Species composition in ants: its role in bio-monitoring the ecosystem of Gorumara National Park area

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***Abstract*:** Ant, family Formicidae, class Insecta, is one of the dominant soil fauna and plays a key role in regulating the soil quality. Thus ants play a pivotal role maintaining the forest as well as agro-ecosystem. The present work aims to assess the ants on its population diversity, dominance, seasonality and its role as an indicator in monitoring the forest ecosystem, in Gorumara National Park, West-Bengal and in adjoining human habitation.

27 species of ants were recorded from four sampling sites in Gorumara National Park area. Soil samples collected from the study areas were analysed for various edaphic factors and results were co-related with the abundance of the ants. Significant results were obtained from such analysis.

With the seasons, population of Ants species shows notable quantitative and qualitative variation. The calculated 't' value for any two of the other sampling sites show significant variation in the prevalence of the ants species and in ecological environment affecting the prevalence. Thus, the ants play important role as bio-indicators. At present, world is leading towards the exhaustion of natural resources scientists are in search of alternative resources. Ants play an important role for sustainable resources in our survival as well, in spite of their natural intricacies.

Index Terms: **Ants, Biodiversity, Bio-indicator, Gorumara National Park**

I. INTRODUCTION: Among the most populous life forms on the planet insect stands as the forerunner. Insect demonstrates amazing evolutionary adaptations and habitat diversity. To foster biodiversity, protection of forest and human dominated land use, proper understanding of its every unit (inhabitant) is necessary in order to conserve our ecosystem and its good health.

Ants are one of the important indicator insects in assessing environmental qualities, ecosystem and community structure and evaluating bio-diversity [18, 37]. [1, 3] proved Ants, extensively, as bio-indicators. Role of Ants in maintaining the forest as well as agro-ecosystem was studied by [5, 7]. The two important eco-regions, the Himalayas and the Western Ghats are listed as biodiversity hot spots and both the ecosystems are under major threat. More than 3,000 kilometers long, the Himalayan system, harbors about 202 species of ants, with 45% being endemic to the region, [5]. Temperature and altitudinal gradients in Himalayan ecology have a remarkable effect on ant species composition and abundance, [7]. As key players in many ecosystems their species composition gives an indication of ecosystem health and functioning. Some attempts have been made earlier to estimate the dominance and species richness of ants in different areas of Indian subcontinents [4, 31, 6, 30, 33, 34, 7] as well as in other continents [24]. Ants have been used as indicators of several environmental impacts, such as fire, deforestation and logging, agricultural intensification, mining, and urbanization [24, 16, 10]. Structure of ground-foraging ant assemblages in relation to land-use change in the northwestern Mediterranean region was reported [20]. Ants as biological indicators of human impact in mangroves of Brazil showed [14]. Ants as bio-indicators of land restoration in a brazilian atlantic forest fragment was reported [11]. The impact of Ants as indicator of ecosystem health was reviewed by [8]. The impact of abundant *Pheidole* ant species on soil nutrients in relation to the food biology of the species was studied [36].

With a population of about 90 million, West Bengal has only 0.02 hectare of forest per capita, one of the lowest rates in Asia. Officially forest covers only 13% of the total land area with 9% as vegetative cover, much of which is severely depleted. By 1993, the standing stock was only $15m^3$ /ha versus a national average of $77m^3$, with more than $200m^3$ in the mountain forest of West Bengal.

Gorumara National Park is tropical Sub-Himalayan humid types with deciduous trees, shrubs and creepers on forest floor. Located in the Malbazar Sub-Division of Jalpaiguri district, West Bengal, India with latitude 26°47'12.5" N to 26°43'25.6" N and longitude 88°52'4.2" E to 88°47'7.3" E. The total area of the National Park is 79.84 sq. km and belongs to the bio-geographical zone of Gangetic Plain.

All's not well in this region owing to the fringe populace. Increased pressure on the forest resources, excessive grazing, land acquisition and use of excessive amount of pesticides have severe damaging effects on its biodiversity.
The present work aims to assess the ants on its population diversity, dominance, seasonality and its role as an indicator in monitoring and its interrelationship in ecosystem in Gorumara National Park region.

II. RESEARCH METHODOLOGY

2.1 SITES OF SAMPLING: Located in the submontane Terai belt of the Himalayan foothills a medium-sized park 79.99 km (49.70 mi) in area with grasslands and forests. Originally as small as 7 km^2, Gorumara has grown by incorporating neighbouring lands to about 80 km^2 and was declared an Indian National Park on January 31, 1994. Since 1895 Gorumara was a reserve forest. The region known as the Dooars in West Bengal, the jungles of North Bengal is an extremely rich biodiversity zone. This region has rolling forests and riverine grasslands.

2.2 BIOTIC FACTORS: Terrain of Gorumara National Park is differentiated into a distinct 4 plateau and a plain area. The soil profile is of alluvial and bhabar formations.

