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Study on Ants Distribution, Density and Diversity in Undisturbed and Disturbed Habitats

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Abstract: The present study deals with the study of ant diversity in undisturbed and disturbed habitats of Cubbon Park, Bangalore city, Karnataka. Ants are good indicators of disturbance, because they show quick response to environmental changes. Ants were collected from two different habitats with varying disturbance levels with the help of pitfall traps, scented traps and hand collection methods. Three different each plot of cubbon park was selected for ant collection as a representative for disturbed and undisturbed areas. The ants were collected by using pitfall traps and hand collection methods. The traps were set up between 9:00 AM to 11:00 AM and were collected after 12 hours. This study was carried out from September 2018 to May 2019. Species richness at different time period, relative abundance and Shannon-Weiner diversity index were calculated for low and high disturbed areas. A total 5 and 4 ant species were collected from low disturbed and high disturbed sites respectively. Out of 6 ant species almost 3 species (50%) were common to both sites, while another 2 species (30%) were found exclusive to the low disturbed sites. From total 6 ant species *Monomorium pharaonis* and *Camponatus compressus* were absent in highly disturbed sites. Whereas, *Tapinoma melanocephalum* were absent in low disturbed sites. With respect to the species richness, we observed that in the study carried in low disturbed sites, showed a high range of richness in the months of September, and a further increase (2%) in the months of December – February. In the high disturbed areas, there was an increase in the species richness in the months of September to November, and a further rise (4%) December to February and a decrease (6%) in the months of March – May. In low disturbed sites, *Camponatus compressus* (142 individuals) was more abundant followed by *Oecophylla smaragdina* (137 individuals), *Crematogaster spp* (106 individuals), *Monomorium pharaonis* (103 individuals). Whereas in highly disturbed sites *Tapinoma melanocephalum* (163 individuals) was more abundant, followed by *Oecophylla smaragdina* (125 individuals), *Crematogaster spp* (122 individuals). Shannon Wiener diversity index for each season of study and respective habitats was used to compare the diversity of between the two habitats, the low disturbed habitat was more diverse, with richer species when compared Highly disturbed conditions.

Keywords – Ants, Low disturbed area, Time period, Relative abundance, Diversity index

I. Introduction

Increased human activities like deforestation, urbanization, agricultural intensification, grazing and mining were creating serious problem to the flora and fauna of many terrestrial ecosystem across the world. Disturbance is nothing but an event that removes biomass (Townsend and Hinumerous ldrew, 1994) and is distinguish from habitat transformation or stress, which minimizes the available resources alters the microclimate or structure of the habitat. (Anderson 2000; Pickett and White 1985)

Ants play an important role within the terrestrial ecosystems because they have numerous interactions with different plant species, including seed dispersers, leaf and seed predators and in some cases, as pollinators. (Suarez AV and Bolger DT, 1998; Hernandez 2005) Ants are found everywhere, except in Iceland, Greenland and Antarctica (Holldobler and Wilson 1990), but the number of species declines with increasing latitude, altitude and aridity. (Fowler and Claver, 1991; Farji-Brener and Ruggiero 1994; Samson et.al., 1997). Some ant species establish mutualistic relationships with many other organisms including invertebrates and vertebrates.

Ants were considered to be very sensitive to habitat transformation and disturbance, and for this reason they have been extensively used as indicator species. (Hoffmann and Andersen 2003) Increase in grazing intensity may also result in decline of ant species richness, especially of litter inhabiting cryptic species and specialized predators, (Bestlemeyer and Wiens 1996) and strong change in species composition, although the relative proportions of different functional groups appear somewhat resilient to grazing pressure.

The effect of urbanization on species richness and most studies implicate urbanization as the major cause of biodiversity loss. However, no study has identified an explicit connection between urbanization and biodiversity loss as the impact of urbanization is typically inferred indirectly by comparing species diversity along urban-rural gradients at a single time point. A different approach is to focus on the temporal rather than the spatial aspect and perform "before and after" studies where species diversity is cataloged over time in the same sites. The current study examined changes in ant abundance and diversity associated with the conversion of natural habitats into urban habitats.

