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Diversity of Ant Fauna (Hymenoptera: Formicidae) Along the Different Altitudinal Gradients of Manjarabad Fort Hill of Hassan District of Karnataka, India

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ABSTRACT

Soil water content monitoring during the generative phase of sweet maize is Ants are eusocial insects in terrestrial ecosystems which play a crucial role in the maintenance and functioning of the ecosystems. The diversity of ants is usually regarded as an indicator of biodiversity and the ecosystem's health. Their diversity and distribution are influenced by environmental conditions, including elevation, temperature, humidity, vegetation structure, soil characteristics, and seasonal variation. Systematic assessment along elevation gradients can help establish species inventories and identify differences in community composition among sampling zones. Such studies also provide an opportunity to examine whether elevation-related patterns persist after accounting for vegetation, microclimate, habitat disturbance, and sampling effort. The present study aimed to assess ant diversity along different elevation gradients: base, middle, and peak. of Manjarabad Fort Hill, Sakleshpur taluk, Hassan district, Karnataka, India during August 2023 to August 2025. The sampling was carried out by employing standard collection methods, including intensive all-out-search method, bait trapping, and pitfall trapping across the selected sampling locations. The result revealed a total 42 species belonging 27 genera and five subfamilies based on external morphological characteristics and appropriate taxonomic keys. The most diverse subfamily was *Myrmicinae* (14 genera with 21 species), followed by *Formicinae* (7 genera with 13 species), *Ponerinae* (3 genera with 4 species) and *Dolichoderidae* (2 genera with 2 species). The least number of species belonging to the *Pseudomyrmicinae* (1 genus with 2 species). Few ant genera are *Monomorium, Aphaenogaster* and *Solenopsis* of Myrmicinae, *Camponotus, Anoplolepis* and *Oecophylla* of Formicinae, *Leptogenys* and *Diacamma* of Ponerinae and *Technomyrmex* and *Tapinoma* of Dolichoderinae are dominant at different elevations of the study area. The study shows that ant diversity declined with increasing elevation. Plausible reasons include increasingly unfavourable environments and the reduced available resources and surface area. The study provides an initial baseline information of ant species along an elevation gradient thus contributing to future biodiversity monitoring and conservation research in the region.

KEYWORDS: Ant diversity, Crematogaster, Myrmicinae, International Union for Conservation of Nature (IUCN), Myrmecologist.

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1. INTRODUCTION

Ants (Hymenoptera: Formicidae) are socially evolved, widely distributed, diversified and ecologically relevant insect groups in all habitats on earth that contribute to soil aeration, nutrient cycling, seed dispersal, predation, decomposition and the maintenance of terrestrial ecosystem functioning. They have been regarded as a best subject of diversity and distribution studies in several ecological contexts because since they are the most successful and are conspicuous in occurrence in terrestrial ecosystems (Agase *et al.,* 2025).

They impose a strong ecological footprint through their diverse roles as deadly scavengers, cunning competitors, leading predators, granivores, and herbivores (Sornapriya *et al.,* 2019). Along with other soil-dwelling fauna, ground-nesting ants play a crucial role in alteration of soil structure by increasing moisture, water-infiltration, aeration, and organic matter (Wills *et al.,* 2018), make them suitable for ecological and behavioural studies (Das *et al.,* 2023; Gowri *et al.,* 2024). They display variability in colour; with black being common, brown or red in colour. Few species are green and some tropical species have a Metallic lusture (Kokilamani *et al.,* 2023). Size ranges from 0.75 to 52 millimetres (Khan, 2019). Their colony constitutes as many as 100 individuals or as large as several million individuals (Ramachandra *et al.,* 2012). They have evolved from a lineage within the Aculeate wasp-like ancestors during the Cretaceous period, about 140 million years ago, and a study suggests that they are a sister group of the Apoidea. They have diversified after the emergence of flowering plants (Nimisha *et al.,* 2022).

Ants contribute to the conservation and proper operation of ecosystem by providing a variety of ecological services (Del Toro *et al.,* 2013). Their numbers decrease with increasing latitude, altitude, and drought (Nimisha *et al.,* 2023). They have been taxonomically regarded as Formicides and are members of the single large family Formicidae, this family is included in the superfamily Vespoidea belongs to order Hymenoptera which is the third largest insect order of phylum Arthropoda (Mahalakshmi *et al.,* 2016).
They are considered to be very sensitive to disturbances like loss of diversity, changes in plant and animal composition, interactions, tropic level changes, introduction of new intolerable conditions and habitat transformation. Their responses to habitat transformations are relatively fast, predictable, and easy to detect and analyse. Thus, ants are used for comparison of habitats and ecosystems (Garcia-Martinez *et al.,* 2015). They are also efficient invaders of new habitats. They also act as effective biocontrol agents of pests, because they feeding on other insects and small invertebrates, thus protecting agricultural and horticultural plants (Yashavantakumar *et al.,* 2016).

As per the recent classification globally the family Formicidae is represented by 26 extant subfamilies, 66 tribes, 428 valid genera, with more than 25,000 valid species (Subedi, 2020) and 2,094 subspecies (Bolton, 2020). Out of these, 152 species are listed endemic by the IUCN and UNEP (2003). *Myrmicinae, Formicinae, Ponerinae* and *Dolichoderinae* are four major subfamilies of ants constituting about 87% of the described ant species in the World (Guenard, 2013). There are more than 15,000 living ant species present in Southeast Asia. The family is represented by 16 subfamilies, 155 genera, and 3700 ant species (http://www.antweb.org/southeastasia.jsp).

