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Diversity of ant species in Yadava College campus, Madurai Tamil Nadu, India

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Abstract
As one of the world's 17 megadiverse countries and four biodiversity hotspots within its borders, India is home to an impressive diversity of life forms. However, much work remains to document and catalog India's species and their geographical distribution, especially for the diverse invertebrate groups. Ants are one of the most diverse and ubiquitous groups of social insects. Ants (Formicidae) are the largest family under the order Hymenoptera. They act as ecological indicators and ecosystem engineers. In the present study, the species diversity and distribution of ants in the Yadava College campus, Madurai, Tamil Nadu, India, is discussed. The species of ants were collected with the help of hand collection method from seven zones of the college campus. In the research region, fourteen kinds of ants were found. Three subfamilies were discovered among the gathered ants. The majority of species were in the Myrmicinae (58%) and Formicinae (35%) followed by Ponerinae (7%). Of these fourteen ant's species, 4 species namely *Pogonomyrmex rugosus, Camponotus herculeanus, Crematogaster Scutellaris, Oecophylla smaragdina,* were collected from the Canteen and Grass land area, 3 species namely *Camponotus ligniperda, Lasius niger, Megaponera analis* were collected from Play Ground area and 3 species *Camponotus pennsylvanicus, Camponotus floridanus, Solenopsis attageminata* from Science block area, one species *Solenopsis xyloni* from Ladies Garden, 2 species *Monomorium minimum, Pheidole megacephala* from Garden area, 1 species *Pogonomyrmex badius* from IQAC area has been observed. The most specious genera in this study were *Camponotus, Solenopsis, Megaponera,* and *Crematogaster.*

Keywords: Biodiversity, invertebrate, ecological indicators, Formicidae and Hymenoptera

Introduction

"Ants are everywhere, but only occasionally noticed. They run much of the terrestrial world as the premier soil turners, channelers of energy and dominatrices of the insect fauna - yet receive only passing mention in text books on ecology. They employ the most complex forms of chemical communication of any animals and their social organization provides an illuminating contrast to that of human beings, but not one biologist in a hundred can describe the life cycle of any species. The neglect of ants in science and natural history is a shortcoming that should be remedied, for they represent the culmination of insect evolution, in the same sense that human beings represent the summit of vertebrate evolution" [1].

The word ant is derived from 'ante' meaning 'the biter'. The Latin word for ant, Formica, is the source of the family name Formicidae. Between 110 and 130 million years ago, during the Cretaceous epoch, ants diverged from wasp-like progenitors, which affected the emergence of flowering plants. They can be recognized by their antennae that are bent inward and by a characteristic node-like structure that forms a narrow waist anterior to the belly [2]. Ants belong to a single large family Formicidae, largest of order Hymenoptera. It is represented by 26 extant subfamilies with 14,711 valid species and 428 valid genera out of these 152 species are listed by IUCN [3]. And from India, 12 subfamilies are represented by 87 genera with 652 species [4]. "Ants represent the culmination of insect evolution, in the same sense that human beings represent the summit of vertebrate evolution". Mostly ants are having most intricate forms of social organization. Its so difficult to reveal the life cycle of any species completely [1].

All living species of ants are eusocial and form highly cooperative societies which is commonly known as a colony [5]. They establish colonies that can range in size from a few of predatory individuals to highly structured colonies that might encompass millions of individuals and occupy huge territory. Because the ants seem to function as a single unit, cooperating to support the colony, the colonies are frequently referred to as "superorganisms [6]."

Among insects, like the bees, ants are considered beneficial [7, 8]. With respect to man, ants are beneficial, harmful or neutral. In fact, the earliest instance of humans using biological control techniques for insect pests is from China, where people used red ants (Oecophylla sp.) to guard citrus plantations against pests. *Oecophylla smaragdina* (Fabricius) are utilized as biological pest control agents [9]. In terrestrial habitats of the tropics, by their sheer abundance, ants have been considered to be excellent turners of soil [10]. Ants are used in food, medicine, and rituals across a wide range of human cultures. However, because they may destroy crops and penetrate houses, ants' capacity to extract resources may put them in conflict with people. Their direct impact on the ecosystem can readily be judged from the fact that in a terrestrial ecosystem, their biomass and energy consumption is greater than all the vertebrate fauna combined [1].