II. MATERIALS AND METHODS

Study area

Cubbon Park, officially called Sri Chamarajendra Park is a landmark 'lung' area of Bangalore city, located (12.97°N 77.6°E) within the heart of the city in the Central Administrative Area. This study was conducted from September 2018 to May 2019 at six sites from two fragments of park having various disturbance levels.

Undisturbed area:

Three different plots of plots of Cubbon Park were selected for ant collection as a representative. These plots are least disturbed areas in Cubbon Park. Human activities are nearly nil from this area. This park has a large number of trees, shrubs and grasses. Park floor has high leaf litter content as that of disturbed park site. The foot-fall measured in this region is considered to be far lesser than disturbed plots. Also, this region is partially free from vehicular pollution and the anthropogenic activities such as grazing, deforestation, etc are nil. (Figure 1)

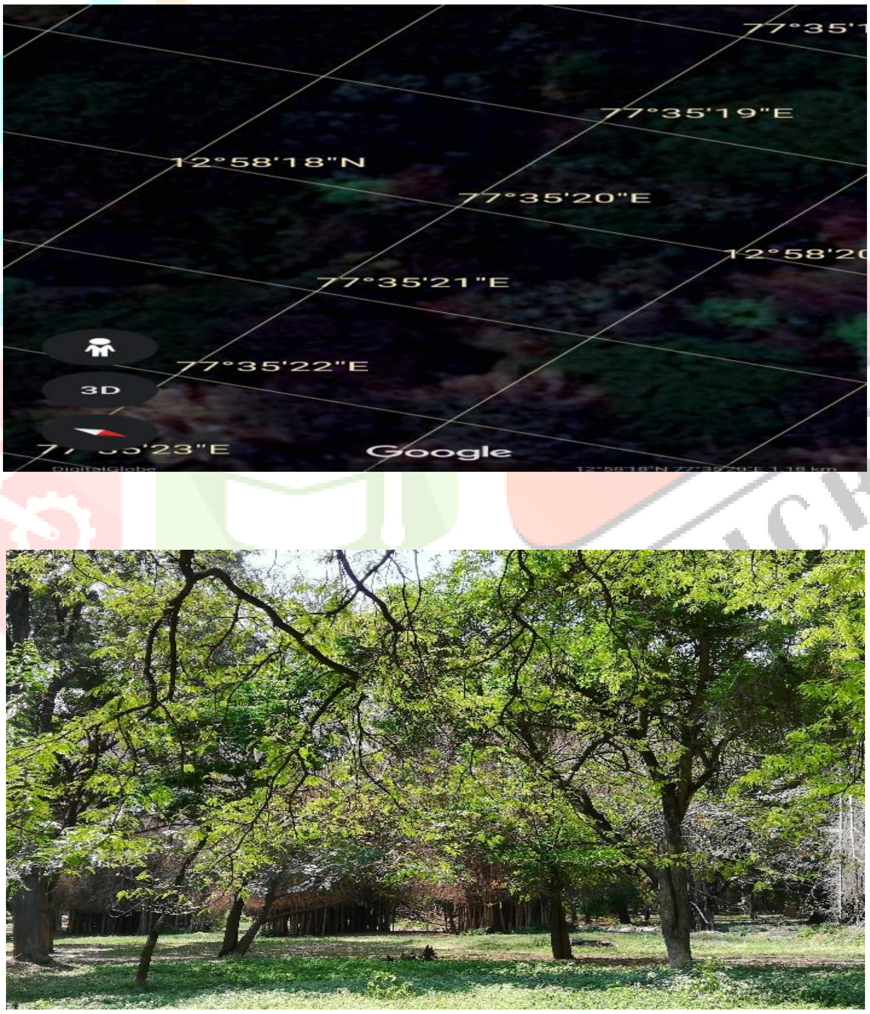

Figure 1: Undisturbed habitat

Disturbed area

Similarly, three plots of Cubbon Park were selected for collection of ants as a representative. These plots are heavily disturbed because of anthropogenic interference, vehicular pollution, deforestation etc. the habitat from this region is adversely affected by human activities. This habitat prominently includes grasses, shrubs and only few tree species like Eucalyptus, Asoka trees are present. Because of roads and tracks, habitat was split into patches. (Figure 2)

