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Seasonal Dynamics Of Ant Communities In Forest Ecosystems: Statistical Analysis And Ecological Insights

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Abstract

A seasonal diversity was conducted in the forest of Bagepalli range of Chikkaballapur forest of Karnataka, India from August 2022 to August 2023. 21 species of ants were observed in this range belonging to 15 genera by following three methods such as pitfall traps, handpicking and bush beating. The abundant subfamily was Formicinae with 5 genera and under Myrmicinae, two genera were observed under the subfamily Ponerinae and one genus each from Subfamilies Pseudomyrmicinae and Dolichoderinae. The most abundant species were found to be *Camponotus compressus* followed by *Oecophylla smaragdina*. From the collection of ants few invasive species were also observed such as *Anoplolepis gracilipes* and *Plagiolepis sp.*. Two statistical indices were followed and those were Shannon-Weaver Index and Simpson Index to study the diversity and compare the species richness from the three seasons – summer, monsoon and winter, and a statistical data was formed, the abundance in species were also observed to study which species were dominant and during which season. The maximum diversity was observed during the monsoon season followed by the summer and the least diversity was during the winter. The ants usually prefer a moist environment. The study assumes that the ant diversity can predict the environment.

Keywords: Ants, seasonal diversity, Chikkaballapur forest, environment.

1. Introduction

The main goal of biodiversity research is to describe and gain knowledge of the patterns of the species diversity. Species diversity is usually distributed in a heterogeneous manner among habitats, landscapes an regions (Rosenzweig & Abramsky, 1993). Ants are the eusocial insects and are insects of prime importance to the ecosystem. They are the dominant components of the terrestrial ecosystem and they are distributed universally and contribute to the greater part of biomass. Ants interact with other insects and plants to enrich the soil and aid in the decomposition process. As a result, they are regarded as good biological indicators. Around 22,000 species of ants have been identified and characterised. (Mack et al., 2000). They are one of the main predators both in forests (Philpott & Armbrecht, 2006) and in agro-ecosystems. Ants have also been observed in banana

cultivation as biocontrol agents (Wang et al., 2016) in mango and citrus (Offenberg & Wiwatwitaya, 2013) (Thurman et al., 2019) and as a result they increase the crop yield (Offenberg & Wiwatwitaya, 2013) (Evans et al., 2011). Since ants are social insects in general, they have a biomass four times that of all vertebrates put together (Hölldobler & Wilson, 1990a). There is a possibility that local variations in vegetation cover could result in an increase diversity in the ant species which is also predicted by the Mosaic concept (Whittaker et al., 1977). Ants have the ability to provide food sources to insect-eating animals and they have a positive effect in the afforestation. Ants are important for testing the hypothesis with respect to species richness (Kaspari et al., 2003) structure and function of the community (Pest A., 1973) (Gotelli & Ellison, 2002), eco-physiological hypothesis (Kaspari & Weiser, 2000) mutualism (Bronstein, 1998) and invasions (Holway et al., 2002). Ants are important in focal taxon in agro-ecological studies. They are more alert to the environmental changes such a agroecosystem intensification (Andersen et al., 2002) (Brühl et al., 2003). It has been studied that ants cannot withstand coffee and cacao intensification (Nestel & Dickschen, 1990) (Roth et al., 1994) (Perfecto et al., 2003) (Armbrecht et al., 2005) (Philpott & Armbrecht, 2006). It has been observed that for ant species to establish its community, it requires proper shade of trees. If the trees are removed, then there will be a reduction in the ant nest community because shaded trees provide litter and twigs for their establishment. It has been observed that formicidae is in majority in the forest. According to (N et al., 1991,) the amount of arthropod fauna of Bornean lowland rainforest by logging the canopy showed that formicidae was not a species-rich group. It was the dominant family and had the commonest species. Ants are highly susceptible to global change such as in grazing and climate (Oliver et al., 2016). Ants are known to be responsive to the habitat which are not always surrounded by trees and to the structure of vegetation (Barlow et al., 2016) (Oliveira et al., 2019) which can lead to the development of different communities among grassland and forest. Ants sometimes act as the ecological indicator of climate change (Costa et al., 2018) by increased species richness during summer than winter which shows cold and dry season. Ants are studied as they can be easily sampled with quadrats. In India very less reports on ant ecology and diversity has been researched. Work on ants from Western Ghats- Sri Lanka hotspot has been published by (Gunawardene et al., 2008) (Kumar et al., 2008) had observed ant species in some areas of Bangalore city. 591 species of ants have been identified from India (Tiwari et al., 1998). They contribute to thirty percent of the entire terrestrial faunal biomass on Earth (Wachkoo et al., 2018). According to (Luke et al., 2014). Among the 17 countries with the highest level of biodiversity worldwide is India. It is home to 45,000 plant species and 91,000 animal species, or 7–8% of all known species worldwide(Pande et al., 2014). India constitutes 828 ant species from 100 genera belonging to 10 subfamilies (Bharti et al., 2016). Karnataka comprises a diverse state in terms of forest types include scrub, semi-evergreen, evergreen, moist deciduous, and dry deciduous, which make up over 20% of the entire land area. There have been 31 species of ants found in the West Coastal portion of Dakshina Kannada and Udupi district, representing 17 genera and five subfamilies(D'Cunha et al., 2014). 24 species of ants belonging to 15 genera and six subfamilies were observed in Karnataka University campus, Dharwad, Karnataka (S et al., 2016)