Due to their high diversity, high abundance, intricate relation and mutualistic behavior with both flora and fauna qualify as excellent ecological indicators. Ants also play the major multiple ecological functions such as herbaceous vegetation structure, population regulation of other insects, biotic interactions, unavoidable organic matter decomposers etc. They also act as soil engineers for control of soil erosion, improvement of soil quality, and enrichment of the soil next to earthworm. They enable control of pest populations by disrupting the food habit and oviposition of pests (Hazarika *et al.,* 2019).
The diversity of ants is remarkable on the Indian subcontinent and a total of 652 ant species from 87 genera and 13 subfamilies is reported (Bolton, 2020). The major ant genus is *Camponotus* with 83 species (one tenth of the total known Indian species), followed by *Polyrhachis* (71 species, 8.5%), *Pheidole* (58 species, 7.0%). *Carebara* (24 species each, 2.9%) (Bharti *et al.,* 2016; Khan, 2019).

Elevation is an important environmental gradient influencing the distribution and composition of insect communities. Elevational gradients are considered as ideal natural laboratories for understanding processes that limit and maintain ecological communities because of the large variation in environmental conditions with concurrent changes in biological communities. Changes in elevation may be accompanied by differences in temperature, relative humidity, rainfall, vegetation structure, soil moisture, litter depth, and resource availability. These environmental factors can influence ant foraging activity, nesting behaviour, colony development, and interactions among species. Consequently, ant diversity may vary between lower, middle, and higher elevations. Some mountain systems exhibit declining species richness with increasing elevation, whereas others show mid-elevation peaks or more complex patterns (Longino *et al.,* 2019; Marathe *et al.,* 2020, Subedi, 2020).

2. MATERIALS AND METHODS

2.1. Study area

The study area Manjarabad Fort Hill is located approximately 5 km southwest of Sakleshpur in Hassan district, Karnataka with humid climatic influence, seasonal rainfall and varied vegetation. The fort stands on a hill approximately 988 m above the surrounding ground level and places it within a landscape characterized by hills, valleys, slopes, forests, and streams (The Government of Karnataka's Hassan district) (Figure-1).

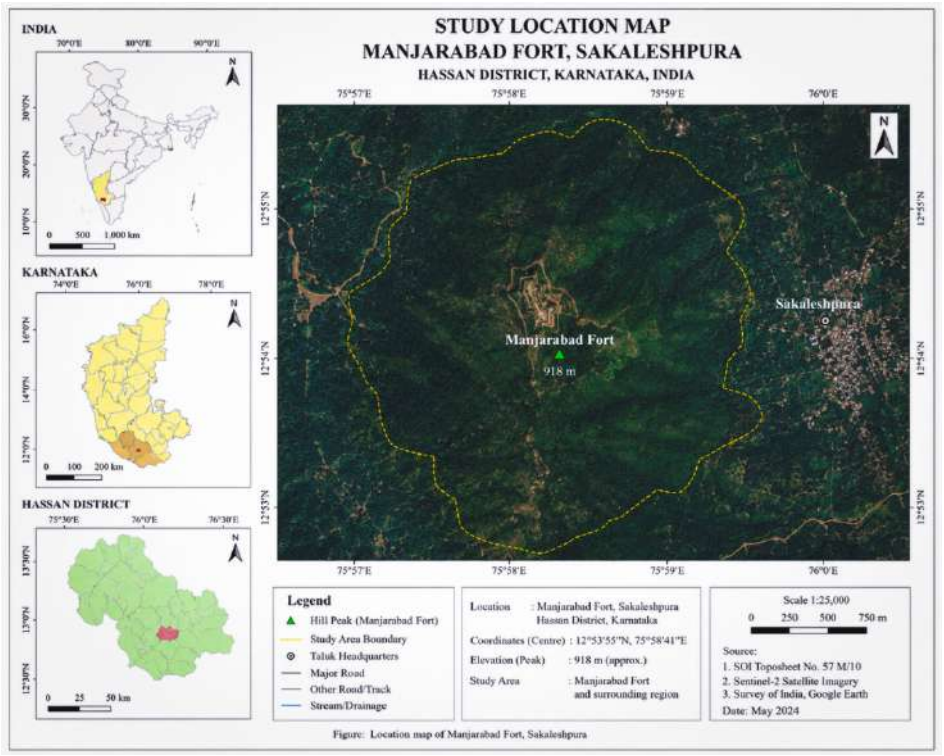


Figure: Location map of Manjarabad Fort, Sakaleshpura

Figure-1. Study location map of the study area (Manjarabad Fort Hill)

2.2. Habitat Characterization

The Manjarabad Fort Hill study, vegetation characteristics include tree density, canopy cover, shrub and herb cover, ground vegetation, leaf-litter depth, fallen wood, exposed soil and rock cover. These characteristics affect ant communities' access to food, nesting materials, shade, and shelter. Vegetation structure may vary between relatively undisturbed patches, open rocky areas, grassy patches and locations affected by human activity.

2.3. Ant sample collection

All necessary experiments were carried out adhering to standard field and Laboratory procedures. Digital, Manual and specimen records were maintained and care taken to avoid errors. During study, ants were collected from different elevation gradients in Manjarabad fort hill of Sakleshpur taluk, Hassan District, Karnataka, India during span of two years. i.e., August 2023 to August 2025. Each location was sampled twice in a season. The collection of ants was done in morning and evening. Sites were visited from 07.00 am to 12.00 pm to standardize effects from the weather (Ambett *et al.,* 2024). The samples were collected by three different methods includes pitfall, bait and all out search (hand picking) methods during different seasons (Gadagkar *et al.,* 1993).