Figure 2: Disturbed habitat

Sampling procedure

Specific areas of Cubbon Park were considered suitable for studying the ant abundance and diversity. Three spots were selected in each of the desired habitats. Based on the extent of anthropogenic interference and green cover, the habitats were classified into disturbed and undisturbed habitats or more precisely classified as moderately disturbed.

The ants were collected by using pitfall traps and hand collection methods. Pit fall traps consisted of a 50 ml of paper cup and vials with an opening of 12 cm in diameter, buried at the ground level. One pit fall were placed in each of the randomly chosen 20m x 20m quadrates of one hectare plot at each site. Totally six traps, that is, three traps were set up in each of the disturbed and undisturbed sites. Each vial or trap contained about 10 grams of sugar crystals, and a little bit of jiggery. The traps were set up between 9:00 AM to 11:00 AM and were collected after 12 hours. (Gadagkar et al., 1993) This study was carried out from September 2018 to May 2019. The seasonal differences also had an impact on the number of ants present, in each habitat. Collected ant specimens were sorted, washed and preserved in 70% ethanol in separate plastic vials and brought to the laboratory for identification. Ants were identified at species level with the help of stereo microscope.

a. **Trap set at 8:00am (disturbed habitat)**

b. **Observations recorded at 11:00am**

c. **Traps set at 8:15am (undisturbed habitat)**

d. **Observations recorded at 11:15 am**

Figure 3: Traps setting

Six such traps were set up, three for each habitat. And corresponding observation were made. The total fall in each trap was calculated, which helped in calculating the relative abundance of each species, with respect to the habitat. And their diversity, and richness corresponding to the level of disturbance observed.

To understand the variations and impact of habitat disturbances, the species richness, relative abundance and diversity indices were calculated. Margalef's Diversity Index was used to calculate the richness of the species. (Margaef R 1991)

$$d = (S - 1) / \ln N$$

Where S is the number of species, and N is the total number of individuals in the sample.

To calculate the diversity of the species, the Shannon – Weiner Diversity index was considered ideal. (Barnes BV et al 1998)

$$D = -\Sigma^{s}{}_{i} p_i \log p_i,$$

where s is the total number of species in the sample, i is the total number of individuals in one species, p_i, (a decimal fraction) is the number of individuals of one species in relation to the number of individuals in the population.

Reliability

The use of ants as bio indicators is founded on the assumption that the extent of ant community change reflects broader ecosystem change. Relevant studies justify this ideology and infer that ant do reflect broader ecological change, rather than providing idiosyncratic responses that are as uninformative as they are unrepresentative. Example, a range of mine site rehabilitation studies show that patterns of ant re- colonization reflect those of other invertebrate groups. (Andersen et al., 2004) It is an important aspect of research because it is essential to understand what ecosystem processes and components ants are representing and what they are not.

III. Results

In the present study area total 6 ant species (from 1467 individuals) were reported. The distribution of species showed a dominance of *Solenopsis germiata* (38%), followed by *Oecophylla smaragdina* (18%), *Crematogaster spp* (16%), *Tapinoma melanocephalum* (11%), *Camponatus compressus* (10%), *Monomorium pharaonis* (7%).

