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A Review on Diversity and Distribution of Myrmecofauna

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ABSTRACT
Ants are eusocial insects of the family Formicidae and, along with the related wasps and bees, belong to the order Hymenoptera. Ants appear in the fossil record across the globe in considerable diversity during the latest Early Cretaceous and early Late Cretaceous, suggesting an earlier origin. Ants evolved from vespoid wasp ancestors in the Cretaceous period, and diversified after the rise of flowering plants. More than 13,800 of an estimated total of 22,000 species have been classified. Ant societies have division of labour, communication between individuals, and an ability to solve complex problems. These parallels with human societies have long been an inspiration and subject of study. Many human cultures make use of ants in cuisine, medication, and rites. Some species are valued in their role as biological pest control agents. Previous research suggests that ant community respond predictably to stress and disturbance.
Key words: Formicidae, Cretaceous, ancestors, medication, control agents

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INTRODUCTION

Ants are eusocial insects of the family Formicidae and, along with the related wasps and bees, belong to the order Hymenoptera. Ants appear in the fossil record across the globe in considerable diversity during the latest Early Cretaceous and early Late Cretaceous, suggesting an earlier origin. Ants evolved from vespoid wasp ancestors in the Cretaceous period, and diversified after the rise of flowering plants. More than 13,800 of an estimated total of 22,000 species have been classified. They are easily identified by their geniculate (elbowed) antennae and the distinctive node-like structure that forms their slender waists. Ants form colonies that range in size from a few dozen predatory individuals living in small natural cavities to highly organised colonies that may occupy large territories and consist of millions of individuals. Larger colonies consist of various castes of sterile, wingless females, most of which are workers (ergates), as well as soldiers (dinergates) and other specialised groups. Nearly all ant colonies also have some fertile males called "drones" and one or more fertile females called "queens" (gynes). The colonies are described as superorganisms because the ants appear to operate as a unified entity, collectively working together to support the colony.

Ants have colonised almost every landmass on Earth. The only places lacking indigenous ants are Antarctica and a few remote or inhospitable islands. Ants thrive in most ecosystems and may form 15–25% of the terrestrial animal biomass. Their success in so many environments has been attributed to their social organisation and their ability to modify habitats, tap resources, and defend themselves. Their long co-evolution with other species has led to mimetic, commensal, parasitic, and mutualistic relationships. Ant societies have division of labour, communication between individuals, and an ability to solve complex problems. These parallels with human societies have long been an inspiration and subject of study. Many human cultures make use of ants in cuisine, medication, and rites. Some species are valued in their role as biological pest control agents. Their ability to exploit resources may bring ants into conflict with humans, however, as they can damage crops and invade buildings. Some species, such as the red imported fire ant (*Solenopsis invicta*), are regarded as invasive species, establishing themselves in areas where they have been introduced accidentally.

The importance of ants in ecosystems is well recognized. Ants play important roles in predation [1], nutrient flow, herbaceous vegetation structure [2, 3] and soil improvement [4]. Their effects are remarkable when they reach extremely high populations. Ant populations often are relatively stable among

the seasons and years. Their abundance and stability make ants one of the most important groups of insects in ecosystems. Ant societies are susceptible to environmental disturbances by being tied to the same location. They are dependent on structure, moisture, and temperature of the soil, as well as the structure of the vegetation and the populations of other arthropods. Because of their great abundance, functional importance, and the complex interactions they have with the rest of the ecosystem, ants are often used as bio-indicators in environmental assessment programs, such as in managed fire [5], vegetation disturbance [6], clearcutting [7], mining [8], waste disposal [9], and land use [10].

