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Diversity and Distribution of Ant Species (Hymenoptera: Formicidae) in Relation to Different Habitats in Western Ghats, India

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Abstract

Konni Forest Division, located in the Western Ghats and on the banks of the Achenkovil River in the Pathanamthitta district, Kerala, has a rich history of forest-human interaction and a diverse range of fauna. No research studies have been carried out on the ant fauna in the Konni area of the Agasthyamala Biosphere Reserve to date. Ant diversity of Evergreen-forest, Teak plantation and Adavi Ecotourism areas in the Naduvathumuzhy range of Konni Forest Division were compared for a period of one year (October 2021 to September 2022). The exploration yielded sixty-four species of ants under 35 genera belonging to 7 subfamilies namely Myrmicinae, Formicinae, Ponerinae, Dolichoderinae, Pseudomyrmecinae, Dorylinae and Amplyponinae. Myrmicinae was the most abundant subfamily in all studied habitats. The highest ant diversity was found in evergreen forest habitats (47 species), followed by less disturbed teak plantations (36 species), and the lowest in altered and disturbed ecotourism (28 species) regions. Among the three environments, Sorenson's similarity index of ant species was highest between evergreen forest (0.602) and teak plantation, and lowest between evergreen forest and ecotourism (0.533). This finding gives an idea about the ecological sensitivities of ants in different habitats and can help in the planning of conservation programmes in this protected area.

Keywords: Ants, Evergreen Forest, Monotypic cultivation, Ecotourism,

INTRODUCTION

Ants belong to the family Formicidae and the order Hymenoptera, which also includes bees, wasps and sawflies. Among the nine suggested indicators, ants are a well-known invertebrate group that is used to evaluate ecological responses (Underwood and Fisher,2006). Common insects like ants are believed to be essential to the wellbeing of ecosystems. They carry out a number of ecological responsibilities, including dispersing seeds, cycling nutrients, and managing the population of other insects. (Grimaldi and Engel, 2005; Holldobler and Wilson, 1990)Ants are increasingly being used as bioindicators to monitor ecosystem health conditions (Akhila and Keshamma, 2022). The ant fauna also somewhat reflects the other invertebrate taxa found in a region (Majer, 1983). Ants are excellent disturbance bioindicators because they are extremely sensitive to ecosystem disruption caused by

species invasion, grazing activities in the forest, along with forest clearing and fragmentation for construction purposes.(da Rocha et al., 2010). Ants have recently been considered as a promising option for ecological restoration projects, environmental monitoring (De Almeida, 2024) and even habitat conservation in the Atlantic Forest biome's conservation area (Lutinski et al., 2024). There are not many studies from India (Narendra et al., 2011; Rajan et al., 2016; Savitha et al., 2008) that explore the use of ants as indicators of habitat disturbance, notably in the Southern Western Ghats region (Anu & Sabu, 2007; Sadasivan et al., 2013; Selvarani & Amutha, 2013).

Konni Forest Division is a part of Agasthyamala Biosphere Reserve which is one of the three primary centres of endemism in Kerala. The distributional pattern of invertebrates in the forest is poorly understood, particularly with regards to ants. The present study compares three sites of Konni Forest Division for species diversity, species composition an effect of disturbances. One site is an undisturbed Evergreen Forest, second one is Teak Plantation and another is a disturbed Ecotourism Area of the Forest Division.

MATERIALS AND METHODS

Sample collection was done at three sites of the Konni Forest Division, on the bank of the river Achenkovil. It was carried out for a period of one year from October 2021 to September 2022. The division area lies between 9° 3' and 9° 15' North latitude and 76° 4' and 77° 6' East longitude. The forest tracts form part of the Western Ghats and are situated mainly on their western slopes. Three sites from the Konni Forest's Naduvathumuzhy range were chosen for this comparison study (Figure 1). The undisturbed site, a dense Evergreen-forest named as Narakanaruvithodu (9°04'48.8"N 77°10'13.5"E), and the disturbed site, the Adavi ecotourism area (9°14’41”N & 76°55’20”E), and monoculture Teak plantation (1968 Mundoormuzhy) with in forest division (9°24’75”N & 76°92’39” E) were chosen for this study.

Figure 1: Administrative map of Konni Forest Division

Ants were collected using different methods (hand picking, bait trap, vegetation beating, tray sifting, sweep netting and litter sifting) as described by Gadagkar et al., (1993) and Agosti et al., (2000). Sampling was done from 4-8 plots (1 x 1 m^2 quadrats) from each habitat. All ants in the quadrat were collected, sorted, cleaned and promptly stored in separate vials containing 70% ethyl alcohol.