2.4. Ant sampling design

The sampling work carried by using standard protocols designed for elevation gradient studies by Fisher (2004). The sampling sites are selected at different elevation gradients above mean sea level (Bharti *et al.,* 2009). The hill was divided into three elevation zones: Base Elevation Zone (Foothills), Mid-Slope (Mid-Elevation Zone) and Peak Elevation Zone (Summit).

2.5. Ant Sampling Methods

Each permanent plot (15 m x 50 m) is divided into three strip quadrats (5 m x 50 m). The ants are extensively collected from different habitats like vegetation, soil surface, bare ground, leaf litter, rotten logs, shrubs, trees (from ground level up to 2 m), and concrete structure with the help of soft brush (soaked in alcohol) and forceps for 30 minutes at each quadrat (Das *et al.,* 2022).

Three different methods were used for the collection of ants.

a. Pitfall trap (PT)

Pitfall traps capture forage ants, epigeic ants and litter ants (Bestelmeyer *et al.,* 2013). The pitfall traps are made of plastic cups with a height of 10 cm and a diameter 7 cm. The traps are level with the soil's surface and buried in the ground. Each trap was filled with water mixed with 5% detergent to immobilize the trapped ants. Approximately one-third of the cup's height is filled with the water detergent mixture, and a plastic cover is placed on top to prevent rainwater from entering. They were positioned in regions chosen at random. Each pit fall was kept for 24 hours; The ants captured in each trap were collected after 24 hours, placed in separate plastic bags, and then brought to the laboratory to count the number of ants and categorize them. Subsequently, ant samples were preserved

in bottles filled with 70% ethanol (Sujak *et al.,* 2023). The entire sampling process was repeated twice in each season (Joy *et al.,* 2017; Triyogo *et al.,* 2020; Adhikari *et al.,* 2020).

b. Bait trap (BT)

Ants were collected using baits as described by Bestelmeyer *et al.* (2000). Honey bait was used to collect nectar-feeding ants (Saleem *et al.,* 2025). Each bait trap was made by keeping 0.25 gm sugar dry coconut, fried items in a 10 cm by 10 cm plain paper with a distance

between them of about five meters. The baits were exposed for two hours (Oliveira *et al.,* 2014) without any disturbances. Ant specimens were collected for a period of twenty minutes from all the baits. This method is widely used and favours the detection of dominant ant species (Adhikari *et al.,* 2020).

c. All-Out-Search method (AOSM)

An intensive All-out search method is used to collect ant species in the study area during different seasons (Raj *et al.,* 2017). It is the second widely used method (Marathe *et al.,* 2020). Research indicates this method provides best results in the morning and evening (Gadagkar *et al.,* 1993). It is a common method in which ants are picked up by hand using brush and fine forceps or sweep net (Gadagkar *et al.,* 1997). Searching for ants was carried out from tree crevices, from the sandy floor, under stones, wood logs, flowers, concrete walls, shrubs, bushes, grasses, by sifting leaf litter etc. (Begum *et al.,* 2021). Irrespective of the scheduled time, ant specimens were collected whenever and from wherever possible during the study period from the study area.

Manual collection of ant species seen in the study sites are picked by using a brush and soft-forceps or Care should be taken to collect ant species. Photograph of collected ant species was carried out using mobile camera (Redmi series; 50 Megapixels) for further identification.

2.6. Specimen processing, Preservation and Labelling

Ants collected through various methods were sorted, cleaned, counted and preserved in 70% ethyl alcohol in separate Eppendorf tubes (5 ml) in the laboratory. The ants were then mounted precisely. For every morphospecies, a minimum of one individual was dry-mounted. The vials were labelled with the place, date of collection. Collected species were identified up to the species level with the help of stereomicroscope (SCW PG Carton Optical Industries).

2.7. Ant identification

The Identification was carried out on the basis of appropriate standard manuals and taxonomic keys (Bolton, 1994; Varghese, 2009; Bharti *et al.,* 2016). Based on their exterior morphology, ant specimens were classified as either species or morphospecies. The major characters studied were presence or absence of eye, sting, joints in pedicel, gastral demarcation, segments in antennae and pronotal structure (Joy *et al.,* 2017; Triyogo *et al.,* 2020).The species identification was confirmed by the myrmecologist Dr.Thresiamma Varghese, Research associate, Centre for Ecological Sciences, Indian Institute of Science, Bangalore, Karnataka. A reference collection is maintained in the laboratory of Zoology, Yuvaraja's college, Mysuru.

2.8. Preservation of ants

Preservation of ant specimens is more critical since the collected specimens are used for identification and further research value. The collected ants were preserved by both wet preservations (in 70% ethyl alcohol) and dry preservation to enable longer periods of preservation.

a. Wet preservation

It is a well-known preservation technique for duplication specimen storage and temporary storage of ant specimens until the specimen can be mounted (Charles *et al.,* 2022). In this method ants were directly inserted into 70% ethyl alcohol. All vials contained labels showing details of the locality, date of collection, name of the collector, habitat (whether it is arboreal or ground dwelling) and all other possible information about the species. Care was taken to ensure that only one species is inserted into the same vial. Use separate vials for different species (Mahalakshmi *et al.,* 2016).

b. Dry preservation

It is the most advisable method of preservation for ants. In this method ants are glued down to the apex of a small triangular strip of paper or card, in the region between the fore and middle coxae (Mahalakshmi *et al.,* 2016).

2.9. Pinning Method for Dry Preservation

In the pinning method, the insect specimens are mounted on pins so that they may be handled and examined with the most excellent convenience. One insect was pinned through the base of the card and labels attached. Standard insect boxes were used to store the pinned specimens (Charles *et al.,* 2022).