Because of their tight evolutionary relationships, especially in tropical environments, ants are an efficient form of defence against herbivorous (phytophagous) animals for plants [11]. Ants may quickly dispatch insects and other small

invertebrates, but they can also irritate larger vertebrates to the point where they retreat from the intrusion. Thus, it is clear that ant-hosting plants (myrmecophytes) have a strong selective advantage, and it is likely that these co-evolutionary connections have developed [12]. Ants are causes of biological invasions in continental and island ecosystems throughout the world that bring economical losses in agriculture. Currently at least 150 ant species are invasive [13]. Some species of ants are pests on plants as they damage the plant by invading it and causing its death or drying. The best example is the *Dorylus orientalis* Westwood on potato and the extensive studies on it all over the Orient. The ant is said to bore holes on the tubers bringing down the yields value and causing losses up to 70% [14].

Ant colonies on the whole, are generally immune to other arthropod attacks as they club a large-scale defence against any predator by releasing alert, aggregate or defence pheromones. Renowned ecologists like La Salle and Gauld [15] have explained how ants dominate their ecosystems in a way that cannot be parallelised with any of the other organism. It is not only the biomass, but also, a multitude of mutualistic ant-plant associations that are known to ensure the survival of many plant species. They explain how ant mosaics constitute a dominant ant species which not only affects and controls the distribution of non-dominant ones, but also influence both the species composition and abundance of other arthropod taxa.

Ants are diverse, abundant, easily found, and can be reliably sampled and visually monitored. They are relatively sedentary, with majority in a colony being wingless, with restrictive ranges but are responsive even to small-scale ecological changes in both space and time [16]. Since ants can be a source of information for communication behavior, foraging behaviour, nesting, development, division of labour and regulation of different castes etc., many have used ants as model organisms for their studies as they can be easily cultured in the laboratory and manipulated [17]. In conclusion, ants exhibit impressive adaptive techniques and specializations, including establishing fungi gardens, gathering seeds, herding and milking other invertebrates, constructing communal nests, hunting in packs, social parasitism, and creating slaves [18, 19].

Despite the high number of species and the great importance of ants, they are a difficult group to identify. Their potential use in land management and conservation is undermined by our incomplete knowledge of their taxonomy, diversity patterns, evolution, and ecology. Ants are underrepresented in science and natural history, which is a flaw that needs to be fixed[1]. Losing biodiversity of ants would be a global ecological experiment without match [20]. Understanding the intricate relations of ants with their habitat that encompasses their dynamics, plant associations, interspecific associations and abiotic impacts on them is an almost immediate necessity. Effective conservation of this taxon is essential given the significance of ants in ecological systems. Ants that depend on relationships with other creatures must be protected with special care [21]. Hence, this present study with the aims, to estimate the diversity of ant species in Yadava College campus, Madurai, Tamil Nadu, India. This list could also aid in locating the main under-sampled regions where future taxonomic and sampling efforts should focus.

Materials and methods

1. Study area

Madurai city is hot and dry for four months of the year. Cold winds are experienced during July to September. The hottest months are from March to July. The city experiences a moderate climate from August to October, tempered by heavy rain and thundershowers, and a slightly cooler climate from November to February. The average annual rainfall for the Madurai district is about 85.76 cm. Yadava College campus is located in Madurai District at geographical location of Latitude:9.985^0N; Longitude:78.138^0E and 330 feet or 101 meters above the mean sea level. There are several different natural ecosystems on the Yadava College Campus, including wetlands, meadows, and small and medium-sized ponds. The entire campus is separated into seven different study locations: (a) the canteen, (b) the playground, (c) the science block area, (d) the ladies garden, (e) the garden, (f) the grassy area, and (g) the IQAC area.

2. Sampling of ants

For collection of ants the standard protocol used with modifications. Various sampling techniques including sugar baits, leaf litter technique, beating vegetation, hand collection was carried out for sampling of ants. From November 2021 to February 2022, the survey was run. Five 10 meter transects were chosen at each study location, and samples were taken along them using various sampling techniques. Each transect had six sugar baits, spaced two meters apart. An area of 5 meters on either side of the transect was manually collected by looking for ants on decaying logs, stumps, dead and live branches, twigs, low vegetation, termite mounds, and beneath stones. An area of 5 meters to the left and right of the transect was used to gather ants while hitting the foliage to move the ants off the plants onto the sheets.