A total 5 and 4 ant species were collected from low disturbed and high disturbed sites respectively. Out of 6 ant species almost 3 species (50%) were common to both sites, while another 2 species (30%) were found exclusive to the low disturbed sites. From total 6 ant species *Monomorium pharaonis* and *Camponatus compressus* were absent in highly disturbed sites, whereas *Tapinoma melanocephalum* were absent in low disturbed sites. The numbers of ants collected from low disturbed sites (832 individuals) were more as compared to highly disturbed sites (635 individuals)

With respect to the species richness, we observed that in the study carried in low disturbed sites, showed a high range of richness in the months of September, and a further increase (2%) in the months of December – February. In the months of March – May, there was a decrease (1.5%) in the richness of the species obtained, owing to the prevailing weather conditons. In low disturbed sites, the high index obtained in the species richness corresponds to the atmosphere they thrive in. In the three traps that were set in the low disturbed sites, there is minimum human interference, and their habitats are not altered by vehicular pollution, or by uprooting of trees which impacts the top soil where ground dwelling ants survive. They were collected in high numbers, some species being indigenous to the habitat. Example: *Monomorium pharonis*, was exclusive to this habitat, which exhibits their preference to thrive in an undisturbed atmosphere. (Figure 4)

In the high disturbed areas, there was an increase in the species richness in the months of September to November, and a further rise (4%) December to February and a decrease (6%) in the months of March – May. In high disturbed habitats, there was heavy vehicular pollution near the resting sites, followed by uprooting of trees that damaged the top soil cover and human trampling. A decline is seen in the species richness in the highly disturbed habitats. This decline depicts the impact of human interference within natural habitats of species. *Tapinoma melanocephalum* (163) is a species that is indigenous to highly disturbed environment showing their adaptability to the changing conditions around them. But when the two sets of data were compared it was observed that overall richness in the low disturbed areas was higher (avg 3%) than that of the high disturbed areas. This is indicative of the fact that with minimal foot fall and anthropogenic influence the nature of species obtained will be richer and indicates a more stable environment for the species to thrive; when compared to high disturbed areas. (Figure 4)

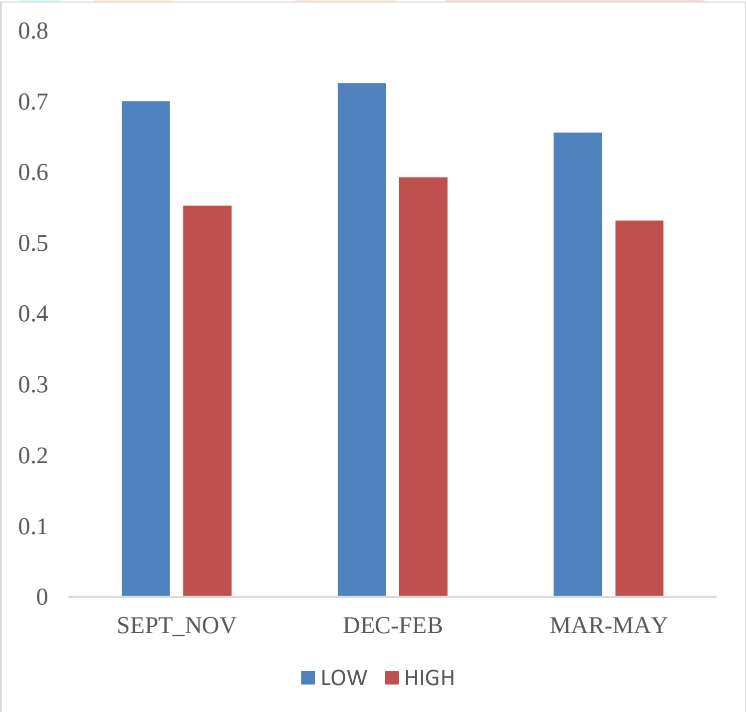

Figure 4: Species richness in low and high disturbed area at different time period

The relative abundance of each species was studied to understand their indigenous nature pertaining to each habitat. In low disturbed sites, *Camponatus compressus* (142 individuals) was more abundant followed by *Oecophylla smaragdina* (137 individuals), *Crematogaster spp* (106 individuals), *Monomorium pharaonis* (103 individuals). This nativeness observed is indicative of their adaptability to the changing conditions which is critically low. These species prefer to thrive in an environment devoid of vehicular pollution and human trampling. *Monomorium pharaonis* is indigenous to this habitat, depicting their sensitivity to the presence of pollutants in the atmosphere. (Figure 5)

