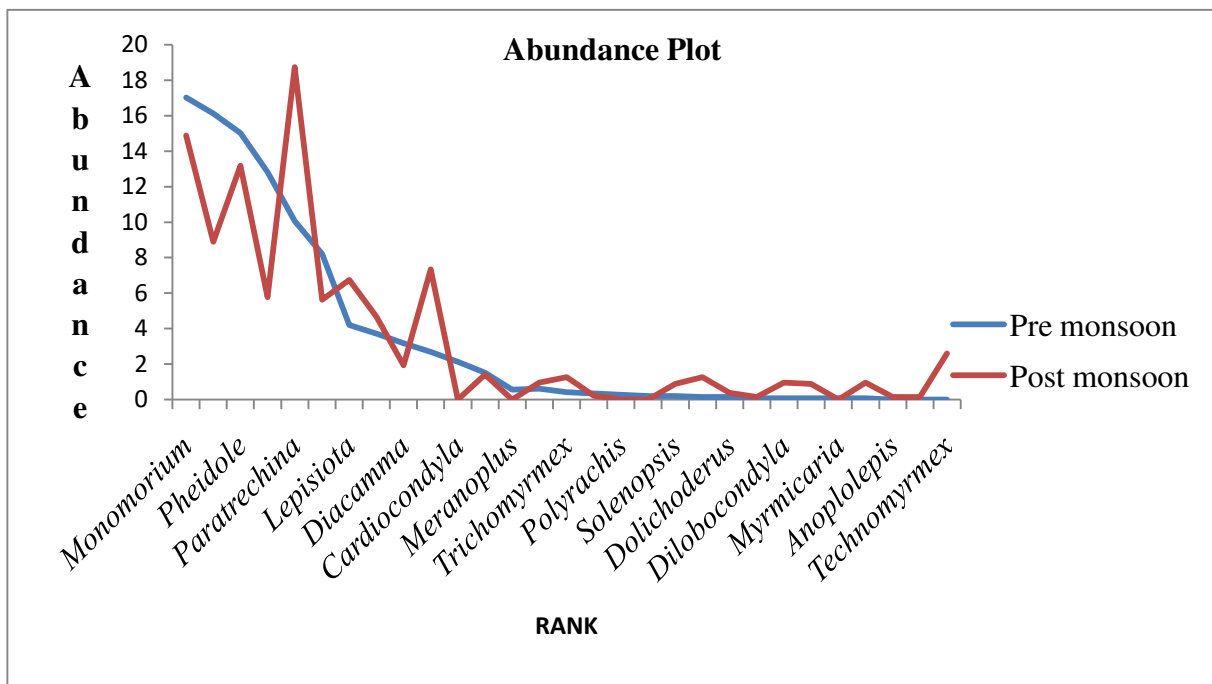


Fig. 2: Species rank abundance plot for pre monsoon and post monsoon periods of Sunderbans

different habitats of Sunderbans. Simpson index value (1-D) ranged between 0.8468-0.9 across the five study sites and 0.76-0.9 in different habitats indicated that the community is mature and stable as the dominance is shared by large number of species. The Pielou index values which are more than 0.5 indicated that the ant community in different habitats was balanced during the study period.

The present study revealed that ant diversity in Sunderbans found rich with 67 species of 31 genera in different localities of Sunderbans. Subfamily Myrmicinae was found the most speciose subfamily, while genus *Momomorium* was the most speciose genus. Of the different habitats of each locality analysed, agricultural lands were

found more preferred and waste lands least preferred habitats for ants. They were also found dominant in Mangroves. In those areas of mangrove where ground is completely covered with silt and mud due to high tide, ants could not be traced in ground soil, but a few genera like *Camponotus*, *Paratrechina* and *Crematogaster* were found on mangrove trees as they were able to survive on arboreal habitat and they are highly invasive. A rare species *Dilobocondyla gastroreticulata* was found from the mangrove areas which showed that this species has a high salt tolerance and is able to survive in disturbed habitats. The presence of genera *Anoplolepis* and *Anochetus* only in post-monsoon and *Cardiocondyla*, *Meranoplus*, *Polyrhachis*,

Brachyponera, *Myrmicaria* and *Pachycondyla* in pre-monsoon is interesting. Availability of preferred food sources and salinity difference in the soil before and after monsoon may be playing a role in the appearance of those species in particular season. Investigation on different aspects for a long period only can make a final statement.

Present study provides a baseline data for further detailed studies on the effect of climate changes on this fragile ecosystem. In particular, it can be used to evaluate not just local richness (alpha- diversity) but also species turnover (beta-diversity).

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