The field of entomology research knows relatively little about the seasonal diversity of ants from Southern Karnataka. Despite the fact that 828 ant species have been found in India, the field of myrmecology, which studies ants, has not gotten much attention in the Chikkaballapur district of southern Karnataka. As a result, research has been done to determine the variety of ant species in the Chikkaballapur district of South Karnataka. The purpose of the study was to look at the distribution and variety of ants in various ecological settings, including dry land, agricultural, and forest habitats. The diversity, distribution, and richness of ant species in and around the Chikkaballapur district will be better understood thanks to the findings of this study.

2. Materials and methods

2.1. Study Area

Chikkaballapur forest, Bagepalli range, Verlakonda, Karnataka, India (13.6433ºN, 77.7845ºE) is located in the Chikkaballapur district of Karnataka, India, (Fig. 1). The climate of Chikkaballapur during monsoon is muggy and overcast, during summer it is hot and sometimes cloudy. The temperature varies from 59º- 94ºF and sometimes below 53ºF or above 100ºF. The area usually consists of dry deciduous and scrub type of forest with plant species give in the table. 1.

Table. 1 Micro-environment of the ants present in the Bagepalli range of Chikkaballapur forest.

SL NO.	COMMON NAME	SCIENTIFIC NAME
1.	Putush/Kongini/Ghaneri	*Lantana Camara*
2.	Mango	*Mangifera indica*
3.	Custard apple	*Annona squamosa*
4.	Common guava	*Psidium guajava*
5.	Pomegranate	*Punica granatum*
6.	Neem	*Azadirachta indica*
7.	Kassod	*Cassia siamea*
8.	Cluster fig	*Ficus racemosa*
9.	Siris	*Albizia lebbeck*

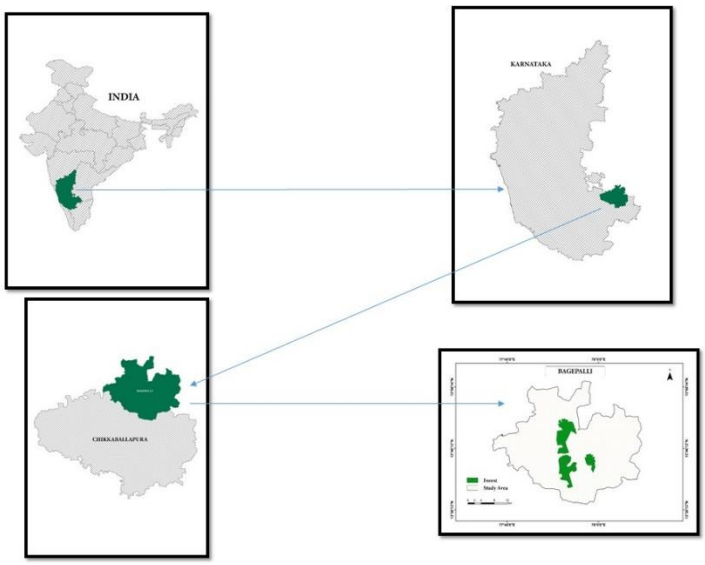

Fig. 1. The geographical location of the study on the diversity of ants in Chikkaballapur forest, Bagepalli Range, Karnataka, India.