3. RESULTS

A total of 42 ant species belonging to 5 subfamilies were documented across three elevational zones (Base, Mid, and Peak) and three sampling seasons (Pre-monsoon, Monsoon, and Post-monsoon) at Manjarabad Fort Hill, Sakleshpur Taluk. Table-1

Summarises the ant diversity and taxonomic distribution of ant subfamilies recorded in the study area. As evident from the table ants belonging to 5 subfamilies were identified comprising a total of 42 species and 27 genera subfamilies based on external morphological characteristics and appropriate taxonomic keys.

Subfamily composition was dominated by *Myrmicinae* with 14 genera and 21 species (50.00% of total species richness), followed by *Formicinae* with 7 genera and 13 species (30.95%). The specialized predatory subfamily *Ponerinae* accounted for 3 genera and 4 species (9.52%). *Dolichoderinae* was represented by 2 genera with 2 species (4.76%) and the least number of species belonging to the *Pseudomyrmecinae* represented by 1 genus with 2 species (4.76%) (Figure 2). Table 2 shows the taxonomic distribution of ant subfamilies recorded at Manjarabad Fort Hill. Few ant genera are *Monomorium, Aphaenogaster* and *Solenopsis* of Myrmicinae, *Camponotus, Anoplolepis* and *Oecophylla* of Formicinae, *Leptogenys* and *Diacamma* of Ponerinae and *Technomyrmex* and *Tapinoma* of Dolichoderinae are dominant at different elevations of the study area.

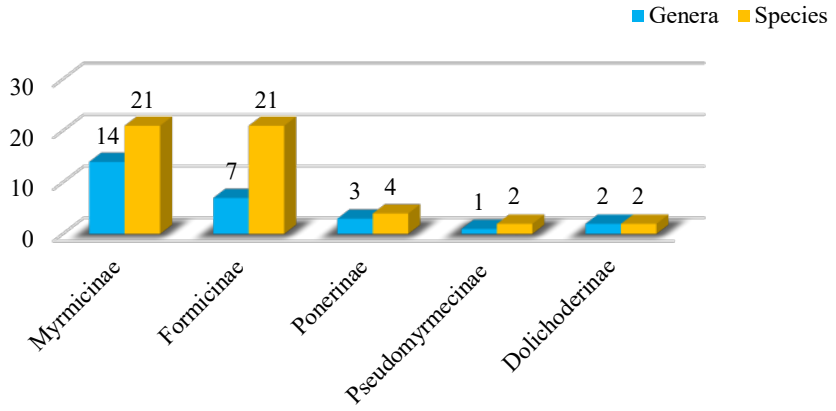


Fig. 2: Taxonomic distribution of ant subfamilies recorded at Manjarabad Fort Hill

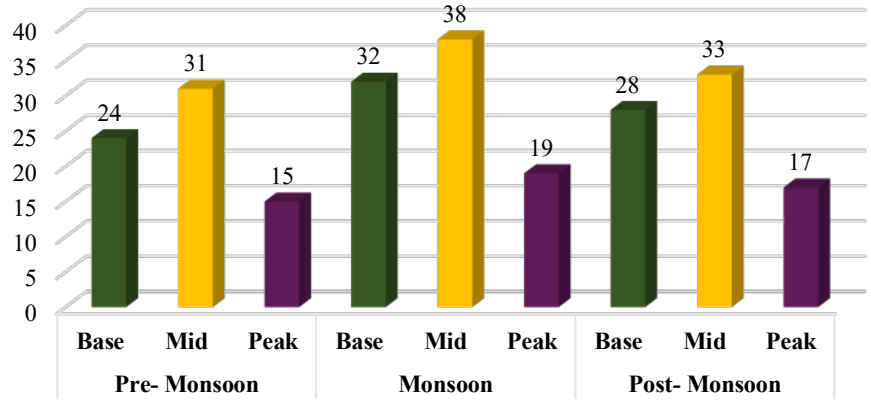


Fig 3: Altitudinal and seasonal diversity of ants at Manjarabad fort hill, Hassan district

Table 2 displays the taxonomic summary of the ant species. A wide range of ant species were reported in agreement with previous reports. A summary of seasonal and elevation distribution at Manjarabad fort is provided in Table-3 at various seasons and altitudes. Base Elevation Zone (Foothills) Supported 38 species (90.48%). Species such as *Pseudoneoponera rufipes*, *Pheidole spathifera*, and *Polyrhachis rastellata* were predominantly clustered at the base and mid-elevations. Mid-Slope (Mid-Elevation Zone) showed the maximum species richness, with all 42 species (100%) present throughout the study periods. The mid-slope zone offers abundant

leaf-litter complexity, moderate temperature stability, and ideal microclimatic canopy cover. The Peak Elevation Zone (Summit) Exhibited a marked decline in species richness, harboring 24 species (57.14%). High exposure to desiccation, increased wind velocity, and reduced vegetation height at the summit restricted colonization primarily to highly resilient or habitat-generalist species (Figure 3).

All elevation zones showed significant seasonal fluctuation in the occurrence of ant species: The pre-monsoon season yielded 36 species of ants (85.71%), with elevational totals of 24 species at Base, 31 species at Mid, and 15 species at Peak. During monsoon season, recorded the maximum overall species richness with 40 species (95.24%). Elevational richness peaked during this period, with 32 species at Base, 38 species at Mid, and 19 species at Peak. High moisture availability and resource flushes triggered increased foraging and surface activity for species like *Lophomyrmex quadrispinosus*, *Cataulacus taprobanae*, and *Carebara affinis*. The number of ants recorded in post-monsoon season, maintained 35 species (83.33%), showing elevational totals of 28 species at Base, 33 species at Mid, and 17 species at Peak.