3. Identification of ants

Using a microscope and an identification key, the collected ants were identified. The collected ants are identified using a variety of taxonomic keys, including body color, pilosity, the presence of a petiole and postpetiole, the presence of spines in the propodeum and petiole, the number of segments on the antennae, the position of the antennae, etc.

4. Data analyses

To calculate the richness and evenness of ant species at various altitudes, standard methodologies were used. Using the Ludwig and Reyonlds software package, the diversity indices were calculated [22]. The Simpson's index (λ) which responds to changes in the most prevalent species in a community, and Shannon's index (H1), which responds to changes in the abundance of uncommon species in the community, are the two indices needed to calculate Hill's diversity numbers.

Results

Seven research areas on the Yadava College campus—the Canteen area, Playground, Science Block, Ladies Garden, Garden, Grass Land, and IQAC area—were selected for the study of the ant population after fourteen species of ants were found there. Three subfamilies of ants were formed from the entire collection. The Myrmicinae (58%) and Formicinae (35%) families had the bulk of species, followed by the Ponerinae (7%). There were 8 species in subfamily

Myrmicinae, 5 species in the subfamily Formicinae, 1 species in Ponerinae. The genus and species levels of these 14 ant species were determined. In this study region, Myrmicinae ants were the most numerous and diversified group (8 Species) (Table 1).

Table 1: Total number of ant species collected from seven places in Yadava College Campus

S.No	Sub family	Species name
1.	Myrmicinae	*Pogonomyrmex rugosus*
2.	Formicinae	*Camponotus herculeanus*
3.	Myrmicinae	*Crematogaster Scutellaris*
4.	Myrmicinae	*Oecophylla smaragdina*
5.	Formicinae	*Camponotus ligniperda*
6.	Formicinae	*Lasius niger*
7.	Ponerinae	*Megaponera analis*
8.	Formicinae	*Camponotus pennsylvanicus*
9.	Formicinae	Camponotus floridanus
10.	Myrmicinae	*Solenopsis xyloni*
11.	Myrmicinae	*Solenopsis attageminata*
12.	Myrmicinae	*Monomorium minimum*
13.	Myrmicinae	*Pheidole megacephala*
14.	Myrmicinae	*Pogonomyrmex badius*

Of these fourteen ant's species, 4 species namely *Pogonomyrmex rugosus, Camponotus herculeanus, Crematogaster Scutellaris,* O*ecophylla smaragdina,* were collected from the Canteen and Grass land area, 3 species namely *Camponotus ligniperda, Lasius niger, Megaponera analis* were collected from Play Ground area and 3 species *Camponotus pennsylvanicus, Camponotus floridanus, Solenopsis attageminata* from Science block area, one species *Solenopsis xyloni* from Ladies Garden, 2 species *Monomorium minimum, Pheidole megacephala* from Garden area, 1 species *Pogonomyrmex badius* from IQAC area has been observed. The most specious genera in this study were *Camponotus, Solenopsis, Megaponera, and Crematogaster*. The seven ecosystems had slightly varying species diversity indices. The garden area had the highest index (1.35), followed by the canteen area (1.09), the grassland (1.08), the science block and play area (1.07), the ladies garden (1.05), and the IQAC area (0.73). The garden, canteen area, and grassland were found to have the highest levels of the richness and evenness indices (Table 2).

Table 2: Ecological indices of ant species structure in the seven different habitats

S.No	Place	Shannon index(H)	Simpson index(D)	Richness		Evenness		
				R1	R2	E1	E2	E3
1.	Canteen	-1.09	0.48	2.25	0.7	0.86	0.02	-0.16
2.	Play Ground	-1.07	0.3	2.2	0.7	0.70	0.01	-0.15
3.	Science Block	-1.07	0.3	2.1	0.7	0.70	0.02	-0.15
4.	Ladies Garden	-1.05	0.2	2.2	0.7	0.80	0.02	-0.16
5.	Garden	-1.35	0.5	2.0	0.5	0.95	0.01	-0.16
6.	Grass Land	-1.08	0.4	2.1	0.6	0.80	0.02	-0.16
7.	IQAC	-0.73	0.1	2.1	0.6	0.33	0.03	-0.05

Discussion

On the campus, gardening has been done every year as a regular process leading to digging, changing of soil, replacement of soil, additional manuring, burning of litter, changing of plants and grass that has resulted in change of topological profile of ant's ecos. The Yadava college campus is about 52 years old, and the campus area has undergone several modifications in the form of floral cultivations and extension of permanent structures, which has become more rapid in the past few years.

