Chapter 1

General Introduction

The red-headed morph of *Camponotus sericeus*

If all mankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed ten thousand years ago. If insects were to vanish, the environment would collapse into chaos."

Edward O. Wilson

Introduction

Hymenopterans (sawflies, wasps, bees and ants) are a useful focus for ecological studies due to their high diversity, role as keystone species in ecosystems and their sensitivity to environmental degradation.

All ants of the world belong to the family Formicidae (Hymenoptera). Formicidae contains 21 subfamilies, 358 genera and 12,000 species worldwide (Agosti, 2000; Bolton 2003). Apart from numbers, ants dominate by their massive biomass constituting about 75 percent of the total insect biomass along with termites, bees and wasps.

The uniqueness of these creatures lies in the fact that they are predatory insects that either live and forage in the soil and rotting vegetation on the ground or are specialized for arboreal life. They have wide range of geographical distribution from arctic region to tropics, from timberline of the loftiest mountain to the shifting sands of dunes and sea-shores, from dampest forests to the driest deserts. Also, ants are a eusocial group with a very rare and advanced form of behaviour, giving them advantage over solitary individuals. Chemical communication system and division of labour helps ants to carry out all tasks required for successful existence.

Therefore, ants deserve thorough attention, research and conservation and have been recognized as excellent insect-candidates for studies based on their diversity, ecological roles and behaviour (Agosti, 2000).

Entomologists have been able to bring forth various aspects of life of ants. The studies conducted so far have brought to light various aspects of the ant community. Yet, in comparison to other insects like beetles and butterflies, ants have been subjected to minimum research. While aspects like behaviour have

been studied in detail by scientists, ecological roles have been less explored. There is also a need for further studies in taxonomy, biodiversity, community composition and biogeography of ants.

Ants in Urban Ecosystems

Formicids have features that make them capable of utilising urban habitats as ecological niches. They are diverse, abundant, easily found, and can be reliably sampled and monitored (Andersen, 1997; Majer, 1983). They are also relatively sedentary, with restrictive ranges and are responsive to small-scale changes in both space and time (Andersen, 1997; Hölldobler and Wilson, 1990; Kremen, 1993; Majer, 1983).

Ant species have successfully occupied urban environments and have achieved wide distribution and abundance. This success is due to their omnivorous food habits and capability to exploit small spaces for nesting, such as crevices and holes. Moreover, many ant species may have achieved high densities, and assumed dominant positions due to the existence of unoccupied niches, absence of competitors, and few natural enemies (Luck and Dahsten, 1974); or the intentional and unintentional introduction of exotic species that have caused the dislocation of native species (Suarez *et al.*, 1998).

Urban ecosystems, being composed of high-density human habitation and profound and constant local human activity, are generally recognized as areas undergoing continuous change. During this process of urbanization environmental modifications occur, which can in turn affect the distribution of organisms in diverse ways.

In India, the process of urbanization is occurring at an accelerated pace, and often advancing on areas that were earlier considered priority for conservation. Urban development has transformed natural ecosystems, resulting in environmental changes such as habitat fragmentation, the invasion of exotic species and the local extinction of native taxa (Lessard and Buddle, 2005).

Urban biodiversity has great intrinsic value for its inhabitants and in the face of increasing population and urban growth, it is imperative that knowledge

regarding the ecology of the species in these locales is attained. Also, as ants have been used extensively as indicators of disturbance (Andersen,1997; Hölldobler and Wilson 1990), their study can help to gauge the changes that have been brought about in urban ecosystems by urbanisation and measures can be taken to curtail further loss of biodiversity.

Although some studies have been conducted in urban areas across the world (Majer and Brown, 1986; Lessard and Buddle, 2005), there very few from India (eg. Bangalore, Savitha *et al.*, 2008) that study the impact of urbanisation on ant communities, and **none from Gujarat**. Therefore, to fulfil the need for a study that explores how ant communities are structured in these areas, or how these assemblages are affected by local and landscape-level factors this study has been conducted.