The forest cover of Gorumara National Park comes under the North Indian Moist Tropical Forest. The park has approximately 48 species of mammals (carnivores and herbivores), approximately 193 species of birds, 22 species of reptiles including 7 species of turtles, 40 species of fishes and other macro and micro fauna. Geographically, the area of Gorumara National Park falls under tropical monsoon climate, with four distinct seasons - summer (February-May), monsoon (June-August), a short autumn (Sept-October) and winter (November-January). The human population colonized in patches and is increasing day by day. And, apart from forest they are dependent on tea cultivation and eco-tourism etc., for their livelihood now-a-days. Ramsai Bhudhuram village, Lataguri forest areas, Kalipur forest village and Dhupzhora zone in the Gorumara National Park areas have been surveyed for the study.

2.3METHOD OF SAMPLING

2.3.1 EXTRACTION OF SAMPLES/ANALYSIS OF BIOTIC FACTORS:

2.3.1.1The ants were collected from the sampling sites of Gorumara National Park areas.
2.3.1.2 The ants have been collected randomly, grouped on visual observation under high power hand lens and were categorized taxonomically on the basis of morphological features following standard techniques of morpho-taxonomy after microscopic observation.
2.3.1.3The identification, enlisting and determination of relative abundance, dominance and diversity of the ants were studied.
2.3.1.4The seasonality of the ants both in and outside the forest area was studied. Soil samples were collected at random from each of the study areas during each field visit and analysed for the Physico-chemical parameters affecting the ant population.

2.3.1.5Analysis of Abiotic Factors:

Soil samples were collected from the study areas of ants and analyzed for its various and edaphic factors, Soil Temperature, Alkalinity, pH, Salinity and Nitrogen, Phosphorus, and Potassium content and the results were co-related with the prevalence of ants. Air temperature was also recorded during sampling in each sampling site.

III.RESULTS AND DISCUSSION:

3.1 Composition of ants fauna from the study sites during the study period: A total of 27 species have been recorded from the study area comprising four sampling sites. Of these 17, 18, 11 and 16 species were found from Forest area, Ramsai, Dhupzhora and Kalipur respectively. The recorded species are: *Cardiocondyla compressus, Cardiocondyla wroughtonii, Cardiocondyla paurinoda, Cardiocondyla breviscapa, Cardiocondyla mauritanica, Carebara raja, Crematogaster biroi smythiesii, Diacama rugosum, Diacama scalpratum, Ectomyrmex astutus, Leptogenys kitelli minor, Lepisiota capensis, Nylanderia indica, Platythyrea sagei, Polyrachis bicolor, Pheiodole jucunda, Pheiodole phipsoni, Tetraponera rufonigra, Technomyrmex brunneus, Technomyrmex horni, Tetramorium tonganum, Tapinoma melanocephalum, Nylanderia bourbonica, Lasius brunneus, Ectomyrmex annamitus, Camponotus angusticollis, Camponotus irritans* [**Table-1**].

Table-1: Accounts of ants of sampling sites in Gorumara national park

	Ants species	RAMSAI	FOREST	DHUPZHORA	KALIPUR	TOTAL	MEAN	SD	SE	t-value
1	*Cardiocondyla compressus*	201	227	157	209	794	198.5	1530.55	765.28	0.0007
2	*Cardiocondyla wroughtonii*	70	477	109	39	695	173.75	72211.93	36105.97	0.0004
3	*Cardiocondyla paurinoda*	0	24	0	0	24	6	249.415	124.71	0.0113
4	*Cardiocondyla breviscapa*	0	78	0	0	78	19.5	2634.45	1317.22	0.0075
5	*Cardiocondyla mauritanica*	0	74	0	0	74	18.5	2371.18	1185.59	0.0147
6	*Carebara raja*	10	0	0	0	10	2.5	205.68	102.84	0.0283
7	*Crematogaster biroi smythiesii*	0	25	0	10	35	8.75	645.91	322.95	0.0180
8	*Diacama rugosum*	0	0	75	16	91	22.75	2200.13	1100.06	0.0080
9	*Diacama scalpratum*	243	578	308	90	1219	304.75	71941.74	35970.87	0.0078
10	*Ectomyrmex astutus*	145	0	0	85	230	57.5	8674.69	4337.34	0.0118
11	*Leptogenys kitelli minor*	0	0	0	42	42	10.5	763.834	381.92	0.0174
12	*Lepisiota capensis*	24	0	0	0	24	6	249.415	124.707	0.0143
13	*Nylanderia indica*	120	98	0	0	218	54.5	6999.217	3499.608	0.0089
14	*Platythyrea sagei*	402	226	105	66	799	199.75	39533.44	19766.72	0.0057
15	*Polyrachis bicolor*	177	65	117	52	411	102.75	5609.963	2804.98	0.0352
16	*Pheiodole jucunda*	10	30	0	0	40	10	346.41	173.2	0.0611
17	*Pheiodole phipsoni*	0	0	21	0	21	5.25	190.95	95.47	0.0053
18	*Tetraponera rufonigra*	26	66	34	355	481	120.25	42939.12	21469.56	0.0051
19	*Technomyrmex brunneus*	0	27	0	13	40	10	287.52	143.76	0.1499
20	*Technomyrmex horni*	23	0	0	2	25	6.25	217.51	118.75	0.0375
21	*Tetramorium tonganum*	46	0	0	26	72	18	863.716	431.858	0.0206
22	*Tapinoma melanocephalum*	23	18	4	0	45	11.25	209.429	104.71	0.0921
23	*Nylanderia bourbonica*	3	0	0	8	11	2.75	24.67	12.33	0.0302
24	*Lasius brunneus*	0	18	0	0	18	4.5	140.29	70.14	0.0241
25	*Ectomyrmex annamitus*	63	0	0	22	85	21.25	1528.1	764.05	0.0188
26	*Camponotus*	6	27	4	0	37	9.25	253.31	126.65	0.0088