As ants could be gathered from this campus each year without any discernible changes in their availability, it appears that none of the factors connected to air or soil pollution have altered the existence of the ants or their abundance in the campus. 14 species of ants, representing 3 subfamilies, were discovered on the Yadava College campus in Madurai. The Myrmicinae (58%) and Formicinae (35%) families had the most species, followed by the Ponerinae (7%). The most specious genera in this study were *Camponotus, Solenopsis, Megaponera, and Crematogaster.*

In this study region, Myrmicinae ants were the most numerous and diversified group (8 Species). This family had a large seasonal difference that has been seen by others. The number of people increased during the rainy season [23]. They built their nests in the humus of the soil, inside the nuts of woody plants, hollow twigs, under bark, and galls. Therefore, it is not strange that we accumulated more of them. Because food and breeding locations were readily available, these ants were highly specialized. Additionally, they are the only terrestrial and arboreal taxa. These findings are consistent with our observations on campus: *Pheidole* nested in dirt, *Crematogaster* nested in dead wood on trees, Myrmicaria nested at tree bases, and *Solenopsis* nested beneath rocks and rotten logs. In the research region, *Formicinae* were the most numerous. The Formicinae subfamily, which has five species, demonstrated great dominance in this investigation. Seasonal differences in Formicinae were insignificant. Nest construction may be impacted by humidity. Four species of the genus *Camponotus* have been identified. Everywhere, *Camponotus* was a species that was regularly encountered. The *Camponotus* had the highest number of individuals. Carpenter ants are so named because of their "Nesting behaviors" [24]. The Garden and Canteen area included the majority of the ant species. Food supplies might have been crucial[23]. Of these, *Oecophylla smaragdina*, a truly arboreal species, was the most prevalent. These ants built their nests in shaded areas and needed large leaves to cover it. All known species of *Lasius niger* are arboreal and live in untouched environments. Although not to the same level of labor, this study also found that these ants built their nests on the ground. The *Ponerinae* subfamily had more specialized eating habits and a particular market [25]. They consume a variety of foods. Food resources might have had a significant impact on the population of Ponerin. *Megaponera analis* nestled in the ground or even inside decaying wood. To build their nests, leptogenys seek openings in logs or big branches. Physical or seasonal variations had no impact on the population of this group.

These solitary foragers build their nests in logs that have rotted and fallen dead wood.

The Garden and Canteen are dominated by the genera *Crematogaster*, *Pheidole*, and *Camponotus.* The fact that IQAC has the lowest dominance score suggests that there are no dominating ant species. Some of the ant genera have single species that are consistently recorded from one or two places. Ants play a variety of ecological activities that are advantageous to people, such as controlling insect populations and preventing soil erosion. The results of the current investigation will provide important details about ant availability in the area.

Compared to other invertebrates, ants show stronger tolerance to toxins, including industrial pollutants [26, 27]. Only 10% of ants are outside during the day's active period, which is one reason for this type of resistance and adaptability, and another is that ants alter their activity patterns in response to exposure to pollutants[16]; frequently, the density of activity decreases as pollution levels rise. The diversity of the biomass of invertebrate, microbial, and plant species has been linked to the richness [28, 29].

Despite all the crimes committed against the ant colony on the Yadava College campus, the ants have shown signs of persistence and have survived for many generations. This study's findings about the rich diversity of ants suggest that there are sufficient nesting sites, food sources, and foraging opportunities. This location is a good habitat for ants as evidenced by the large diversity of ants found there. This study demonstrated that ants might persevere in the face of adversity, and the study area functioned as a small-scale model to investigate the persistence of different ant species in a given area.

Conclusion

Ants can be found in a variety of settings, including dirt, dead logs, leaf litter, and trees. Ants are effective habitat invaders and bioindicators. Ants are employed to compare habitats and ecosystems to estimate biodiversity. They perform crucial ecological functions such seed distribution, nitrogen cycling, and controlling the population of other insects. Ant colonies are able to divide labor, communicate among members, and resolve complex issues. Pheromones, noises, and touch are all used by ants to communicate with one another. Humans utilize ants in food, medicine, and ceremonies. Some species are prized for their capacity to act as natural pest controllers. According to the data provided here, ants function as excellent environmental indicators. We think the findings of this early study support the beginning of more thorough ant research.

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