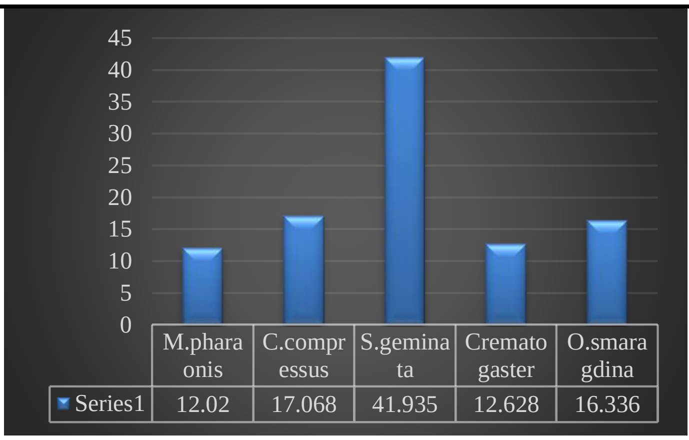

Figure 5: Relative abundance for low disturbed area

Whereas in highly disturbed sites *Tapinoma melanocephalum* (163 individuals) was more abundant, followed by *Oecophylla smaragdina* (125 individuals), *Crematogaster spp* (122 individuals). *Tapinoma melanocephalum* is indigenous to this habitat. This suggests their evolutionary and changing adaptability towards human interference in natural habitats. Studying about Solenopsis geminata in particular we observed that their numbers were significantly the highest in both the habitats. In low disturbed areas, around 300 ants were collected and in high disturbed conditions around 200 ants were collected. The difference in their numbers can be attributed to anthropogenic influences, such as vehicular pollution, human trampling, uprooting of trees. Their dwindling numbers in a disturbed environment depicts their sensitivity to pollutants and changing conditions in their habitats. (Figure 6)

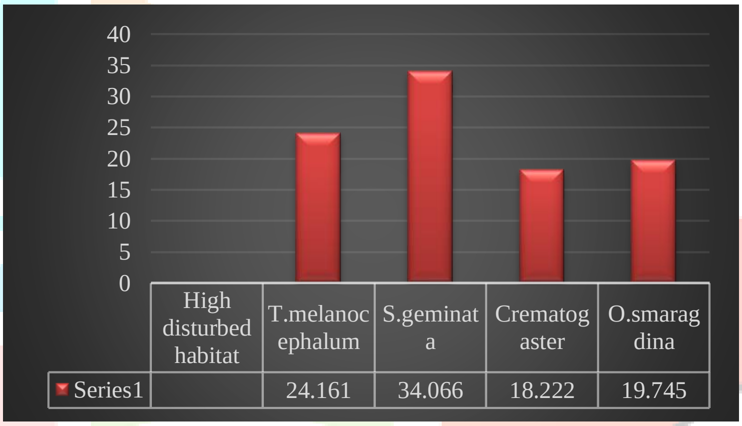

Figure 6: Relative abundance for high disturbed area

Shannon Wiener diversity index for each season of study and respective habitats were studied. In low disturbed habitat; a slight variation is seen in the diversity between the months of September to November and December to February. The diversity is more by around 5% in the months of December- February. A considerable decrease is seen in the diversity in the months of March – May. (25%). The variations between the period of study in the same habitat corresponds to the changing weather conditions. In the case of highly disturbed habitat; the diversity index is higher (20%) in the month of December to February, and a drop (40%) is seen in the months of March to May. (Figure 7)