Community parameters like species richness, composition and abundance of ants of urban ecosystems have been studied with the objective of assessing these areas for biodiversity conservation. Thus, my study fills the lacuna, and hopes to satisfy the objective of assessing the ant diversity and distribution across sites with different degrees of anthropogenic disturbance in and around Vadodara, one of the fastest growing industrial cities of India, which has a estimated population of about 1.7 million in 2009 (www.worldgazetteer.com).

Ants in Agricultural Ecosystems

Until recently, efforts to preserve biodiversity have focused on natural ecosystems, despite the fact that these areas make up only about 5% of the terrestrial environment . In contrast, approximately worldwide, 50% of land is currently under agricultural production (Western and Pearl, 1989). Given this pattern, there is increasing recognition that most species interact with agricultural systems, even if their primary habitat is in natural areas. Moreover, a large proportion of the total species of a region are likely to be found in agroecosystems (Pimentel *et al.*, 1992). India is an agricultural country with 60% of the land area under agriculture (http://www.nationsencyclopedia.com/). Vadodara is characteristically surrounded by agricultural fields. Varying farming

traditions, combined with specific soil and climate conditions, have resulted in diverse and highly characteristic agricultural landscapes.

Agriculture is one of the main agents of changes in biodiversity and fragmentation of ecosystems (Benhin, 2006). It has a significant impact on biodiversity, mainly as a production technology involving pesticides, fertilizers, and soil disturbance; and as a biological process resulting in habitat fragmentation and species invasions (Carroll, 1990). The expansion of agriculture has transformed landscapes into mosaics of managed and unmanaged ecosystems, resulting in habitat loss and fragmentation for many species of flora and fauna. Modern commercial agriculture is dominated by monoculture, and this reduced plant diversity influences the composition and abundance of the associated biota, such as wildlife, pollinators, insect pests, their natural enemies, soil invertebrates, and microorganisms (Matson *et al.*, 1997). Management of these agricultural systems can dramatically affect overall levels of biodiversity, as well as the success of particular species.

Nevertheless, the loss of biodiversity in agricultural habitats during the past few decades has been high. The major pressures on biodiversity on agricultural land result from changes in the type and intensity of farming which generate changes in agricultural landscapes. Such changes can result either from intensification or abandonment, both of which can be detrimental to biodiversity. The most significant pressures currently affecting farmland biodiversity are habitat degradation, loss and fragmentation of semi natural habitats, the introduction of invasive species, the direct effects of pesticide or mechanical treatments and water consumption for irrigation, as well as the loss of varieties and races. Species richness and habitat diversity have declined due to increased pesticide and fertiliser use and the simplification of crop rotations.

Ants have potential as a biological indicator of soil condition and management for crop growth and ecosystem services in agro ecosystems because they are sensitive to changes in the environment (Peck *et al.*,1998).

Also, their response to known levels of change can be calibrated so that changes in biological response can be connected to changes in the

environment. Studies of ant communities in agroecosystems have contributed to the knowledge of the influence of agriculture activities on natural environments (Lobry de Bruyn, 1999). Some studies have also helped to identify ant species with potential for biological control in several types of crops (Carroll and Risch, 1990). Furthermore, several authors consider ants as ecosystem engineers, because ants respond to changes in physical and chemical properties of the soil, increasing its drainage, aeration and nutrient quantity, which contribute to agricultural practices of low ecological impact (Folgarait, 1998; Lobry de Bruyn, 1999).

Ecological Role of Ants

Studies highlighting various aspects of ant communities and their roles in ecosystem have been conducted all over the world.

The role of ants in mine site reclamation and land assessment and monitoring programs in Australia has been extensively studied by Majer (1985) and workers. It has been proved that ants are reliable indicators of the general environment in which they occur i.e. they are useful as indicator species in biodiversity studies. Ants are shown to reflect the response of other invertebrates to environmental stress and disturbance. A positive correlation was demonstrated between aboveground ant activity and belowground decomposition processes at disturbed sites, thereby providing support for the use of ants as indicators of restoration success following disturbance by Andersen (1993).

Formicids have been termed as 'Ecosystem Engineers' by Haemig (1996), for their ability to recycle the nutrients of the earth and also create, modify and maintain habitats.