Identification of ant species was done with the help of a stereo microscope based on the taxonomic keys of Bingham (1903) and Bolton (1994; 2007). Sorenson's Similarity index was calculated using the data collected from both sites (Chao et al.,2005). The functional groups of collected ants were classified on the basis of classification provided by Andeson (1995,2000) and Bharti etal., (2013).

RESULTS AND DISCUSSION

A total of sixty- four species of ants belonging to 35 genera and 7 families (Table.1) were recorded from the study area during the study. These ant species were represented by seven sub families namely, Myrmicinae, Formicinae, Ponerinae, Dolichoderinae, Pseudomyrmecinae and Amplyponinae (Figure.2). The subfamily Myrmicinae showed high species diversity (47%) followed by Formicinae (23%) Ponerinae (14%), Dolichoderinae (8%), Pseudomyrmecinae (5%), Dorylinae (2%) and Amplyponinae (1%). Species from the Amplyponinae and Dorylinae subfamilies were exclusively observed in the evergreen forest. *Pheidole and Crematogaster* were represented with higher number of species than others.

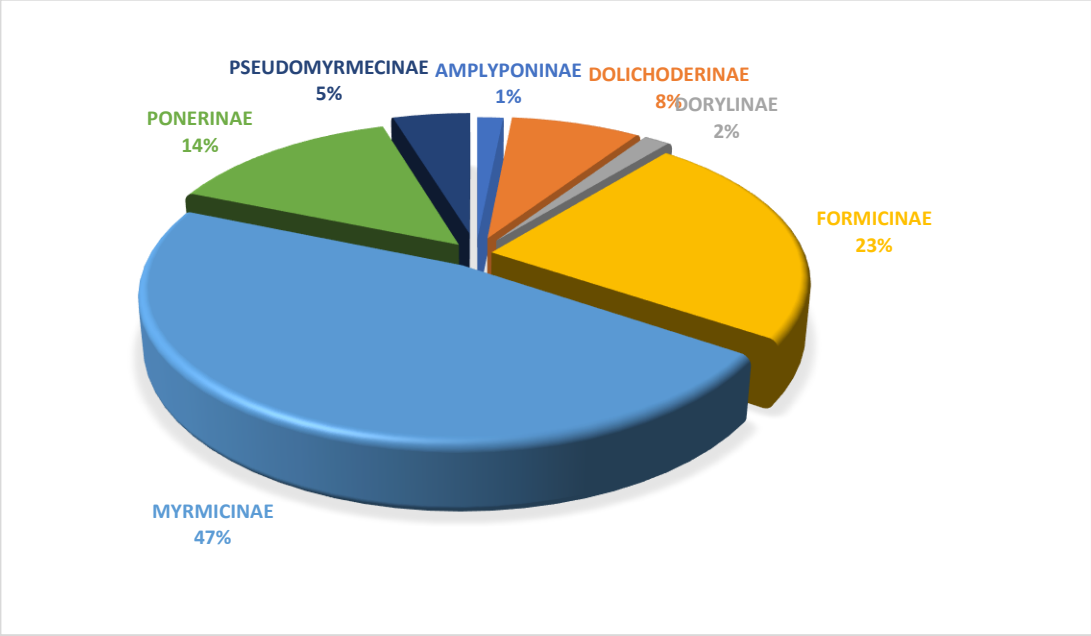

Figure 2: Species-richness pattern of subfamilies in the study area.

Table 1: Checklist of Ants (*Hymenoptera: Formicidae*) collected during study

SUBFAMILY	GENUS	SPECIES
AMPLYPONINAE	Stigmatomma	*Stigmatomma minutum* (Forel, 1913)
DOLICHODERINAE	Chronoxenus	*Chronoxenus walshi* (Forel, 1895)
	Tapinoma	*Tapinoma indicum* (Forel, 1895)
		Tapinoma melanocephalum (Fabricius, 1793)
	Technomyrmex	*Technomyrmex albipes* (Smith, 1861)
		Technomyrmex indicus (Bolton, 2007