	angusticollis									
27	*Camponotus irritans*	237	222	5	30	494	123.5	26193.8	13096.9	0.0118
	Total	**1829**	**2053**	**996**	**1065**	5943				
	Mean	**67.74**	**76.04**	**36.89**	**39.44**	220.1				
	SD	**102.59**	**146.09**	**70.9**	**77.46**					
	SE	**19.74**	**28.11**	**13.64**	**14.9**					
	t-value	**0.989**	**0.991**	**2.705**	**2.023**					

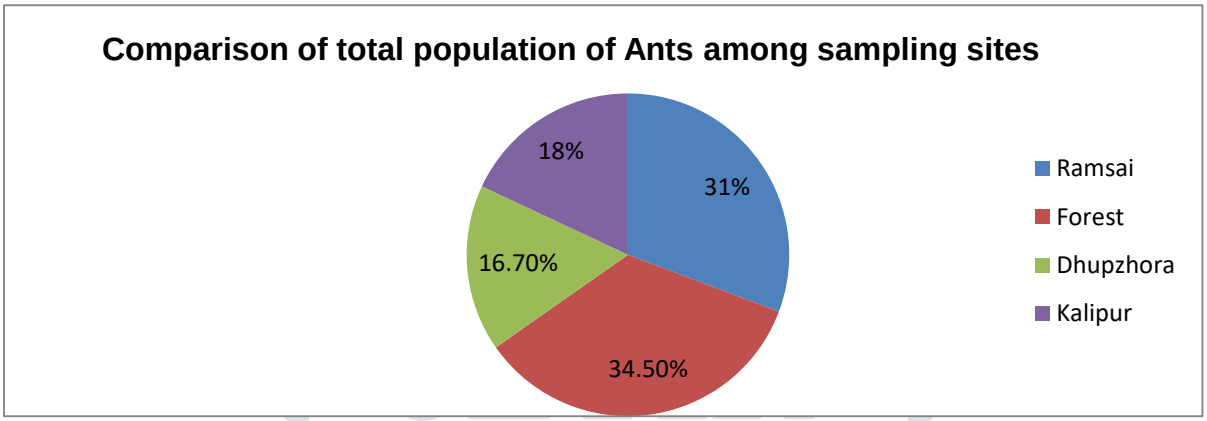

Figure-1 Comparison of total population of Ants collected from four different sites under study