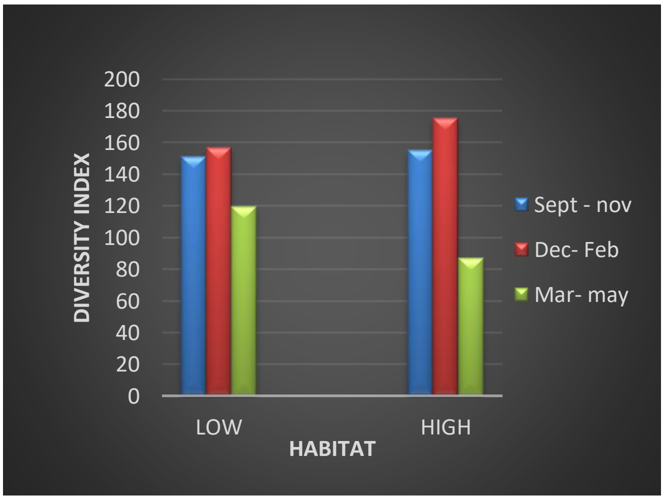

Figure 7: Shannon-Weiner diversity index for low and highly disturbed areas

The idea of Shannon Weiner Diversity Index is to compare the diversity between two habitats. So, when the two habitats were compared, it was concluded that the low disturbed habitat was more diverse, with richer species when compared Highly disturbed conditions. Vehicular pollution in and around the region of study proves to impact the diversity of the species found in the habitat. The presence of pollutants and lack of stable environment to thrive in, leads to dwindling of species number, eventually causing them to either evolve or migrate to a stable and pollutant free environment. The diversity of each habitat has to be maintained in order to retain its stability. The decrease in the diversity index marks the unstable conditions of the highly disturbed environment.

IV. DISCUSSION

From the results obtained the species richness, diversity and relative abundance were higher in low disturbed sites as compared to high disturbed sites. Species diversity is determined not only by the number of species within a biological community *i.e.*, species richness but also by the relative abundance of individuals in that community. Species richness: S is the simplest measure of biodiversity and is simply a count of the number of different species in a given area. This measure is strongly dependent on sampling size and effort. In our study we used Margalef's Diversity Index to calculate the richness of the species which can easily be calculated. Previous studies on species richness with respect to insect fauna suggest that the type of landscape, agricultural or urban, may have had a greater effect on species richness than the agroecological zone (unimodal vs. bimodal rainfall regime). Thus, species richness variation appeared more influenced by border effects than by climatic parameters. As a result, no one community contains the same biodiversity as any of the others, even in rather homogeneous landscapes, due to site-specific characteristics of soil, topography, vegetation, weather, and other environmental factors that may govern each species settlement. (Gann et al 2019)

Ant species richness and abundance both responded unimodally to development at the neighborhood scale (300–500 m), appearing to peak at intermediate levels of land development. These results suggest that ants, despite their confined movements, are affected by environmental alterations in surrounding landscapes. This unimodal response pattern is likely to be a function of a peak in within-patch spatial heterogeneity created by ground disturbance from human activities and forest management, both of which were observed to increase with surrounding urban development. Thus, ant diversity is robust to limited amounts of urban land development and use, but starts declining as human uses begin to dominate the landscape. (Hooper et.al.,2005)

Our findings also substantiate with previous studies where *Solenopsis geminata, Crematogaster and Camponotus sps.*; where obtained in high numbers throughout the study, their decline being seen in the varied habitats. The variation in numbers of species like *Solenopsis geminate* in case of highly disturbed environment is associated with human interference and disturbance. Urbanization affected species richness in a variety of ways. The majority of ant species, especially those that nested in above-ground material, were physically removed from the site when the tree cover and the topsoil were removed. Urbanization also affected species richness through the species-area effect: the negative relationship between the area of a habitat and the number of species found within that area. In all urban habitats, large expanses of impervious concrete and asphalt pavement reduce and fragment the area available for life to survive. The typical size of a residential plot in this study was approximately 1,000 square meters. A typical footprint for the house, including concrete driveway and sidewalks, was approximately 350 square meters. Therefore, the area available for nesting and foraging was reduced by approximately 35%.