DORYLINAE	Centromyrmex	*Centromyrmex feae* (Emery,1889)
FORMICINAE	Acropyga	*Acropyga acutiventris*(Roger, 1862)
	Anoplolepis	*Anoplolepis gracilipes* (Smith, 1857*)*
	Camponotus	*Camponotus irritans* (Smith, 1857)
		Camponotus parius (Emery, 1889)
		Camponotus rufoglaucus (Jerdon, 1851)
		Camponotus sericeus (Fabricius, 1798)
	Lepisiota	*Lepisiota binghami* (Harshana & Dey 2022)
	Nylanderia	*Nylanderia taylori* (Forel, 1894)
		*Nylanderia yerburyi (*Forel, 1894)
	Oecophylla	*Oecophylla smaragdina* (Fabricius, 1775)
	Paratrechina	*Paratrechina longicornis* (Latreille, 1802)
	Polyrhachis	*Polyrhachis exercita* (Forel, 1907)
		Polyrhachis punctillata (Roger, 1863)
		Polyrachis gracilior (Forel, 1893)
		Polyrhachis illaudata (Walker, 1859)
MYRMICINAE	Cardiocondyla	*Cardiocondyla parvinoda* (Forel, 1902)
		Cardiocondyla wroughtonii(Forel, 1902)
	Carebara	*Carebara affinis* (Jerdon, 1851)
		Carebara diversa (Jerdon, 1851)
	Cataulacus	*Cataulacus taprobanae* (Smith, 1853)
	Crematogaster	*Crematogaster biroi* (Mayr, 1897)
		Crematogaster dohrni (Mayr, 1879)
		Crematogaster flava (Forel, 1886)
		Crematogaster sagei (Forel, 1902)
		Crematogaster rogenhoferi (Mayr, 1879)
		Crematogaster wroughtonii (Forel, 1902)
	Meranoplus	*Meranoplus bicolor* (Guerin-Meneville, 1844)
		Meranoplus rothneyi (Forel,1902)
	Monomorium	*Monomorium floricola* (Jerdon, 1851)
		Monomorium monomorium (Bolton, 1987)

		Monomorium pharaonis (Linnaeus, 1758)
	Myrmecina	*Myrmecina urbanii* (Tiwari, 1994)
	Myrmicaria	*Myrmicaria brunnea* (Saunders, 1842)
	Pheidole	*Pheidole minor* (Jerdon, 1851)
		Pheidole watsoni (Forel, 1902)
		Pheidole constanciae (Forel, 1902)
		Pheidole wroughtonii. (Forel, 1902)
		Pheidole sulcaticeps (Roger, 1863)
		Pheidole spathifera (Forel, 1902)
	Recurvidris	*Recurvidris recurvispinosa* (Forel, 1890)
	Solenopsis	*Solenopsis geminata* (Fabricius, 1804)
		Solenopsis nitens (Bingham, 1903)
	Tetramorium	*Tetramorium inglebyi* (Forel, 1902)
		Tetramorium smithi (Mayr, 1879)
	Trichomyrmex	*Trichomyrmex destructor* (Jerdon, 1851)
PONERINAE	Anochetus	*Anochetus myops* (Emery, 1893)
	Brachyponera	*Brachyponera luteipes* (Mayr, 1862)
	Diacamma	*Diacamma indicum* (Santschi, 1920)
		Diacamma ceylonense (Emery,1987)
	Hypoponera	*Hypoponera assumuthi* (Forel, 1905)
		Hypoponera confinis (Roger, 1860)
	Leptogenys	*Leptogenys processionalis* (Jerdon, 1851)
	Mesoponera	*Mesoponera melanaria* (Emery, 1893)
	Odontomachus	*Odontomachus simillimus* (Smith, 1858)
PSEUDOMYRMECINAE	Pseudoneoponera	*Pseudoneoponera rufipes* (Jerdon, 1851)
	Tetraponera	*Tetraponera allaborans* (Walker, 1859)
		Tetraponera rufonigra (Jerdon, 1851)
Total	**35**	**64**

A total of 47 species of ants in 31 genera of 7 sub-families were collected from Evergreen Forest. Myrmicinae was found to be the most diverse sub-family, with 11 genera and 20 species. It is followed by Formicinae with 7 genera and 10 species Least genus and species diversity were

recorded in subfamilies Amplyponinae and Dorylinae. Similar dominating pattern of subfamily Myrmicinae and Formicinae was observed by Rabeesh et al. (2008), Gayathri and Roopavathy (2019) and Rajasree et al. (2023). The above results line up with the global pattern (Herwina et al., 2020). *Crematogaster* was observed to be the most dominant genera with 6 species.