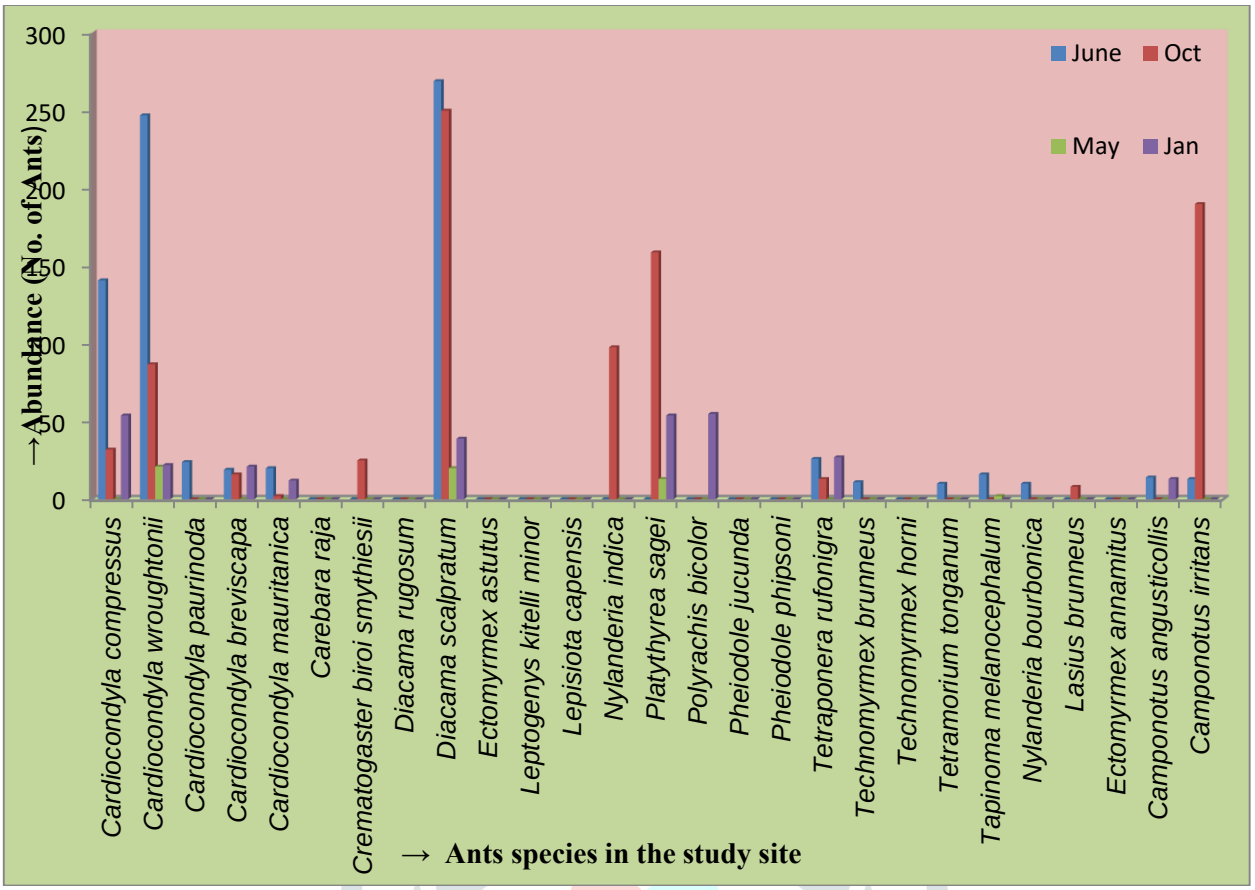

Figure-2 Ants species in Forest site of Gorumara National Park area

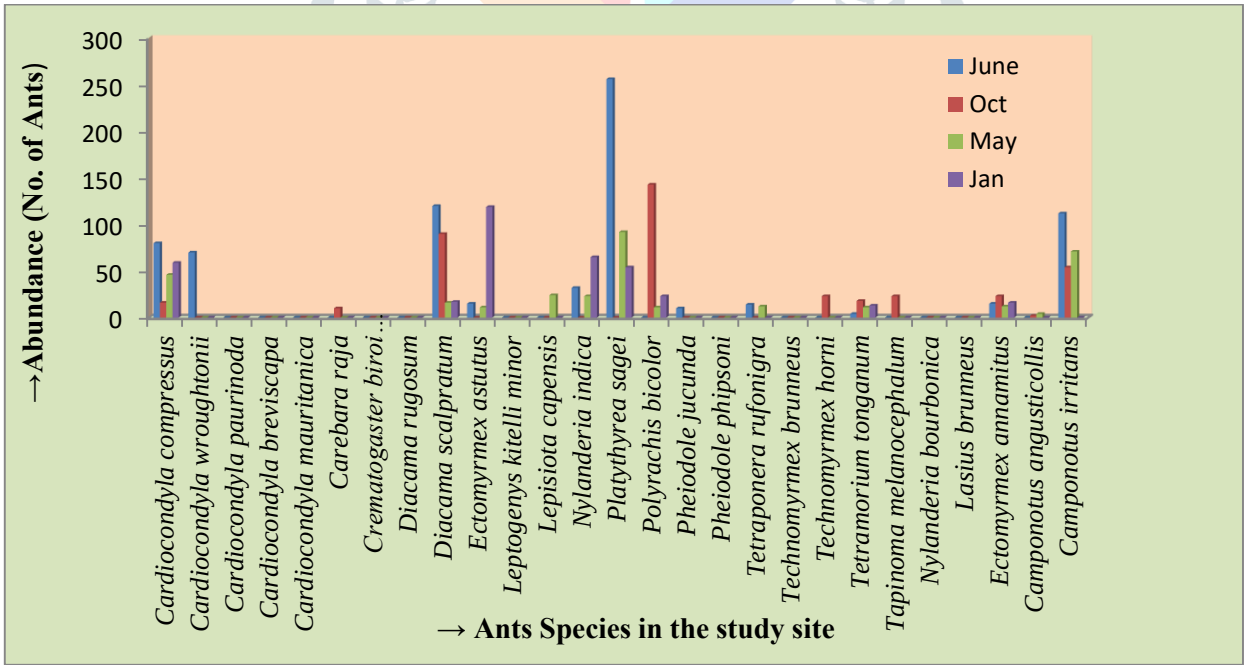

Figure-3 Ants species in Ramsai site of Gorumara National Park area

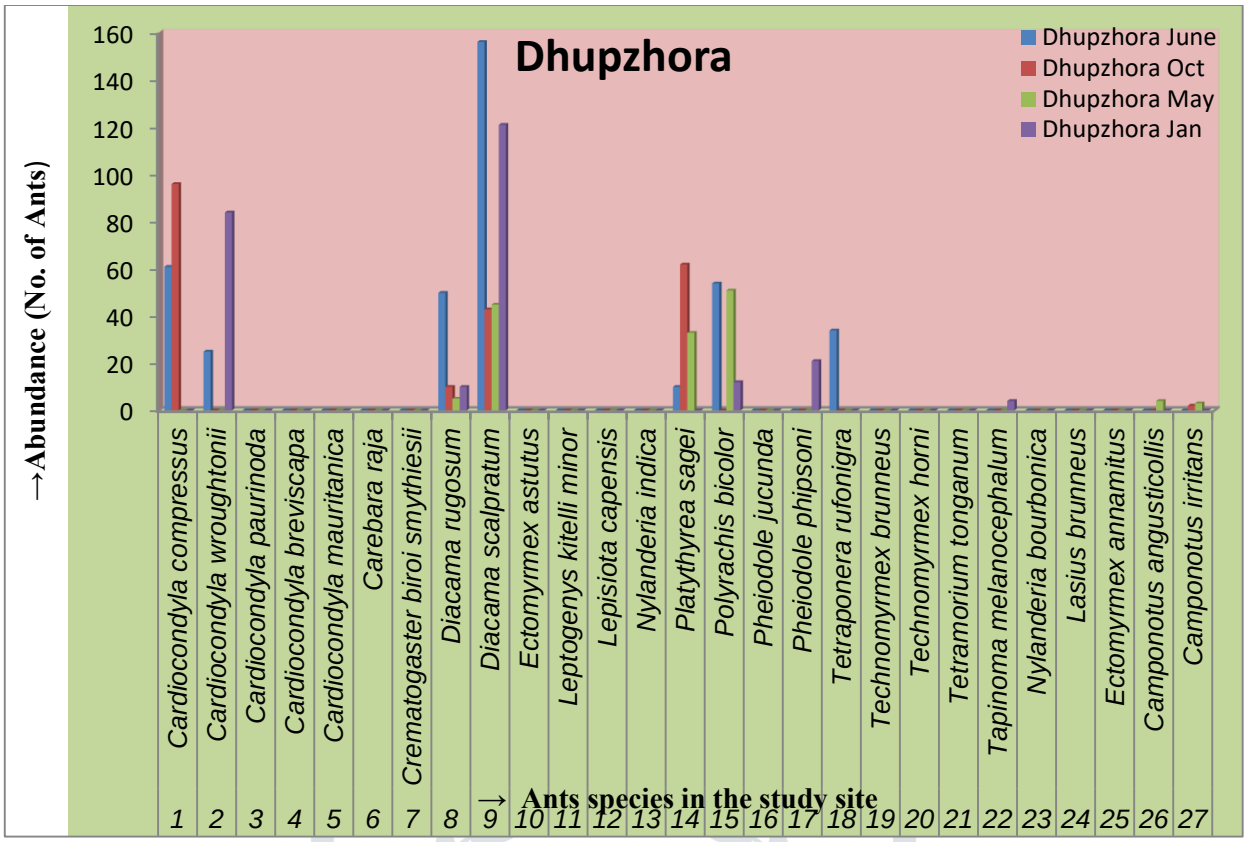

Figure-4 Ants species in Dhupzhora site of Gorumara National Park area

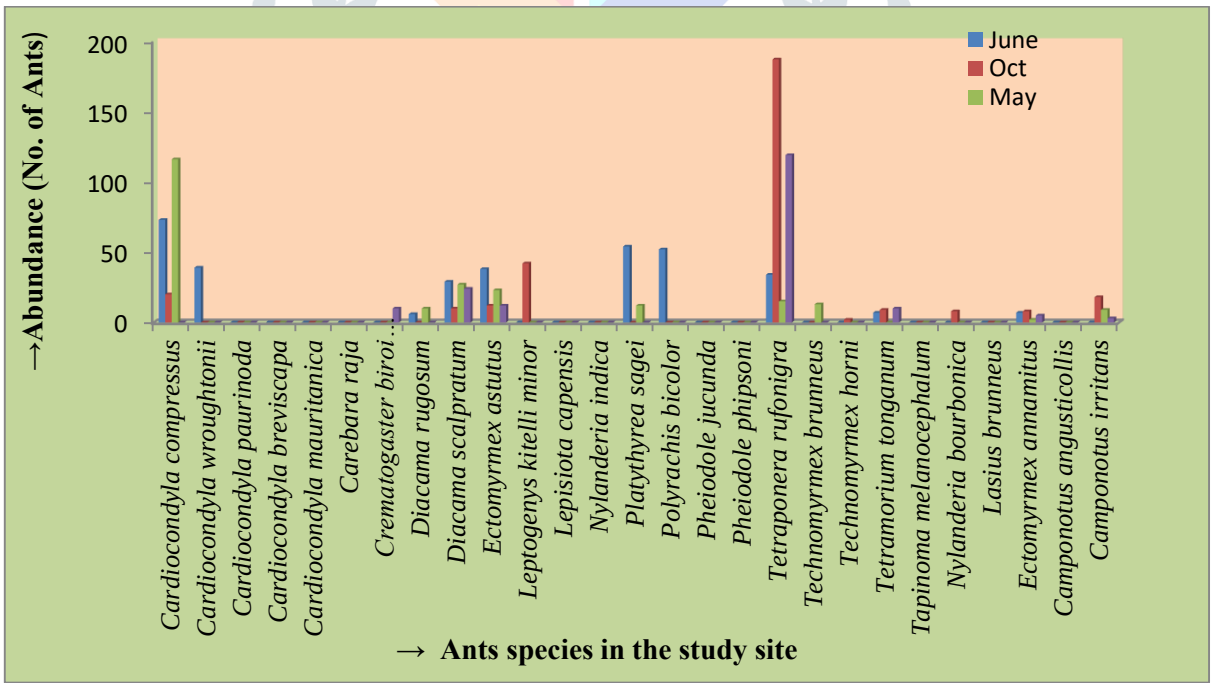

Figure-5 Ants species in Kalipur site of Gorumara National Park area

Seasonal fluctuation of Ants species in different study sites during study period: Population of Ants species exhibited quantitative and qualitative variation with change in seasons in Forest area prominently. In Forest area, the population size reached the highest level in October (Autumn), after Monsoon, the

minimum in March (Late Winter). **[Table-1 and Fig.-2]**. In Ramsai, the abundance was maximum in May (before Monsoon). **[Table-1 and Fig.-3]**. Population of Ants in Dhupzhora and Kalipur did not exhibit significant variation with change in seasons. In both these sites, minimum number was found in May (Summer), before Monsoon and maximum in June (Monsoon) and in March (Late Winter) **[Table-1 and Fig.-4 and 5]**.