Exactly 9 species (21.43%) demonstrated broad environmental tolerance, occurring consistently across all 9 spatial-temporal sampling units (all three elevations across all three seasons). They are *Solenopsis geminata* (Tropical Fire Ant), *Aphaenogaster beccarii* (Beccari's Funnel Ant), *Camponotus compressus* (Indian Black Carpenter Ant), *Camponotus irritans* (Irritating Carpenter Ant), *Anoplolepis gracilipes* (Yellow Crazy Ant), *Oecophylla smaragdina* (Asian Weaver Ant), *Leptogenys processionalis* (Processional Ponerine Ant), *Technomyrmex albipes* (White-Footed Ant) and *Tapinoma melanocephalum* (Ghost Ant).

4. DISCUSSION

Estimated number of ants on earth corresponds to 20×10^{15}, with a biomass of almost 12 megatons (Schifani *et al.,* 2024). Their abundance is unevenly distributed in earth and peaks in the tropics (Kass *et al.,* 2023; Subedi, 2022). Their distribution can be seen on almost every landmass in all continents but not in Antarctica, and only a few large Islands such as Greenland, Iceland, parts of Polynesia and the Hawaiian Islands lack native ant species. Ants are inevitable part of the ecosystem functioning as "ecosystem engineers" by changing the chemical and microbial properties of the soil they occupy (Antony *et al.,* 2021). They influence invertebrate, plant and soil microbial diversity (Subedi, 2016; Wills *et al.,* 2018). Ants have several roles in soil ecology in hill and forest niches. Through extensive tunnelling and hill/mound construction, they loosen soil, improve water infiltration, and help prevent soil erosion on steep slopes (Wills *et al.,* 2018). Ant hills capture solar heat and circulate air through underground chambers, altering local moisture and temperature profiles (Parr *et al.,* 2022). By breaking down organic debris, carrying plant fragments underground, and managing waste, ants accelerate decomposition and enrich poor hill soils (Rupali *et al.,* 2024). Ants transport seeds aiding in forest regeneration and plant diversity (Pol *et al.,* 2025).

Currently in India a list of 828 valid species has been reported that belong to 100 genera categorized under 13 subfamilies (Bharti, 2016). Ants in India, occupy a variety of habitats such as leaf litter, trees, soil, and dead logs, while tramp species prefer human modified areas. There are thirteen subfamilies of ants are found in India. They are *Aenictinae, Amblyoponiae, Cerapachyinae, Dolichoderinae, Dorylinae, Ectatomminae, Formicinae, Leptanollinae, Myrmicinae, Ponerinae, Proceratiinae,* and *Pseudomyrmecinae.* Recently, a new subfamily *Martialinae* has been added to the family Formicidae (Hazarika, 2019). This contributes about 6% of the total world species. West Bengal has the highest number of ant species (382) under 65 genera among the 30 Indian states (Bharti, 2016; Khan, 2019; Hazarika, 2019). Himalaya and the Western Ghats harbor a large number of ant species, 656 species from 88 genera were recorded from Himalaya, and 455 species from 75 genera were recorded from the Western Ghats, especially in Tamil Nadu, 184 species from 51 genera were recorded (Raj *et al.,* 2017).

The Manjarabad fort hill is exactly located between 12° 54′ 36″ North latitudes and 75° 45′ 18″ East longitude and an elevation of 988 meters above sea level with landscape characterized by hills, forest patches, valleys, and seasonal climatic variation. These regional characteristics render the surrounding landscape relevant for ecological investigations. As evident from the table-1 ants belonging to 5 species were identified. The *Myrmicinae* recorded the highest (15 genera and 21 species). *Myrmicinae* ants show high species richness and numerical dominance in hill and mountainous regions globally. The data is in agreement with reports of Dad *et al.,* 2019 who report three dominant subfamilies from Western Ghats viz., *Myrmicinae* (n = 70); *Formicinae* (n = 36) and *Ponerinae* (n = 33). Previous studies in India identified ants belonging to the family Formicidae from Jhabua District of Madhya Pradesh (Sisodia, 2025). Rajan report *Myrmicinae* (47%), *Formicinae* (28%), *Ponerinae* (12%) in Kerala state.

A total of 21 ants belonging to *Myrmicinae* were recorded in the current study. The *Myrmica* is the dominant species in fauna of the Central Asian mountains (Bharti *et al.,* 2016). In India subfamily, *Myrmicinae* forms the bulk of Indian diversity and the subfamily of Formicidae contains 138 genera with maximum species diversity of 42.7% (2500 species) with genera *Phediole* and *Crematogaster* recording highest species. The subfamily *Formicinae* is the second largest ant group having 39 genera and have 29.1% of species diversity (2500 species) with genera *Camponotus* and *Polyrhachis* constituting the majority of the diversity. The subfamily *Ponerinae* with 25 genera contributes about 13.4% of species (900 species) of which genera *Leptogenus* the most diverse (Gunawardene, 2008), *Dorylinae* 6.6% and *Dolichoderinae* 3.6 % (Bharti, 2016; Khan, 2019; Chanda, 2017). Varghese (2009) has reported 266 species from Karnataka belong to 63 genera and 11 subfamilies. According to Bharti *et al.* (2016), Karnataka state is home to an estimated 257 species of ants, which are divided

into 61 genera and 11 subfamilies. *Myrmicinae* is one of the largest and most abundant ant subfamilies found across various ecosystems in Karnataka (Kumar *et al.,* 1997;Varghese *et al.,* 2025).In upland and hill regions like the Sharavathi River basin and Western Ghats (such as Kodagu/Coorg coffee agroforestry and evergreen zones), *Myrmicinae* often makes up over 50% of all ant species **(**Priya *et al.,* 2025**).** Adaptation to patchy resources and fluctuating microclimates in *Myrmicinae* could be a plausible reason for their dominance in hill regions.