Ants belonging to five subfamilies and 23 genera comprising 28 species were collected from the Adavi Ecotourism Area. Subfamily Myrmicinae showed the maximum diversity with 8 genera and ten species followed by Formicinae with six genera and nine species. The subfamily Pseudomyrmecinae exhibited the least diversity. Result emphasizes the dominancy exhibited by the subfamily Myrmicinae and Formicinae with in the ant communities, due to their ability to adapt to different niche. Genus *Camponotus* was recorded to be the most species rich with three species. *Camponotus* is one of the most adapted genera in riverine and cultivated area (de Souza et al., 2017; Sornapriya and Varunprasath,2018).

A total of 36 species were identified from Teak plantations, which represent 27 genera and 5 subfamilies, including Dolichoderinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae. With 10 genera and 16 species, Myrmicinae was the most diverse subfamily. *Camponotus* is the richest genera with 3 species. The diversity of ant species in the Teak plantation is greater than that of the Adavi ecotourism area (disturbed area) and less than that of the Evergreen Forest (undisturbed area), because this habitat lies in between the other two habitats in terms of disturbance and vegetation. The diversity of ant species increases with vegetation and vice versa (Sunil et al., 1997) and similar results were reported from the current study.

This study reflects remarkable differences in diversity and composition of ants among different habitats (Table 2). Ant diversity was found to be highest in evergreen forest habitat, followed by less disturbed teak plantations and lowest in altered and disturbed ecotourism areas (Figure 3). Because ants specialize to the greatest extent possible for nesting, mating, and food availability, they are very specific to the habitat in which they live. The intricate vegetation might provide creatures with food and shelter. Ant species richness commonly differs between monocultures and native forests (Cerda et al., 2009).

Table 2: Distribution of ant species in three different habitats of Western Ghats, Kerala

Sl.No.	Species name	Ecological Habitat		
		Evergreen Forest	Teak Plantation	Adavi Ecotourism
1	*Stigmatomma minutum* (Forel,1913)	+	–	–
2	*Chronoxenus walshi* (Forel,1895)	+	+	+
3	*Tapinoma indicum* (Forel,1895)	+	+	+
4	*Tapinoma melanocephalum* (Fabricius, 1793)	+	–	–
5	*Technomyrmex albipes* (Smith, 1861)	+	–	–
6	*Technomyrmex indicus* (Bolton, 2007	+	+	+

7	*Centromyrmex feae* (Emery,1889)	+	–	–
8	*Acropyga acutiventris*(Roger, 1862)	–	+	–
9	*Anoplolepis gracilipes* (Smith, 1857*)*	+	+	+
10	*Camponotus irritans* (Smith, 1857)	+	+	+
11	*Camponotus parius* (Emery, 1889)	+	+	+
12	*Camponotus rufoglaucus* (Jerdon, 1851)	+	+	–
13	*Camponotus sericeus* (Fabricius, 1798)	–	–	+
14	*Lepisiota binghami* (Harshana&Dey,2022)	+	+	–
15	*Nylanderia taylori* (Forel, 1894)	–	+	+
16	*Nylanderia yerburyi (*Forel, 1894)	+	+	+
17	*Oecophylla smaragdina* (Fabricius, 1775)	+	+	+
18	*Paratrechina longicornis* (Latreille, 1802)	+	+	+
19	*Polyrhachis exercita* (Forel, 1907)	–	+	–
20	*Polyrhachis punctillata* (Roger, 1863)	+	–	–
21	*Polyrachis gracilior* (Forel, 1893)	–	–	+
22	*Polyrhachis illaudata* (Walker, 1859)	+	–	–
23	*Cardiocondyla parvinoda* (Forel, 1902)	+	+	+
24	*Cardiocondyla wroughtonii* (Forel, 1902)	–	+	–
25	*Carebara affinis* (Jerdon, 1851)	+	+	–
26	*Carebara diversa* (Jerdon, 1851)	+	–	–
27	*Cataulacus taprobanae* (Smith, 1853)	+	+	–
28	*Crematogaster biroi* (Mayr, 1897)	+	+	+
29	*Crematogaster dohrni* (Mayr, 1879)	+	–	–
30	*Crematogaster flava* (Forel, 1886)	–	+	–
31	*Crematogaster sagei* (Forel, 1902)	+	–	–
32	*Crematogaster rogenhoferi* (Mayr, 1879)	+	–	–
33	*Crematogaster wroughtonii* (Forel, 1902)	+	–	+
34	*Meranoplus bicolor* (Guerin-Meneville, 1844)	+	+	+
35	*Meranoplus rothneyi* (Forel,1902)	–	+	–
36	*Monomorium floricola* (Jerdon, 1851)	+	–	+