It has been established that ants have great potential to structure insect communities. They influence insect community structure by predation of insects that are present on plants. Furthermore, they provide benefit to plants while foraging. They forage in large numbers throughout their ranges collecting insects including hemipterans, beetles, sawfly larvae, caterpillars, and other herbivores (Hölldobler and Wilson, 1990).

Mutualistic association of ants with plants has been reported in many studies such as those on ants and *Macaranga* ant plants by Linsenmair *et al.* (2001) which indicate that ants are attracted to plants secreting extrafloral nectar. Inouye and Taylor (1979) reported that ants collect the nectar for food, and simultaneously guard the plant from herbivores by patrolling the flower head. In some cases, mutualisms have evolved in which ants protect plants from predators, and in turn are housed or fed by the plants (Hölldobler and Wilson, 1990). The mutualistic association of ants with plants has also been extensively studied by Bronstein (1998).

Ants are associated with other insect species in a wide variety of ways. In agricultural ecosystems, ants directly reduce undesirable pests by preying upon them, by chemically deterring them and by causing pests to drop from the host plants that they are attacking (Way and Khoo, 1992). They also reduce fungal phytopathogens by removing spores (de la Fuente and Marquis, 1999) or by restricting interactions between plants and disease vectors (Leston, 1973; Khoo and Ho, 1992).

Ants, in both natural and agricultural systems, exhibit top down effects by limiting herbivore communities and by increasing plant growth and reproduction (Schmitz *et al.*, 2000).

Ants have been successfully employed as biological control agents in a broad variety of settings (Perfecto and Castin˜eiras, 1998). The first written record of biological control, dating from 304 AD is that of the weaver ant *Oecophylla* in China for controlling *Selenothrips rubrocinctus*, which are pests of cashew plant. *Oecophylla smaragdina* has also been reported as biocontrol agent of mirids (Way and Khoo, 1989) and pod weevils (Stapley, 1973).

For IPM strategies on mango *Oecophylla smaragdina* has been used as a key element in Vietnam . It was helpful in preventing pests of mango like tip borer, the leaf roller, scale and mealy bug. *Oecophylla* ants are (until now) known to be able to protect more than 12 different tropical crops against more than 40 species of pests.

Many ant species control cacao pests or fungal diseases. *Dolichoderus thoracicus* has been used as a biological control agent and to reduce pesticide use in sapodilla orchard (Van and Cuc, 2001).

The ability of ant species as bio control agents needs further research and evaluation. IPM strategies involving ants are under thorough research throughout the world. Such studies could establish them as important ecosystem entities.

Ants are also an important group to monitor for the arrival and impact of invasive species. Few species of ants have been under scrutiny for their role as urban pests. But, ant research in India is limited to studies on their diversity in Western Ghats (Sabu *et al.*, 2008), ants of IISc. Bangalore by Varghese (2004) and checklist of ants of India by Bharti (www.antdiversity.com) beside a few isolated studies on behaviour .

There does not exist an ant inventory for any region and there is no description of ecological roles played by ants in various ecosystems. Further, there are no studies comparing ant communities of urban and agro ecosystems and the impact of urbanisation and intensive agricultural practices on ant diversity has not been recorded. Invasive ants and their impact on native communities have been extensively studied throughout the world but no such studies have been conducted in India.

In India, there are 12 subfamilies, 73 genera and 621 species (Bharti and Alpert, 2007). India is an agricultural country with urbanisation taking over along with the population boom. In such situation it is imperative to conduct biodiversity studies and evaluate the role of the existing species on the ecosystems.

As the role of ants has been successfully established as bioindicator species which are also ecosystem engineers and successful biocontrol agents, they need special attention.

Therefore, this study has been conducted to bring to focus these seemingly small yet very important components of our biodiversity.

This study may be a small contribution with the vast information about these insects still unknown and unexplored, yet, it will solve the purpose of paving way for encouraging other workers to delve into the life and roles of these tiny creatures and help in their conservation.