1. Edaphic/ Physico-Chemical parameters in the study sites: The ecological factors for all the sampling sites have been estimated [**Table-2**]. In Forest and in Ramsai, the parameters were correlated with the ant population and positive correlations were recorded with all the soil parameters as well as with Air temperature **[Table-3,4].** In Kalipur, also positive correlations were recorded with Air temperature(r= 0.336), Soil Temperature (r= 0.160), Soil Alkalinity (r= 0.502), Soil Nitrogen (r= 0.052), Soil Phosphorus (r=0.00) and Soil Potassium (r = 0.511). Whereas negative correlations were found with Soil pH (r= -0.355) [**Table-6**]. In Dhupzhora negative correlations were recorded with Air temperature (r= - 0.349), Soil Temperature (r= - 0.5956), Soil Alkalinity (r= - 0.3686), Soil Nitrogen (r= - 0.2692), Soil Phosphorus (-0.888) and Soil Potassium (r = - 0.546), whereas positive correlations were found only with soil pH (r= 0.383) and [**Table-5]**.

Table-2
Analysis of physico-chemical parameters in sampling sites of Gorumara national park

Parameters		FOREST				DHUPZHORA				RAMSAI				KALIPUR			
		Jan	May	June	Oct	Jan	May	Jun	Oct	Jan	May	June	Oct	Jan	May	June	Oct
Temp	Air	29	26.5	30	28	25.9	26	31	26	30.5	30	30.3	28	25.6	26.3	30.5	26
Temp	Soil	27.3	23.5	25	28	24.2	24.5	27	27	28.2	29.5	29.5	28	23.5	24.5	30	27
Light Intensity (LUX)		50000	25000	NA	49100	50200	35000	35000	50100	50100	40000	NA	24000	50200	35000	NA	50000
Atm. Pressure (%)		72	79	72	72	70	74	72.25	71.5	72	77	72.25	71.5	70	84	72.25	71.5
Alkalinity(Soil) (ppm)		10	10	15	15	25	15	15	20	10	10	15	15	25	15	NA	NA
pH	Soil	6.5	7	7	6	7	7	7	6.5	7	6.5	6	7	6.5	6.5	6.5	6.7
Salinity	Soil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil	Nitrogen (Kg/Acre)	50	100	125	175	50	65	125	50	50	50	125	125	50	65	125	125
Soil	Phosphorus (Kg/Acre)	2	15	5.5	15	9	13	2	5	13	9	13	13	13	13	13	13
Soil	Potassium (Kg/Acre)	100	37	135.5	150	65	65	100	135.5	135.5	65	100.5	135.5	65	25	150	150

Table-3: Correlation analysis and the regression equation for ecological parameters Vs ants in Forest site