In northeastern forests of the United States, gypsy moth, Lymantria dispar (L.), periodically causes serious defoliation to hardwood forest species, especially oaks (Quercus spp.), over large areas. Aerial application of insecticides is one of the common methods used to control this pest. From 1991 through 1994, 850,000 ha (2.1 million acres) of eastern forests were treated with the microbial insecticide, Bacillus thuringiensis Berliner (B.t.), and 10,522 ha (26,000 acres) were treated with a gypsy moth nuclear polyhedrosis virus product, Gypchek, for gypsy moth suppression [11]. Because of the large scale at which the B.t. pesticide is currently used and possible wide application of Gypchek in the future, it is a concern that these pesticides may have nontarget effects.

Bacillus thuringiensis can affect ants indirectly through increasing or decreasing food abundance, because it is toxic to many different invertebrate species [12]. The variety used for gypsy moth suppression, Bacillus thuringiensis variety kurstaki (B.t.k.) is also toxic to other Lepidoptera [13]. The species most affected are early spring foliage feeders whose larvae are feeding on foliage when B.t. is applied to control gypsy moth populations. In a study of the nontarget effects of B.t. application in eastern deciduous forests, a significant drop in abundance of lepidopteran larvae during the treatment year and post treatment year was reported [13]. Reductions in species richness and abundance of larval Lepidoptera were also observed after three applications of B.t. during a single year as part of a gypsy moth eradication program in Oregon [14]. Two studies have included the effect of B.t. application on ants. Legotai [15] tested the effect of an application of BTB-202, used to control the cabbage pest Pieris brassicae L. (Lepidoptera: Pieridae) on beneficial insects. Results showed that BTB-202 had no distinct effect on Formica pratensis Retzius after the ants ingested the pesticide. Progar [16] studied the effect of B.t.k. application on nontarget arthropods and found that ant abundance was not affected. The majority of economically important entomopathogenic viruses are DNA viruses found in the family Baculoviridae, genus Baculovirus. In general, baculoviruses have a narrow host range and no evidence of direct toxicity to natural enemies has been documented [17]. We hypothesize that application of gypsy moth nuclear polyhedrosis virus (NPV) will not affect the ant communities directly.

Diversity studies of ant (Indian context):

The myrmecofauna of Indian subcontinent shows considerable biological diversity and regional endemism. The earliest descriptions of myrmecofauna from this region appear in 19th and early 20th century, in widely scattered taxonomic papers. In the Indian sub-continent, 632 ant species, from 81 genera and 13 sub families have been recorded by Gadagkar et al. [18].

Jerdon, catalogued ants found in southern India, listed ants from the then Sri Lanka, documented and collected ants from the Indo – Malayan and Australia regions. He described the ants species collected from Tibet, India, Sri Lanka and Singapore along with notes on their biology and behavior [19].

Bingham, compiled all the earlier works and his own contributions in the faunal volumes. He included 498 species belonging to 79 genera, 5 sub families and provided keys and descriptions [20]. Ants remained largely unstudied since thereafter till a review on Indian ants was published [21]. Ant diversity in various regions of Western ghats was studied and 140 species of ants were listed by Gadagkar et al. [22].

Bharti and colleagues provided a holistic view of diversity and distribution of Indian ants by providing comprehensive and critical list of Indian ants with up to date state
-wise distributions. From India, distributional data for 828 species and sub species was reported, representing 100 genera grouped in 10 sub families [23].

The Zoological Survey of India (2012) has listed five regions as the biodiversity hotspots of India. Among these, the Himalayas and Western Ghats have always been a crib for new discovery of flora and fauna. Both areas are listed as prime biodiversity hotspots and their ants merit special mention.

The social parasitic life of ants makes them strong candidates for the Red List [24]. The red listing of endemic Indian ant species is in progress. The IUCN Red List includes 152 ants, considered at least vulnerable [24].