37	*Monomorium monomorium* (Bolton, 1987)	+	+	–
38	*Monomorium pharaonis* (Linnaeus, 1758)	–	+	–
39	*Myrmecina urbanii* (Tiwari, 1994)	+	–	–
40	*Myrmicaria brunnea (*Saunders, 1842)	+	+	–
41	*Pheidole minor* (Jerdon, 1851)	+	–	–
42	*Pheidole watsoni* (Forel, 1902)	+	–	–
43	*Pheidole constanciae* (Forel, 1902)	–	+	–
44	*Pheidole wroughtonii.* (Forel, 1902)	+	+	+
45	*Pheidole sulcaticeps* (Roger, 1863)	–	–	+
46	*Pheidole spathifera* (Forel, 1902)	+	–	–
47	*Recurvidris recurvispinosa* (Forel, 1890)	+	–	–
48	*Solenopsis geminata* (Fabricius, 1804)	–	+	+
49	*Solenopsis nitens* (Bingham, 1903)	–	+	–
50	*Tetramorium inglebyi* (Forel, 1902)	+	–	+
51	*Tetramorium smithi* (Mayr, 1879)	–	+	–
52	*Trichomyrmex destructor* (Jerdon, 1851)	–	–	+
53	*Anochetus myops* Emery, 1893	+	–	–
54	*Brachyponera luteipes* (Mayr, 1862)	+	+	+
55	*Diacamma indicum* (Santschi,1920)	+	+	+
56	Diacamma ceylonense(Emery,1987)	+	–	–
57	*Hypoponera assumuthi* (Forel, 1905)	+	+	–
58	*Hypoponera confinis* (Roger, 1860)	+	–	+
59	*Leptogenys processionalis* (Jerdon, 1851)	+	+	–
60	*Mesoponera melanaria* (Emery, 1893)	–	–	+
61	*Odontomachus simillimus* (Smith, 1858)	+	+	+
62	*Pseudoneoponera rufipes* (Jerdon, 1851)	+	+	–
63	*Tetraponera allaborans* (Walker, 1859)	–	–	+
64	*Tetraponera rufonigra* (Jerdon, 1851)	+	–	–
	Ant Species Richness	**47**	**36**	**28**

+ (Present), -(Absent)

The least diversity of ant species was found in ecotourism site. The presence of invasive species, external disturbances and human interference are the reasons for the decrease in ant species diversity in ecotourism area (Roselle et al., 2024). Compared to disturbed habitats, it was found that forested areas had greater diversity and less dominance. The species composition varies depending on the habitat. These results are concordant with ant diversity studies in other parts of Western Ghats (Anu and Sabu, 2007; Joseph and Thomas, 2021).