2.2. Ant sampling

Ants were observed and collected from the Bagepalli range of Chikkaballapur district of Karnataka, India during a span of 1 year i.e., August 2022 – August 2023. The ant samples were sampled by various methods such as: Pitfall traps (Bestelmeyer et al., 2000) by Plastic containers containing 70% ethanol (Greenslade and Greenslade, 1971) were kept at the soil level and left it for 24 hours and after that they were collected. 16 such pitfall traps were buried in the range. Second method was handpicking where ants from trees, bushes and grasses were randomly picked and kept in plastic containers containing 70% ethanol. The last method used was bush beating (Agosti & Alonso, 2000; Underwood & Fisher 2006; Yeo et al ., 2013) where a bush or a small plat was vigorously shaken and a white paper was kept under the bush from that paper only the ants which fell on the paper were collected. For further analysis, ants were sorted, observed under the microscope and identified using taxonomic keys given by Bingham (C., et al., 1903)(12) and Bolton (Bolton, 1994).

2.3. Statistical Analysis

Using PAST software version 4.03, the Evenness Index and Shannon-Weaver Index were used to compute the graphical depiction of the relative abundance of the data collected from the forest range. The percentage of a species in a sample of a community is known as its relative abundance.

Where:

Pi= ni/N

ni= no. of individuals in each species

N= Total no. of individuals

Shannon-Weaver shows the species richness and evenness

Shannon-Index ranges from 1.5-3.5

Therefore, Shannon-Index [H'] = $\sum_{i=1}^{N} Pi\ lnPi$

Where ni= no. of individual in each species; N is the total number of individuals of all species; Pi is the proportion of individuals of species i and ln denotes natural logarithm.
Evenness index is used to study how evenly species were present in a sample of a community.
Evenness index (J') = $H' / \log N$
N = total number of species
H' = Shannon-Weaver Index.
A curve is made to find out the total number of individuals in each species for a whole year.
A graphical representation was brought out to show the maximum seasonal diversity.
According to the Engelmann scale, each species' dominant status was noted for the following aspects of relative abundance: eudominant = 32–100%, dominant = 10-31.9%, sub-dominant = 3.2–9.9%, recedent = 1.0–3.19%, sub-recedent = 0.32-0.99%, and sporadic = < 0.32%.

2.4. Analysis on the basis of their origin

An analysis on the geographical distribution of ants was studied and labelled them as native or invasive in the area. Invasive species as they were somehow brought to that place and they don't originate from that place unlike native species. Exotic ants also known as tramp ants which are transported unknowingly by cargo ships, trains, etc by humans because of macro size, general nesting habits and opportunistic food diets and they result as the world's worst invasive species (Xu et al., 2022). These type of ant species invasive species if they spread in the range where they are introduced and become ecologically dominant and affect ecosystems, biodiversity, urban environments and human health (Mack et al., 2000). The study and observation of ants regarding geographical distribution was done on the basis of AntWeb and AntWiki.

3. Results of the study

A total of 21 ant species were observed throughout the study. Formicinae was the most abundant subfamily with 11 species belonging to 5 genera followed by the subfamily Myrmicinae with 5 genera, two genera were observed under the subfamily Ponerinae and one genus each from the subfamilies Pseudomyrmicinae and Dolichoderinae. The genus *Camponotus* was highest in number with 7 species. It was observed from the Rank Abundance curve (Fig. 2) and table. 2 that *Camponotus compressus* was the abundant species and the least abundant species was *Polyrhachis sp.* Majority of the species were native species while few of them were invasive species such as *Anoplolepis gracilipes*, *Plagiolepis*, etc. According to the Engelmann scale the recedent class the highest (52.38%) followed by Subdominant class (33.33%), then dominant class (9.52%) and Sub-Recedent class (4.76%) as shown in Fig-4. The present study also showed the comparison in the number of species from three seasons and according to the Shannon-Weaver Indices Fig: 5 and Simpson-Diversity Indices Fig: 6 showed that the summer showed the highest ant diversity with Shannon- Weaver Index (2.91) and Simpson Index (0.9362), followed by winter with Shannon-Weaver Index (2.82) and Simpson Index (0.9319) and last is monsoon with Shannon- Weaver Index (2.49) and Simpson Index (0.8511) in table. 3. The Species- Richness was found out by Brillouin test and It was found that during summer the species-richness is maximum with a value of 2.855 followed by winter with 2.699 and then monsoon with 2.473.