In the current study highest number of 21 species of ants were found forming (45.1%) of the data. *Pheidole, Tetramorium,* and *Monomorium* are the most abundant genera found foraging in leaf litter, grass seeds, and woody debris across dry deciduous, semi-evergreen, and evergreen hill forests (Gizaw *et al.,* 2017; Starr *et al.,* 2021). *Cataulacus taprobanae* (Deceptive serrated ant) is the frequently reported from southern Karnataka hill and lowland wooded localities (Hayarnnisa *et al.,* 2024). Next 13 species of ants from *Formicinae* genus was documented (30.95%). *Camponotus* (carpenter ants) is the most diverse and frequently encountered *Formicinae* genus (Lalitha *et al.,* 2024). Yellow Crazy Ants (*Anoplolepis gracilipes*), Black Crazy Ants, and Ghost Ants are frequently documented in urban, domestic, and agricultural and hill landscapes (Charles *et al.,* 2022). *Oecophylla smaragdina* is a species of arboreal ant that makes nests in trees, made of leaves stitched together using the silk produced by their larvae. *Polyrhachis are* Spiny or armored arboreal/ground-dwelling ants often found in wooded and shrubby habitats. These ants are commonly found in hill ranges of Western Ghats (Raut *et al.,* 2022). The Species belonging to the Subfamily *Ponerinae, Pseudomyrmecinae, Dolichoderinae* formed a minor section of the total ants documented (19%). Several notable species and records of *Ponerinae* ants have been documented across Karnataka, India. Ants of this subfamily are predatory known for their powerful stings and active hunting habits. *Diacamma ceylonense* (Greater Straited Bispinous Ant) and species belonging to *Leptogenys* are well-represented in across biodiversity hotspots like the Western Ghats and even peri-urban areas (Wachkoo *et al.,* 2018; Vijayakumar, 2025). In the hill regions of Karnataka, the ant subfamily *Pseudomyrmecinae* (slender ants or twig ants) is exclusively represented by the genus *Tetraponera*. These ants are specialized for living in the forest canopy and wood cavities (Bharti *et al.,* 2016). *Dolichoderines* represent a relatively minor component of the overall ant abundance in Karnataka's hill forests represented by genus *Technomyrmex and Tapinoma* (George *et al.,* 2024).

The seasonal differences also had an impact on the number of ants present, in each habitat. Highest population of ants were found in Monsoon forming 37% of the data with highest in the mid Zone of the hill. Next highest population was found post- monsoon (32%) with highest in the mid Zone. Ant population in pre-monsoon was 29.53% highest in the mid Zone. Ants in hill and mountainous ecosystems show distinct seasonal shifts in their distribution, activity, and community richness driven by temperature, moisture, high and food resources and canopy cover (Madhumati *et al.,* 2025). The study is in agreement of previous reports. David & Tomson, Majesh, 2024 study on seasonal diversity in the forest of Bagepalli range of Chikkaballapur forest of Karnataka report maximum diversity during the monsoon season followed by the summer and the least diversity was during the winter. In monsoon high humidity and favourable moisture leads to certain subfamilies experience drops or changes in evenness. Monsoon rainfall and nest flooding dislodge underground colonies. Thus, ants rely on behavioural shifts, architectural changes (like waterproof or elevated structures), and physiological adaptations. Further monsoon triggers reproductive cycles in several ant species. For instance, several ant species were documented in all the seasons viz., *Solenopsis geminate, Monomorium pharaonic, Aphaenogaster beccarii, Anoplolepis gracilipes, Camponotus irritans, Oecophylla smaragdina, Leptogenys processionalis, Technomyrmex albipes,* and *Tapinoma*. In post-monsoon ant population shifts dramatically as colonies recover from soil saturation, rebuild underground structures, and respond to new vegetation and prey availability (Bakra, 2023). Studies in tropical hill and forest regions show distinct post-monsoon assemblages of *Paratrechina longicornis* and *Monomorium floricola* ants (George *et al.,* 2025). During pre-monsoon dry, warming conditions characterized by rising temperatures and occasional pre-monsoon thunderstorms. Ant species richness in reported to be low with *Crematogaster, Camponotus* and *Tetraponera* being the common species (Kadu *et al.,* 2026). In congruence with previous studies the altitude was a variable in the species recorded across the three altitudes. In all the three seasons mid Zone of the hill recorded higher species. Sabu *et al.,* 2008 study of Western Ghats in Kerala, southern India report abundance and species richness peaked at mid-elevations and suggest that site-specific abiotic and biotic factors should be considered while examining the distribution patterns litter ants along altitudinal gradients. Many global and regional studies show a hump-shaped pattern, where ant diversity peaks at intermediate elevations (Kunene *et al.,* 2022). Balance of warm temperatures, high primary productivity, and diverse microhabitats are the main ecological factors contributing to the species richness (Joseph *et al.,* 2017).

Ant diversity serves as a sensitive and reliable indicator of hill and mountain ecology because ant communities shift rapidly in response to changes in altitude, soil composition, microclimate, and human disturbance (Bharti *et al.,* 2016). An ancillary outcome of the study is the demonstration of the utility of ants for ecological study. Ants can be captured quickly using standard methods like pitfall traps and quadrats hence are an advantage in comparison to other tools. In summary, the study reports a range of ants from 4 subfamilies with highest belonging to *Myrmicinae*. Further factors altitude and season had an effect on the ant population. Midlevel hill and Monsoon showed maximum ant diversity and richness owing to a range of ecological factors. The study also forms a baseline data on this Hill and opens scope for diverse research on ant research.