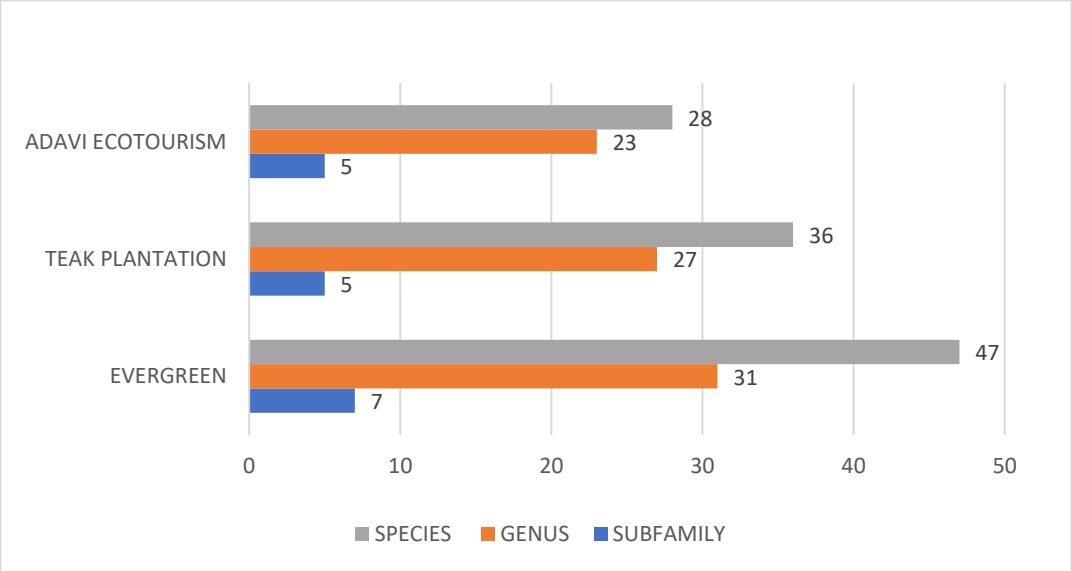

Figure 3: Comparison of Sub-family- genus- species wise distribution of ants (*Hymenoptera: Formicidae*) during the study

A greater diversity of invasive species was found on the teak plantation and in the Adavi ecotourism region. Three invasive species have been identified in the Adavi ecotourism area: *Trichomyrmex destructor, Anoplolepis gracilipes* and *Paratrechina longicornis*. In the teak plantation, *Paratrechina longicornis, Anoplolepis gracilipes* and *Monomorium pharaonic* were noted. In the Evergreen Forest, *Anoplolepis gracilipes* and *Paratrechina longicornis* were also observed.

Myrmicinae was the most abundant subfamily in all the three habitats (Figure 4). Out of the total 64 species observed, 18 were unique to evergreen forests, 9 were unique to teak plantations, and 6 were unique to ecotourism areas. However, 15 species were common to the three habitats. The Evergreen Forest and Teak Plantation had the highest similarity index (0.602), while the Evergreen Forest and Ecotourism Area had the lowest (0.533). Similarity index between teak plantation and ecotourism areas was 0.563. Ants can be effectively used as an indicator because they immediately respond to any alteration in the surrounding environment.

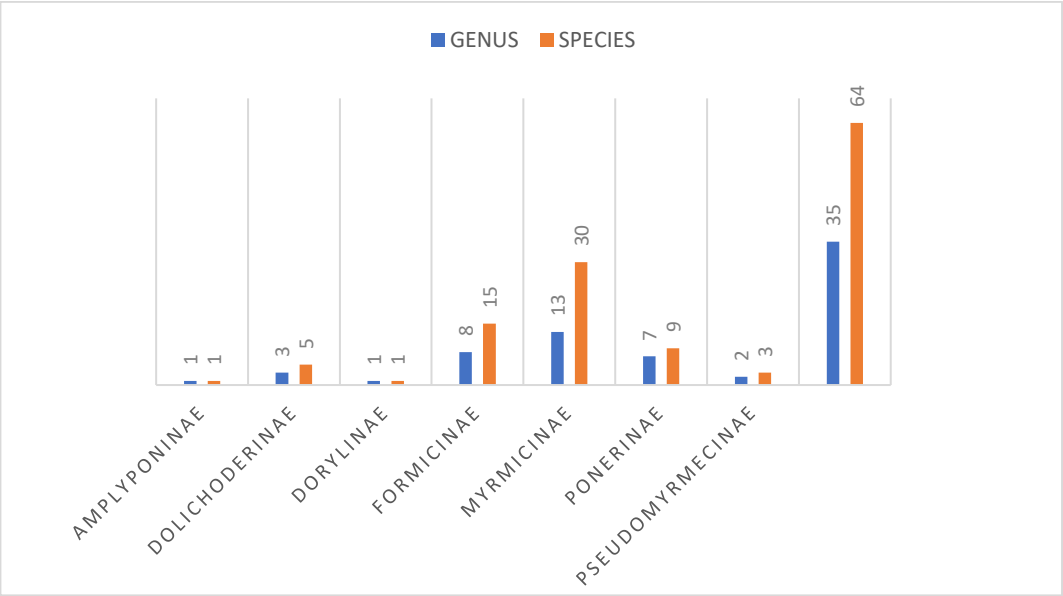

Figure 4: Genus – Species wise distribution in different Sub-families of ants (*Hymenoptera: Formicidae*) collected during the study

Eight functional groups were identified from collected ants (Andeson 1995,2000; Bharti etal., 2013). Eight functional groups observed in Evergreen Forest had a higher proportion of specialized ants. Opportunists prefer disturbed environments over undisturbed sites. The functional group abundance is greater in evergreen forests and teak plantations than the ecotourism area (Figure :5). In this context, ants play as major functional groups that can provide a widespread and predictive understanding of community responses to ecological disturbance (Hoffman & Andersen, 2003; Lassau & Hochuli, 2004; George & Prasad, 2023).