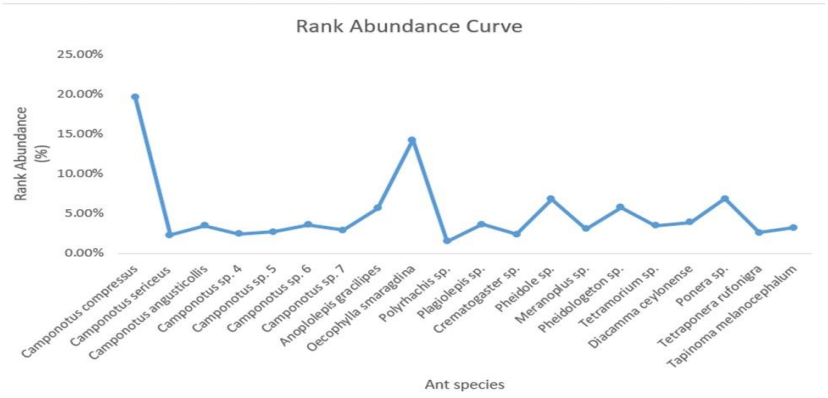

Fig. 2: The Rank Abundance Curve of 21 species observed during summer, monsoon and winter in Chikkaballapur forest, Bagepalli range, Karnataka, India.

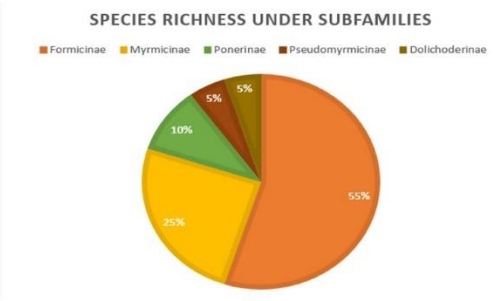

Fig. 3: Species richness pattern of the sub-families in the Chikkaballapur district, Bagepalli range, Karnataka, India.

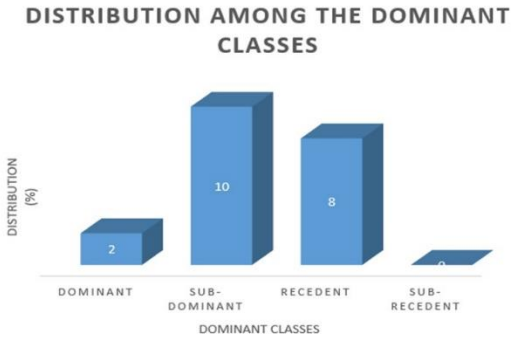

Fig. 4: Distribution of ant species under the Dominant classes with Sub-dominant showing the highest number of species and sub-recedent the lowest in Chikkaballapur forest, Bagepalli range, Karnataka, India

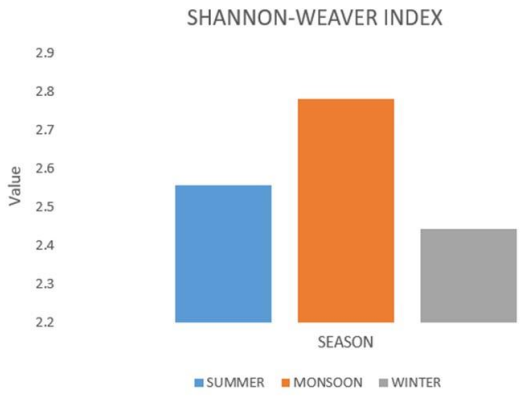

Fig. 5: A graph on the seasonal diversity of ants by Shannon-Weaver Index representing three seasons – Summer, monsoon and winter with maximum diversity observed during the monsoon season in Chikkaballapur forest, Bagepalli range, Karnataka, India.

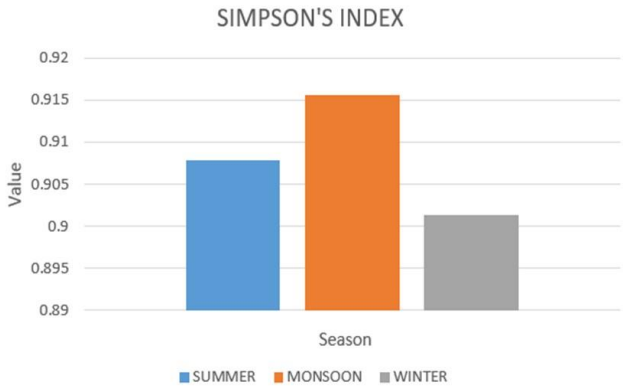

Fig. 6: A graph on the seasonal diversity of ants by Simpson Diversity Index representing three seasons- Summer, monsoon and winter with maximum diversity observed during the monsoon season in Chikkaballapur forest, Bagepalli range, Karnataka, India.