5. CONCLUSION

The investigation of ant diversity along elevation gradients at Manjarabad Fort Hill, Sakleshpur taluk, Hassan district, Karnataka, provides a framework for examining spatial and seasonal variation in ant communities. Thus, comparison of the base, mid, and peak zones across pre-monsoon, monsoon, and post-monsoon periods can help characterize species diversity and indicators of hill ecology.

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Table-1 Summary of the ant diversity and taxonomic distribution of ant subfamilies recorded at Manjarabad Fort Hill.

Subfamilies	Genera	Species	Percentage Contribution (%)	Key Representative Genera
Myrmicinae	14	21	50%	*Cardiocondyla, Dilobocondyla, Lophomyrmex, Cataulacus, Tetramorium, Pheidole, Meranoplus, Myrmicaria, Aphaenogaster, Erromyrma, Crematogaster, Monomorium, Carebara,* and *Solenopsis*
Formicinae	7	21	31%	*Camponotus, Paratrechina, Polyrhachis, Oecophylla, Anoplolepis, Plagiolepis,* and *Nylanderia*
Ponerinae	3	4	9.52%	*Leptogenys, Diacamma, Pseudoneoponera*
Pseudomyrmecinae	1	2	4.76%	*Tetraponera*
Dolichoderinae	2	2	4.76%	*Technomyrmex, Tapinoma*
Total	**27**	42	100%	**27 genera**

Table-2. Taxonomic summary of the List of Ant species in the study area

Sl.No	Subfamily	Ant species (Scientific Name)	Common Name
1	Myrmicinae	*Cardiocondyla wroughtonii*	Wroughton's Heart-node Ant
2	Myrmicinae	*Solenopsis geminate*	Tropical Fire Ant
3	Myrmicinae	*Dilobocondyla bangalorica*	Bangalore Tree Ant / Two-lobed Node Ant
4	Myrmicinae	*Carebara affinis*	Asian Burrowing Marauder Ant
5	Myrmicinae	*Lophomyrmex quadrispinosus*	Four-spined Ground Ant
6	Myrmicinae	*Cataulacus taprobanae*	Sri Lankan Tree Turtle Ant
7	Myrmicinae	*Tetramorium walshi*	Walsh's Pavement Ant
8	Myrmicinae	*Monomorium pharaonic*	Pharaoh Ant
9	Myrmicinae	*Tetramorium simillimum*	Similar Grooved-head Pavement Ant
10	Myrmicinae	*Pheidole spathifera*	Spatulate Big-headed Ant
11	Myrmicinae	*Meranoplus bicolor*	Bicolored Shield Ant / Two-colored Armor Ant
12	Myrmicinae	*Myrmicaria brunnea*	Brown Drop-tail Ant / Curved-spinous Ant
13	Myrmicinae	*Aphaenogaster beccarii*	Beccari's Funnel Ant
14	Myrmicinae	*Erromyrma latinodis*	Broad-node Little Yellow Ant
15	Myrmicinae	*Crematogaster lineolata*	Lined Acrobat Ant
16	Myrmicinae	*Pheidole watsoni*	Watson's Big-headed Ant
17	Myrmicinae	*Monomorium minimum*	Little Black Ant
18	Myrmicinae	*Crematogaster cerasi*	Cherry Acrobat Ant

19	Myrmicinae	*Carebara diversa*	Asian Marauder Ant
20	Myrmicinae	*Pheidole sp.1*	Big-headed Ant (Species 1)
21	Myrmicinae	*Crematogaster sp.1*	Acrobat Ant (Species 1)
22	Formicinae	*Paratrechina longicornis*	Crazy Ant / Long-horned Crazy Ant
23	Formicinae	*Camponotus compressus*	Common Black Carpenter Ant / Indian Giant Ant
24	Formicinae	*Camponotus parius*	Black Hairy Carpenter Ant
25	Formicinae	*Polyrhachis rastellata*	Rake-headed Spiny Tree Ant
26	Formicinae	*Camponotus nirvana*	Nirvana Carpenter Ant
27	Formicinae	*Plagiolepis dichroa*	Two-colored Dwarf Ant
28	Formicinae	*Anoplolepis gracilipes*	Yellow Crazy Ant
29	Formicinae	*Camponotus irritans*	Irritating Golden Carpenter Ant
30	Formicinae	*Camponotus sericeus*	Golden-backed Carpenter Ant / Silky Carpenter Ant
31	Formicinae	*Nylanderia yerburyi*	Yerbury's Crazy Ant / Hairy Ant
32	Formicinae	*Polyrhachis laevissima*	Smooth Shiny Spiny Ant
33	Formicinae	*Polyrhachis armata*	Armed Spiny Tree Ant
34	Formicinae	*Oecophylla smaragdina*	Asian Weaver Ant / Green Tree Ant
35	Ponerinae	*Leptogenys processionalis*	Indian Processional Raiding Ant
36	Ponerinae	*Leptogenys chinensis*	Chinese Slender Raiding Ant
37	Ponerinae	*Pseudoneoponera rufipes*	Red-legged Tooth-jawed Ant / Hairy Ponerine Ant
38	Ponerinae	*Diacamma ceylonense*	Sri Lankan Harpoon Ant / Sculptured Ponerine Ant
39	Pseudomyrmecinae	*Tetraponera rufonigra*	Giant Arboreal Bicolored Ant / Red-and-black Twig Ant
40	Pseudomyrmecinae	*Tetraponera allaborans*	Slender Black Tree Ant / Small Twig Ant
41	Dolichoderinae	*Technomyrmex albipes*	White-footed Ant
42	Dolichoderinae	*Tapinoma melanocephalum*	Ghost Ant