Sl.No.		Site: Forest		
	Ants Vs Ecological Parameters	**r-Value**	**t-Value**	**Correlation Equation**
1.	Air Temperature	4.037	2.527	19.2949 +0.0177 X
2.	Soil Temperature	2.781	-2.625	17.431 + 0.0166 X
3.	Soil Alkalinity	1.130	-5.260	6.113 +0.0118 X
4.	Soil pH	2.850	-2.616	4.624 +0.0039 X
5.	Soil Salinity	0.000	0.000	0.0 +0.0 X
6.	Soil Nitrogen Content	1.0337	-9.729	33.498 + 0.154 X
7.	Soil Phosphorus Content	0.6725	2.225	2.808 + 0.0128 X
8.	Soil Potassium Content	0.759	2.854	49.708 +0.109 X

Table-4: Correlation analysis and the regression equation for ecological parameters Vs ants in Ramsai site

Sl.No.		Site: Ramsai		
	Ants Vs Ecological Parameters	**r-Value**	**t-Value**	**Correlation Equation**
1.	Air Temperature	7.472	-2.465	-4.662 + 0.138 X
2.	Soil Temperature	11.073	-2.458	-7.23 +0.1447 X
3.	Soil Alkalinity	0.938	6.619	1.793 + 0.043 X

4.	Soil pH	4.413	-2.510	-1.841 + 0.034 X
5.	Soil Salinity	0.000	0.000	0.0 + 0.0 X
6.	Soil Nitrogen Content	0.232	0.584	47.411 + 0.161 X
7.	Soil Phosphorus Content	0.828	3.614	5.526 +0.026 X
8.	Soil Potassium Content	0.290	0.742	70.032 + 0.157 X

Table-5: Correlation analysis and the regression equation for ecological parameters Vs ants in Dhupzhora site

Sl.No		**Site: Dhupzhora**		
	Ants Vs Ecological Parameters	**r-Value**	**t-Value**	**Correlation Equation**
1.	Air Temperature	- 0.349	- 0.912	29.713 - 0.0055X
2.	Soil Temperature	-0.5956	-1.816	27.978 – 0.00504 X
3.	Soil Alkalinity	-0.3686	-1.044	23.197 – 0.0097 X
4.	Soil pH	0.383	1.016	6.631 + 0.00053 X
5.	Soil Salinity	0.000	0.000	0.0 + 0.0 X
6.	Soil Nitrogen Content	-0.2692	-0.684	97.73 – 0.0530 X
7.	Soil Phosphorus Content	-0.888	4.737	3.443 + 0.0234 X
8.	Soil Potassium Content	-0.546	-1.597	43.722 – 0.104 X

Table-6: Correlation analysis and the regression equation for ecological parameters Vs ants in Kalipur site

Sl.No.		Site: Kalipur		
	Ants Vs Ecological Parameters	**r-Value**	**t-Value**	**Correlation Equation**
1.	Air Temperature	0.336	0.873	24.438 + 0.010 X
2.	Soil Temperature	0.160	0.397	24.652 + 0.006 X
3.	Soil Alkalinity	0.502	1.422	9.964 + 0.033 X
4.	Soil pH	-0.355	-0.994	6.656 – 0.0004 X
5.	Soil Salinity	0.0009	-0.000	0.00 + 0.00 X
6.	Soil Nitrogen Content	0.052	0.127	98.705 – 0.028 X
7.	Soil Phosphorus Content	0.00	0.00	13 + 0.00 X
8.	Soil Potassium Content	0.511	1.456	-16.528 + 0.171 X

Ants would turn out to be good indicators of ecosystem as these had become a most dominant and successful component of ecosystem showed by [13]. Ants as the index organisms are being explored in different parts of the world [13, 25]. The role of ants in conservation monitoring was also showed by [37].

In this present investigation, Ants in Gorumara National Park region were studied in four different sites over a period of one year through four different seasons.

A total of 27 species were found from the study sites. Out of which, in both Forest and Dhupzhora, *Diacama scalpratum* occupied the dominant position followed by *Cardiocondyla wroughtonii* as the second most prevalent one. Whereas, in Ramsai, the first and second most dominant species were *Platythyrea sagei* and *Diacama scalpratum* respectively. In Kalipur, *Tetraponera rufonigra* showed its dominance over others **[Table-1**, **Fig.-2-5]**. Ants are capable of changing their food habits when required reported by [12]. *Diacama scalpratum* in both forest and Dhupzhora adapted themselves for better survival and for better sustenance to utilize whatever food resources in two such environmental conditions. Compared to forest and other sampling sites their number decreases significantly in Dhupzhora. Moist, rich food reserves, soil humidity, soil and air temperature, prevalent habitat plants, low sunlight favoured the dominance of *Diacama scalpratum* in forest as well as in Dhupzhora which is nearest to the forest cover.

The ability of the ants to withstand the habitat changes by mobilizing different behavioural defensive mechanisms to modify the habitat and altering their populations was reported by [26].