Another negative impact on biodiversity is related to the severe structural simplification of vegetation in urbanized areas. Trees serve as important nesting sites for many ant species and trees colonized by honeydew-producing hemipterans provide important feeding sites for many species. During urban development, mature trees were removed and replaced with various landscaping plants once construction was completed. The remaining area was covered by a monoculture of grass to create lawns. Previous studies show that the percentage canopy cover is an important factor influencing ant species richness. A study also demonstrated that land development can significantly affect ant diversity, even in areas that retain a substantial component of native vegetation. (Buczkowski Gand Richmond DS 2014) Land development and disturbance of 30–40% appeared to be the level above which ant diversity began to decline.

Relative abundance refers to the evenness of distribution of individuals among species in a community. Two communities may be equally rich in species but differ in relative abundance. For example, each community may contain 5 species and 300 individuals, but in one community all species are equally common (*e.g.*, *Solenopsis geminata*) while in the second community one species significantly out numbers the other four (*Tapinoma melanocephalum*) It refers to how common or rare a species is relative to other species in a defined location or community. Relative abundance is the percent composition of an organism of a particular kind relative to the total number of organisms in the area. (Khan et al, 2018) Relative species abundances tend to conform to specific patterns that are among the best-known and most-studied patterns in macro-ecology. Different populations in a community exist in relative proportions; this idea is known as relative abundance. With reference to other insects, the relative abundance is studied with respect to their habitats- Ground dwelling, canopy dwelling, insects occupying sub-terranean regions etc. Where majority of the dipterans, and lepidopterans were seen in the ground and canopy, whereas coelopterans were seen in the sub-terranean region.

Our results agree with previous studies, that identified *Solenopsis*, *Camponotus* and *Crematogaster* as the most prevalent ant genera globally. (Ryder Eilkie et al, 2010) Ant abundance, however, differed according to strata in our study. In the canopy, *Camponotus* and *Crematogaster* were the most abundant genera, occurring in 35% of all canopy samples, *Cr. carinata* and *Cr. brasiliensis* comprising 12% of the total. The most abundant *Camponotus* species in the canopy were *C. atriceps* and *C. excisus*. The genus *Solenopsis,* was overwhelming on the ground, comprising 46% of all ground samples. *Monomorium pharaoh*, *Oecophylla smaragdina* were the most abundant species on the ground where the disturbance was less, although each occurred in only ~3% of all ground samples. *Tapinoma melanocephalum* was found only in highly disturbed environments, claiming their abundance there, along with dwindled numbers of *Solenopsis geminata.* We found more species of *Camponotus* and *Solenopsis* overall in both the habitats, but their dwindling numbers at the regions of disturbance, raises an alarm over the presence of pollutants in the atmosphere.

The components of species diversity respond differently to various environmental conditions. A region that does not have a wide variety of habitats usually is species-poor; however, the few species that are able to occupy the region may be abundant because competition with other species for resources will be reduced. Trends in species richness may reveal a good deal about both past and present conditions of a region. Previous studies on other insects' diversity indicate that the Hymenopterans were the most abundant (329) whiles Diptera was the most diverse with 39 families followed by Coleoptera with 21 families. (Kato et al, 1990; Belamkar NV and Jadesh m 2012) The Halictidae (sweat bees), Hymenoptera, were the most abundant family with over 1600 individuals recorded. (Bhandari et al, 2018) Sweat bees are ground nesters forming their nests in clay soil or sandy banks of streams. A few species are attracted to sweat and may sometimes sting if disturbed. They were recorded in large numbers along the banks of streams within the reserve. The Formicidae (ants), the second most abundant family thrive well in the warm moist weather conditions. (Kyerematen et al, 2014) Most forage on the ground and low vegetation and nest in leaf litter, soil and rotten wood which were abundant in the sampling areas. Dipterans were mainly caught in the malaise traps set along moist soil conditions since many are aquatic and are trapped on emergence or as they come to oviposit close to or in the water. The high insect diversity in September at the end of the rainy season may be attributed to the fact that during this time of the year, there are ample food resources for the insects and the rainfall is not too heavy; heavy rainfall tends to sweep most insects away and destroy many of their food resources. In our study, the diversity indices were higher for low disturbed environment when compared to high disturbed environment. This corresponds to their preference to stable conditions, devoid of vehicular pollution, moist soil conditions, reduced footfall and anthropogenic activities. Low disturbed conditions portray a wide range of micro habitats, which facilitate their high diversity indices. This confers upon them a stable and diverse habitat, when compared with that of highly disturbed areas.