The altitudinal diversity of ants in the Himalayan regions was discussed in detail for the first time by Bharti [25]. Bharti and colleagues described the ant species of the Himalayan regions that stretches along the North Western edge of India, ranging about 3,000 kilometers long and harbouring more than 202 species of ants, with 45% being endemic to the region. Himalayan ecology was termed as temperature dependent and altitudinal gradients were recorded to have remarkable effect on ant species composition and

abundance. An updated information on distribution and ecology of the Himalayan *myrmica* species and redefined altitudinal ranges for most of the *myrmica* species in the Himalaya was reported [26].
Bharti and colleagues presented the first inventory of the ants of Indian North Western Shivalik in one of the most comprehensive surveys of ant fauna undertaken in India [27]. In another study they measured diversity, community patterns, species composition and the influence of invasive species of Formicidae in Shivalik mountains of the Himalayas [28].

Disturbance dynamics of ants:

Previous research suggests that ant community respond predictably to stress and disturbance. This knowledge has been utilized to assess the ecological status of habitats by monitoring the changes in composition and diversity of their ant communities [29, 30, 31].
Ants constitute an important fraction of the animal biomass in terrestrial ecosystem and respond to stress on a much finer scale compared to vertebrates [32]. Floren investigated the influence of anthropogenic disturbance on the structure of arboreal Formicidae communities in South Eastern Asian low land forests. Human disturbance in addition to changing faunistic composition of community also changes the dynamics of whole system [33].
Savitha and colleagues studied distribution and abundance of ant species across a disturbance gradient in and around Bangalore city. They concluded with the remarks that urbanization has differential effect on various taxa depending upon their dispensability and adaptability to human settings [34].
Ants were used as ecological indicators to assess the ecological status of Shivalik mountains of Himalaya in terms of species diversity and impact of invasive species. Ants were collected at 75 sites from 44 locations in three habitats: primary forest, secondary forest and non forest area, using six collection techniques. They observed highest species richness in secondary forest and minimum in non forest area, highest abundance of invasive species in secondary forest and highest percentage of invasive species in primary forest. Their study pointed towards a disrupted, degraded ecosystem with high anthropogenic impact and reduced ecosystem health [28]. Recently Andersen proposed five principles for understanding the disturbance dynamics of ants [35]. Linking of disturbance response to ecological traits provide a substantiallly improved foundation for the use of individual taxon as bioindicators in land management [36].

Ants as bioindicators:

Ants have been used as bioindicators in Australia for many years and have been considered for use in other areas of the world as well. They appear to be an ideal candidate for use as an indicator [37]. Ant's value as bioindicators has been reviewed by Andersen and Majer [38]. The most comprehensive study on ants as bioindicators was conducted by Lawton and colleagues ,they investigated nine taxa, including canopy ants and ground dwelling ants in a sub deciduous humid forest in Southern Camerron, Africa. Species richness of these taxa was compared across a gradient of habitat types of increasing intensity and frequency of disturbance. They found few correlations between species richness and disturbance gradient [39].
Majer compared the species richness of ants to the species richness and abundance of plants and several invertebrate at several Western Australian sites. A significant positive association was reported between the species richness of ants and plants in rehabilitated bauxite mine sites of differing ages and rehabilitation treatment [40]. Several positive associations were found between ant species composition and that of seven other taxa in the Kakadu regions of Australia's Northern territory [8]. A study by Crantson and Trueman, found several positive relationships between the species richness of ants and that of another taxon, in this case plants [41].
Burbridge and colleagues compared the species richness of ants to the number of vertebrate species and found no significant correlation between ant species richness of reptiles, birds or mammals [42].
A study concluded that ants perform moderately well as environmental and extremely well as biodiversity indicator. Their study suggested further investigation into the utility of ants as bioindicators in more temperate regions of the world to yield promising results [43].
Ants are often used as bio indicators in environmental assessment programmes [44]. Various researches suggest that ant communities respond predictably to stress and disturbance. This knowledge has been used to assess the ecological status by monitoring the changes in composition and diversity of their ant communities [29, 30, 31).
Studies by Segat and colleagues highlighted the strong relationship between ants and some of the physical, chemical and biological soil properties of different areas of Brazilian Atlantic Forest [45]. Studies on ants as bioindicators of climate change in small Island of Indonesia was done by Latumahina and Mardiatmoko [46].

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