Altogether 5943 ants were collected during the study period from all the sites together. Forest exhibited 34.5% (2053 ± 28.11), followed by Ramsai 30% (1829 ±19.74) while at Dhupzhora the occurance was

minimum with 16.7% (996 ± 13.64) [**Table-1]**. Maximum number of species was obtained from Forest (18) followed by Ramsai (17) and the lowest recorded in Dhupzhora (11) [**Table-1 and Fig.-1**].
While analysed statistically the availability of ants species exhibited no significant difference between the Forest and Ramsai (t= 0.989, 0.991 respectively) but, the other sampling sites, Dhupzhora and Kalipur showed significant variation in the prevalence of the ants species [**Table-1**]. Noticeable variation was not recorded in ecological factors between these two sites. This was because of similarity in environmental conditions and available vegetation. A favourable vegetation and other environmental condition at Forest and Ramsai accounted for high population of Ants at both these sites in comparison to Dhupzhora and Kalipur [**Fig.-1, 5 and Table-1**]. Expanding human habitation which led to forest fragmentation causing loss of growth of vegetation in Dhupzhora and Kalipur have resulted into the Ant community in shifting their homes from the sites. Vegetation directly or indirectly influenced the population of soil arthropods was observed by [9, 35]. The diversity of ant species was less in polluted area in comparison to the other as reported by [19]. Forest fragmentation in central Amazonia and its effects on litter-dwelling ants was observed by [10]. The tendency of the Ants to avoid habitats intensively managed by man as reported by [27, 28]. The findings of [32, 21], as general tendency of soil arthropods to attain maximum population during monsoon and minimum during summer is corroborative with this findings as maximum population was recorded in Forest in both pre- and post-Monsoon period and in Ramsai, Kalipur and Dhupzhora during Monsoon and minimum in summer (Forest, Ramsai and Dhupzhora) or in winter (Kalipur) [**Table-1, Fig.-2-5**]. But, in Dhupzhora and Kalipur, population of Ant species did not exhibit significant seasonal fluctuation. Ants are also sensitive to changes in the environment [22, 2, 38]. [1, 24] observed the changes in ant community structure found reflecting the fluctuations in many other invertebrate communities indicating the alterations in the habitat and other components in the ecosystem. According to [15] ants were able to detect changes in the external environment and make appropriate responses in order to operate efficiently. On co-relation analysis, all the sites, except Dhupzhora exhibited positive relationship between the ant population and air and soil temperature and soil alkalinity [**Table-3-6**]. In Forest and Ramsai sites availabilty of ant with maximum number and species were because of prevalence of favourable vegetation and other factors. In Kalipur, significant positive relationship was found. Whereas, in Dhupzhora negative relationship between the ant population and air and soil temperature and soil alkalinity was observed. Soil pH on the other hand, exhibited positive relationship in all the sites except Kalipur. In Dhupzhora, insignificant positive relationship was recorded. The result in Dhupzhora highlights the adverse effects of increasing land use for habitation by man and for tea gardens. Significant negative relationship of pH with the ant population in Kalipur suggests the presence of more acidophilic forms due to human habitation and grazing. No effect of soil salinity was found in ant population in any site. [23] reported that the majority of ants and termites probably increase C and nutrient levels, especially N, P and K in the Australian environment. Later, it was successfully showed by [17] that ants increased the cycling rate of nitrogen (N), phosphorus (P), potassium (K) nutrients in boreal and mountain forests of Europe and Asia. The present findings are also in accordance with those. The soil nitrogen had a significant positive relationship in Forest and Ramsai but insignificant positive relationship (r= 0.052) in Kalipur and negative relationship in Dhupzhora (r= - 0.2692). [29] indicated that environmental pollution, specifically nitrogen exerted negative effect on the size of ant communities and decrease in number of species etc. Similarly, concentration of soil phosphorus exhibited positive correlation with ant population in Forest and Ramsai and negative relationship in Dhupzhora, whereas, no relationship was in record with soil phosphorus in Kalipur. Significant positive correlation was also observed with soil potassium content with ants in Forest, Ramsai. But insignificant positive relationship was exhibited in Kalipur and negative in Dhupzhora. As depicted from the present study the increasing human interference on forest land acquisition and use, its resource utilization, grazing and others have significant damaging effects on ant population in Gorumara National Park area. Thus, this work estimates species composition of ants, its diversity, dominance, seasonality, interrelationship and its role as an indicator in monitoring the ecosystem of Gorumara National Park region.

IV.ACKNOWLEDGEMENT: Author is grateful to UGC, Govt. of India for financial support in the form of Minor Research Project (MRP). I would like to thank Principal, Victoria Institution (College), Dr. Nibedita Chakraborti for providing me space required to do my biochemical works. Thanks are also

indebted to Dr. Narayan Chandra Das, Associate Professor in Zoology, Scottish Church College, Kolkata for his valuable advises and critical suggestions.

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