From the above results it is concluded that species richness, diversity and abundance were higher in low disturbed sites as compared to high disturbed sites. This is due to habitat destruction and increase in disturbance by various anthropogenic activities. Related studies on ants, and beetles, have shown that species richness and diversity decrease with increase in disturbance. (Kunte, 2001; Pachpor and Ghodke, 2001) Studies from different regions of world many studies have shown that habitat degradation, disturbance and fragmentation have negative effect on ant diversity and abundance. (Watt et al, 2002). One of the emerging results on the effects of fragmentation on ant communities is that environments that are more similar to forest structure will promote inter – fragment connectivity, dispersal movements for foraging and nest – building activities. Ant populations in isolated fragments may be more extinction prone. (Bulton et al, 2020) A large fraction of anthropogenically modified landscapes is designated for parking of vehicles, recreational activities such as walking and other fitness related activities. There is an increasing concern about the intense and constant disturbance associated with unsustainable management of parks. Ant richness is dramatically higher in low disturbed areas compared with intensively disturbed areas. Removal of vegetation or growth of weedy plants following disturbance can have a significant effect on ant assemblages through changes to the micro climate. Seasonality and vertical stratification may contribute to ant species assembly. Resources such as nest and food sites, are important for ant community assembly. They can become increasingly limited as natural habitats are disturbed or converted to productive parks. At soil level, local patches of litter are impacted and evidence shows that plant succession occurring in these disturbed patches alter species composition and may constitute a mechanism of diversity maintenance. (Campos et al., 2007).

Relative abundance of *Solenopsis geminata* and *Tapinoma melanocephalum* were high in the high disturbed sites. This is due to presence of microhabitats which are ideal for above mentioned ant species. *Tapinoma melanocephalum* is from Dominant Dolichodrinae (DD) functional group and they prefer hot and open habitats. They are exceptionally active, aggressive and posing a strong competitive influence on other ants. (Suriyapong Y, 2003) *Solenopsis germiata* are categorized cryptic species functional group by Andersen, (Anderson 2000) and relative abundance is increased in vulnerable to the establishment of introduced ant species. (Tschinkel 1988; Suarez et al, 1998)

Habitat with abundant trees supports high diversity of ants. Thus, habitat variables such as canopy cover and litter content in the soil can provide an appropriate habitat for ants. This is because of habitat complexity and heterogeneity was high in the low disturbed sites as compared to high disturbed sites. Habitat complexity provides hiding, nesting and foraging grounds to the many ant species, but high disturbed sites fail to provide a complex habitat with varying degrees of complexities. From species diversity indices it can be concluded that the ant diversity is varied in both type of habitats and abundance may change with the canopy cover, habitat complexity and level of disturbance.

V. CONCLUSION

From the above study we can conclude that the anthropogenic activities, habitat disturbances have significant impact on ant community. Generally human disturbances result in greater changes in ant species composition than natural disturbances. As with other animal communities disturbance impact will depend on frequency and intensity of disturbance and time over which habitat recover. If we consider one species from our study, *Solenopsis geminata* their numbers were higher in both the habitats and were obtained in nearly all the six traps. But upon counting, we noticed that there was a variation in the numbers that were obtained in low disturbed and highly disturbed habitats. The decrease in number in the highly disturbed conditions shows the sensitivity of the species towards anthropogenic activities and the corresponding impact human activities have on the existing ant communities. This explains how ants functions as biological indicators. From the study conducted for a period of 400 days, the recovery of ant species was significantly low in the highly disturbed areas. As ants are ecological indicators, soil nourishers, replenishers, pollinators and are involved in nutrient cycling, the human interference and habitat disturbance is considered as an important factor responsible for their sensitivity to the altering conditions. And, sustainable landscape designs for recreational facilities and maintenance of parks should be adopted.

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