Table 2 Ant species with subfamily and their relative abundance with dominant class and their origin

TAXA				
SUBFAMILY		**RELATIVE ABUNDANCE**	**DOMINANCE CLASS**	**STATUS**
Formicinae	*Camponotus compressus*	19.63%	Dominant	Native
	Camponotus sericeus	2.28%	Recedent	Native
	Camponotus angusticollis	3.46%	Sub-dominant	Native
	Camponotus sp. 4	2.43%	Recedent	Native
	Camponotus sp. 5	2.68%	Recedent	Native
	Camponotus sp. 6	3.59%	Sub-dominant	Native
	Camponotus sp. 7	2.87%	Recedent	Native
	Anoplolepis gracilipes	5.65%	Sub-dominant	Invasive
	Oecophylla smaragdina	14.26%	Dominant	Native
	Polyrhachis sp.	1.49%	Recedent	Native
	Plagiolepis sp.	3.62%	Sub-dominant	Invasive
Myrmicinae	*Crematogaster sp.*	2.40%	Recedent	Native
	Pheidole sp.	6.80%	Sub-dominant	Native
	Meranoplus sp.	3.06%	Recedent	Native
	Pheidologeton sp.	5.77%	Sub-dominant	Invasive
	Tetramorium sp.	3.46%	Sub-dominant	Native
Ponerinae	*Diacamma ceylonense*	3.87%	Sub-dominant	Native
	Ponera sp.	6.84%	Sub-dominant	Native
Pseudomyrmicinae	*Tetraponera rufonigra*	2.59%	Recedent	Native
Dolichoderinae	*Tapinoma melanocephalum*	3.21%	Sub-dominant	Native

Table 3 Shannon-Weave Index and Simpson Index

SL NO.	**SEASON**	**SHANNON-WEAVER INDEX**	**SIMPSON INDEX**
1.	SUMMER	2.557	0.9078
2.	MONSOON	2.783	0.9156
3.	WINTER	2.443	0.9013

4. Discussion

The present paper states that during the monsoon season the diversity of ant species were maximum and then comes the summer season followed by winter season. Similar kind of observation was also made by that ant species richness and activity increases at the starting of monsoon and gradually decreases towards the end of the monsoon season (Cook et al., 2011). A seasonal diversity based on the studies observed that the diversity of ants were high during the South-West monsoon season (Panneer Selvam et al., 2013).
The foraging activity of the ants increases as soon as the winter decreases due to increase in the number of workers (Hölldobler & Wilson, 1990b). On the other hand some species are not observed during extreme summer (Whitford, 1978). The tropical region's ant diversity was highest during wet season (Vikram Reddy & Venkataiah, 1990) (Lindsey, 2001). The arboreal ant communities in advanced stages of Tropical Dry Forest may form mosaics of dominant species during the wet season (Neves et al., 2010). The diversity of ants was maximum during the wet season and not during the dry season. It is mainly due to the availability of food sources (Watanasit et al., 2000). The ant species richness in Kellerberrin, Western Australia was low during winter and high during summer and spring (L D et al., 1993). Ants usually forage for food and from the study we can say that the diversity can be observed maximum when the food sources availability is maximum. During the spring time the queen starts laying eggs, larvae development begins and pupae appears. New workers develop into adults. During the summer oviposition and brood development takes place and stops as the winter approaches as they go towards a temporary inactive stage. A similar research was done in New South Wales and it was observed that the richness of ant species and their activity decreases as winter approaches and increases as spring enters (Stevens et al., 1998). The species richness and their activity increases during summer and monsoon. One explanation can be given is that since ants are thermophilic they prefer warmer and moist environment for their activities so the species richness and diversity are maximum during these seasons. The species rank abundance curve showed that there was a fluctuation in the species in all the three seasons and throughout the sampling collection the *Camponotus compressus* and *Oecophylla smaragdina* were highest in number and they were observed everywhere in the field study. The diversity of ants can also be due to a disturbance in the environment. The disturbed area can also show less diversity and the ones where the disturbances are less can show more diversity. An important relation was also observed between ants and plantation. Few invasive species of ants were also observed where they could have been displaced by native species but in this study no such significant decrease was observed in the area. One of the main components for the diversity of ant species could be because of the presence of open and dry habitats favourable for ant species.

Conclusion

The present study observed there is a seasonal fluctuation in the species of ants. The Shannon-Weaver Index, Simpson-Index and Rank abundance curve showed that a relative significant values in all the seasons. The temperature plays a significant role in the study as it shows that the diversity of ant species was more during the monsoon as ants prefer a moist environment and resource to its favour. During dry season as in winter the ants are assumed to be gone into an inactive stage and again shows their diversity during the monsoon season. The microenvironment plays a major role as the arboreal ants collected were in a significant number. The methods followed such as pitfall traps, bush beating and handpicking the pitfall traps showed the maximum collection of ants as they are ground dwellers.

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