Table-3a. A summary of seasonal and elevation distribution at Manjarabad fort

Sl. No.	Subfamily	Ant species	Pre-monsoon			Monsoon			Post-monsoon		
			Base	Mid	Peak	Base	Mid	Peak	Base	Mid	Peak
1	Myrmicinae	*Cardiocondyla wroughtonii*	-	-	-	-	-	-	-	✓	-
2	Myrmicinae	*Solenopsis geminate*	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Myrmicinae	*Dilobocondyla bangalorica*	-	-	-	✓	✓	-	✓	-	-
4	Myrmicinae	*Carebara affinis*	-	✓	-	✓	✓	-	✓	✓	-
5	Myrmicinae	*Lophomyrmex quadrispinosus*	-	-	-	-	✓	✓	-	-	-
6	Myrmicinae	*Cataulacus taprobanae*	-	-	-	-	✓	✓	-	✓	-
7	Myrmicinae	*Tetramorium walshi*	✓	✓	-	✓	✓	-	-	✓	-
8	Myrmicinae	*Monomorium pharaonic*	✓	✓	✓	✓	✓	✓	✓	✓	✓
9	Myrmicinae	*Tetramorium simillimum*	-	✓	-	-	-	-	✓	✓	-
10	Myrmicinae	*Pheidole spathifera*	✓	-	-	-	✓	-	-	✓	-
11	Myrmicinae	*Meranoplus bicolor*	✓	✓	-	✓	✓	-	✓	✓	✓

12	Myrmicinae	*Myrmicaria brunnea*	✓	✓	-	✓	✓	-	✓	✓	-
13	Myrmicinae	*Aphaenogaster beccarii*	✓	✓	✓	✓	✓	✓	✓	✓	✓
14	Myrmicinae	*Erromyrma latinodis*	-	✓	-	-	✓	-	✓	✓	-
15	Myrmicinae	*Crematogaster lineolata*	-	-	-	✓	✓	-	-	✓	✓
16	Myrmicinae	*Pheidole watsoni*	-	✓	-	✓	-	-	✓	✓	-
17	Myrmicinae	*Monomorium minimum*	✓	✓	-	✓	✓	-	-	✓	-
18	Myrmicinae	*Crematogaster cerasi*	-	✓	-	✓	✓	-	-	-	-
19	Myrmicinae	*Carebara diversa*	✓	✓	-	✓	✓	-	✓	✓	-
20	Myrmicinae	*Pheidole sp.1*	-	✓	-	-	✓	✓	-	-	-
21	Myrmicinae	*Crematogaster sp.1*	✓	✓	✓	✓	-	✓	✓	✓	-
22	Formicinae	*Paratrechina longicornis*	✓	✓	-	✓	✓	-	✓	✓	✓
23	Formicinae	*Camponotus compressus*	✓	✓	✓	✓	✓	✓	✓	✓	✓
24	Formicinae	*Camponotus parius*	✓	-	✓	✓	✓	-	-	✓	✓
25	Formicinae	*Polyrhachis rastellata*	✓	-	-	✓	✓	-	-	-	-
26	Formicinae	*Camponotus nirvana*	-	-	-	✓	✓	✓	✓	✓	-
27	Formicinae	*Plagiolepis dichroa*	-	✓	✓	✓	✓	✓	✓	✓	✓
28	Formicinae	*Anoplolepis gracilipes*	✓	✓	✓	✓	✓	✓	✓	✓	✓
29	Formicinae	*Camponotus irritans*	✓	✓	✓	✓	✓	✓	✓	✓	✓
30	Formicinae	*Camponotus sericeus*	✓	-	✓	-	✓	-	-	-	-
31	Formicinae	*Nylanderia yerburyi*	✓	✓	-	-	✓	-	-	-	-
32	Formicinae	*Polyrhachis laevissima*	-	✓	-	✓	✓	-	✓	✓	-
33	Formicinae	*Polyrhachis armata*	-	✓	-	✓	✓	✓	✓	✓	-
34	Formicinae	*Oecophylla smaragdina*	✓	✓	✓	✓	✓	✓	✓	✓	✓
35	Ponerinae	*Leptogenys processionalis*	✓	✓	✓	✓	✓	✓	✓	✓	✓
36	Ponerinae	*Leptogenys chinensis*	-	✓	-	✓	✓	-	✓	✓	-
37	Ponerinae	*Pseudoneoponera rufipes*	✓	-	-	-	✓	-	-	-	-
38	Ponerinae	*Diacamma ceylonense*	-	✓	✓	✓	✓	✓	✓	✓	✓
39	Pseudomyrmecinae	*Tetraponera rufonigra*	✓	✓	-	✓	✓	-	✓	✓	-

40	Pseudomyrmecinae	*Tetraponera allaborans*	-	✓	-	✓	✓	✓	✓	-	✓
41	Dolichoderinae	*Technomyrmex albipes*	✓	✓	✓	✓	✓	✓	✓	✓	✓
42	Dolichoderinae	*Tapinoma melanocephalum*	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Total	**24**	**31**	**15**	**32**	**38**	**19**	**28**	**33**	**17**

Table-3b : Seasonal and Elevational distribution of ants in the study area

Pre- Monsoon			**Monsoon**			**Post- Monsoon**		
Base	**Mid**	**Peak**	**Base**	**Mid**	**Peak**	**Base**	**Mid**	**Peak**
24	31	15	32	37	19	28	33	17