Scope and Aims

The fundamental objective of this study is to characterize and document the various ant communities that form an integral part of the ecosystem of Vadodara, Gujarat, to understand some of the mechanisms shaping their community structure and to provide information about the useful ecosystem services they offer.

The major focus areas of this study are the urban habitats like community parks and private gardens, construction sites, pavements and roads, homes and offices. The fragmented landscapes have also been surveyed for presence of ant species. The agricultural fields surrounding Vadodara are a conspicuous characteristic of this city. Ant communities survive in these fields inspite of the heavy spray of pesticides. Fields and field margins of various food, vegetable and flower crops have been studied in this research.

The specific objectives of this study are as follows:

- To identify the ant species that exist in Vadodara, Gujarat and design an ant inventory.
- To establish species composition of the ant community in urban and agricultural ecosystems of Vadodara and to assess ant diversity in both ecosystems.
- To determine the impact of environmental parameters on ant diversity.
- To determine the nature of interactions between ants and other organisms.
- To explore the ecological role of ants in providing ecosystem services.
- To study the nesting behaviour and foraging ecology of ants.

Motivation

Thoroughly understanding ecosystems has become extremely important, as humankind's practices have led to a decline in environmental conditions. There is a widely held idea that mass decline of species diversity causes ecological instability, which directly affects all life on earth (Agosti *et al.*, 2000). Luckily, considerable research is underway to investigate patterns of biodiversity in the context of the ongoing mass extinction (Agosti *et al.*, 2000).

One emerging method is that of rapid assessments; these studies take a picture of local diversity and often produce regional lists that not only aid in further research but also are beneficial to local communities by raising awareness. Once a common practice in biology, the creation of regional lists for species is not a common practice today yet, the need is apparent.

At the moment, arthropods sampled from India represent a small proportion of the total known ant community. Data on ants of both natural and man-made habitats are poor, especially for the Indian region (Gadagkar *et al.*, 1993). Most of the research has been about the social life and behaviour of these Hymenopterans with little information on species diversity and abundance.

The prime motivation for this study has come from the fact that in India limited research coverage has been accomplished as far as investigations into taxonomy, biodiversity, community composition, biogeography, and basic ecology of a regional biota of ants are concerned.

Inspiration has been drawn from the outstanding work on Ants by eminent myrmecologists like Bert Hölldobler, E. O.Wilson, Barry Bolton, Donat Agosti, Alan N. Andersen, D. Gordon , W.M.Wheeler, R.R Snelling, P.S Ward, J.D Majer, M Kaspari W.R.Tschinkel ,S.M.Philpott, A.Suarez, Rudy Kuhout, Carsten A Bruhl, K. Eguchi, K. Mody, Martin Pfeiffer and John Fellowes.

Research by Indian myrmecologists like Dr. Himender Bharti, on diversity of Himalayan ants, Prof. Raghvendra Gadagkar, on Insect diversity and Dr. T. Varghese on ant diversity of IISc. Bangalore, has provided direction and encouragement to bring the ants of Gujarat on focus in the Indian myrmecology

scene. The book written by Ajay Narendra and Sunil Kumar '*On A Trail With Ants - A Handbook Of The Ants Of Peninsular India*' has proved to be very informative . The photographs of most of the ants in this thesis are field images taken in concurrence with the authors' idea of non- intrusive form of identification of ants.

The exchange of information and interaction with myrmecologists of ANeT (International Network for Study of Asian Ants), which aims to promote myrmecology in Asia, has added quality to this research.

With the unconstrained increase in urbanization, biodiversity is suffering a continuous decline. According to a study conducted by Naidu (2008) the insect population of Vadodara, Gujarat, has declined in the last three years. This is reason enough for bringing to focus these ecologically important organisms as subjects of thorough research.

This study primarily focuses on ants of urban and agricultural environments. While the ants of urban areas have been only targeted as pests, those of agricultural fields have been completely ignored. Further, there has been no study which compares the ant diversity of agricultural and urban environments of an area along with explorations of their ecology, taxonomy, biogeography and behaviour.

Hence, there was a need to take up this pioneering study to inspire other researchers and pave way for similar future research.