Table :3 Functional groups of ants recorded during the study

Subfamily	Species	Functional Group
AMPLYPONINAE	*Stigmatomma minutum*	*CS*
DOLICHODERINAE	*Chronoxenus walshi*	*TCS*
	Tapinoma indicum	*OPP*
	Tapinoma melanocephalum	*OPP*
	Technomyrmex albipes	*OPP*
	Technomyrmex indicus	*OPP*
DORYLINAE	*Centromyrmex feae*	*UI*
FORMICINAE	*Acropyga acutiventris*	*CS*
	Anoplolepis gracilipes	*CS*
	Camponotus irritans	*SC*
	Camponotus parius	*SC*
	Camponotus rufoglaucus	*SC*
	Camponotus sericeus	*SC*
	Lepisiota binghami	*OPP*

	Nylanderia taylori	*OPP*
	Nylanderia yerburyi	*OPP*
	Oecophylla smaragdina	*TCS*
	Paratrechina longicornis	*OPP*
	Polyrhachis exercita	*SC*
	Polyrhachis punctata	*SC*
	Polyrachis gracilior	*SC*
	Polyrhachis illaudata	*SC*
MYRMICINAE	*Cardiocondyla noda*	*OPP*
	Cardiocondyla wroughtonii	*OPP*
	Carebara affinis	*CS*
	Carebara diversa	*CS*
	Cataulacus taprobanae	*TCS*
	Crematogaster biroi	*GM*
	Crematogaster dohrni	*GM*
	Crematogaster flava	*GM*
	Crematogaster sagei	*GM*
	Crematogaster rogenhoferi	*GM*
	Crematogaster wroughtonii	*GM*
	Meranoplus bicolor	*HCS*
	Meranoplus robinhofin	*HCS*
	Monomorium floricola	*OPP*
	Monomorium monomorium	*OPP*
	Monomorium pharaonis	*OPP*
	Myrmecina urbanii	*CCS*
	Myrmicaria brunnea	*TCS*
	Pheidole minor	*GM*
	Pheidole watsoni	*GM*
	Pheidole wroughtonii.	*GM*
	Pheidole constanciae	*GM*
	Pheidole sulcaticeps	*GM*
	Pheidole spathifera	*GM*
	Recurvidris recurvispinosa	*CS*
	Solenopsis geminata	*TCS*
	Solenopsis nitens	*OPP*
	Tetramorium inglebyi	*OPP*

	Tetramorium smithi	*OPP*
	Trichomyrmex destructor	*OPP*
PONERINAE	*Anochetus myops*	*SP*
	Brachyponera luteipes	*CS*
	Diacamma indicum	*OPP*
	Diacamma ceylonense	*OPP*
	Hypoponera assumuthi	*CS*
	Hypoponera confinis	*CS*
	Leptogenys processionalis	*SP*
	Mesoponera melanaria	*UI*
	Odontomachus simillimus	*SP*
PSEUDOMYRMECINAE	*Pseudoneoponera rufipes*	*TCS*
	Tetraponera allaborans	*TCS*
	Tetraponera rufonigra	*TCS*

CS- Cryptic species, TCS- Tropical climate specialists, SP-Specialist Predators, OPP- Opportunists, SC-Subordinate camponotini, GM- Generalised Myrmicinae, HCS- Hot climate specialists, CCS- Cold climate specialists, UI -functional group not categorised.

CONCLUSION

In the present investigation, comparatively high species diversity was observed in Evergreen Forest (7 sub-family, 31 genera and 47 species) than the Teak plantation (5 sub-family, 27 genera and 36 species) and Adavi Ecotourism area (5 sub-family, 23 genera and 28 species).It will definitely be the result of excessive number of visitors to the forest as part of ecotourism, as well as a regular shift in habitat structure as a result of the implementation of various ecotourism projects. The Evergreen Forest and Teak Plantation had the highest similarity index (0.602), while the Evergreen Forest and Ecotourism Area had the lowest (0.533). The teak plantation and ecotourism areas had a similarity index of 0.563. This value substantiates a significant difference in the species composition across the studied habitats. The result of the present investigation has significance in understanding the ecological sensitivities of ants in different environments and can help in the planning of conservation programmes in this protected area.

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