Chapter 7

General Discussion And Conclusions

Solenopsis invicta, the 'fire ant'

This research represents a study of the biodiversity and ecology of the formicid fauna of Vadodara, Gujarat. This is the first contribution to the taxonomy and ecological study of ants of this region which has received no attention by any myrmecologist. Earlier work on insects includes the study of Insect Biodiversity of Vadodara by Naidu (2008) and butterflies by Kumar Dolly and Shivkumar, (2003). In a study of termites, Pardeshi (2008) reported 15 species from agricultural fields in Vadodara district. Ants of Gujarat find a brief mention in Bingham's' *The Fauna of British India, including Ceylon and Burma. Hymenoptera,-Vol-II, Ants and cuckoo-wasps* (1903) as ants of Western India. The absence of a record of ant fauna of Gujarat is apparent and this work fills that gap.

The sampling may not be termed as complete as only urban areas (four Community gardens, four Residential areas and two Fragmented habitats) and four agricultural fields have been sampled for ant fauna. The forest areas of Vadodara have not been surveyed.

Sampling methods have been employed based on their applicability to various objectives of this research as also suggested by Agosti (2000). Pitfall trapping, one of the most reliable methods for collecting insects (Majer, 1983), was employed to sample ants at all Agricultural study sites along with hand collection while baiting was used as the method of collection in Urban areas along with hand collection.

The sampling period of the four years 2005-2008 was divided into two phases: Faze I from January to April and Phase II from September to December .The months of May and June have been excluded as there are less chances of encountering foraging ants due the intense heat which also makes field trips difficult. The months of July and August have been excluded as Vadodara experiences heavy rainfall during these months. Pitfalls overflow and field trips prove non-productive as urban areas and agricultural fields get flooded alike.

Ants if encountered during this period, either due to flooding of nests or for nuptial flights, however, were considered for taxonomical purposes.

Species Inventory of Ants

The subtropical climate and the diversity of habitats in urban and agricultural ecosystems harbour a considerable diversity of ants. 28 species of ants belonging to 17 genera and 6 subfamilies have been found in this study. The subfamilies are Formicinae, Ponerinae, Myrmicinae, Pseudomyrmecinae, Dolichoderinae and Dorylinae. The largest subfamily in terms of species richness and abundance is Formicinae followed by Myrmicinae.

Keys have been designed on the basis of morphological features of worker castes (Bolton 1994) as these are easy to find and collect.

Subfamily Dolichoderinae is represented by a single genus *Tapinoma*, of which a single species *Tapinoma melanocephalum* has been found in all urban sites of Vadodara. *Tapinoma* sp. is one of the best adapted taxons as suggested by a study conducted by Anu and Sabu (2006) in the Wayanad region of Western Ghats.

Subfamily Dorylinae is the only group of ants that do not have eyes. Very few individuals of *Dorylus labiatus* have been encountered during the entire study period. Formicinae is the second largest subfamily of Formicidae, worldwide and in India.7 genera and 9 species of this subfamily have been found in this study. *Camponotus* is the largest and most cosmopolitan genus with 52 described species from India (Bharti and Alpert, 2007).*C.compressus and C. sericeus* are the major species found in Vadodara. Two morphs of *Camponotus sericeus* one with a completely black body and the other with a blood red head and black body have been collected. Narendra and Kumar (2006) have also reported the two morphs from Bangalore. *Oecophylla smaragdina* is one species that has received great attention from myrmecologists for multiple reasons. The nests built by *Oecophylla* ants are perfect examples of expert architecture. These nests, made by sewing leaves together by help of larval secretions, have been mainly found on *Mangifera indica* trees in most of the urban and agricultural study sites. This species has been used as Biocontrol agents in mandarin citrus orchards for controlling leaf feeding insects (DeBack, 1964) and is being further studied as a biocontrol agent. The other species of

Formicinae subfamily found in this study are *Formica rufa, Lasius* sp., *Paratrechina longicornis, Polyrhachis lacteipennis and Prenolepis* sp.

The ants of the largest subfamily Myrmicinae are mainly known for their polymorphism, modified mandibles and spines on propodeum .5 genera and 10 species of this subfamily have been reported in this study. Crematogaster sp. is easily identifiable due to their heart shaped gaster and arboreal habits (also described by Narendra and Kumar, 2006. *Meranoplus bicolor* is a sluggish ant with a hairy body (Rastogi *et a.l*, 1997). *Monomorium* species *M.minimum* and *M. pharaonis* are considered household pests as they are found in large numbers foraging inside houses. They are also noticed due to their foraging in trails. *Pheidole* spp. is polymorphic with minor and major workers. Major workers are called 'soldiers' because of their large mandibles. Extensive work on *Pheidole* has been done by Eguchi (www.antbase.net) .New species *Pheidole* of India have been reported by Bharti (2001).

Pheidole megacephala, the big-headed ant, native to sub-Sahara Africa, is perhaps the most widely distributed and dominant ant species is reported to be an invasive ant in many countries of the Pacific region (Loope and Krushelnycky, 2007). In this study, *P.megacephala*, *P.watsoni* and 2 unidentified species are being reported to be found in all urban and agricultural study sites.

Solenopsis ants, commonly known as 'Fire ants' have also been extensively studied due to their threat as invasive ants. It has been reported as an invasive agricultural pest by the U.S Department of Agriculture (www.invasivespeciesinfo.gov/). *Solenopsis invicta* and *S. geminata* and one unidentified species are being reported here.

Subfamily Ponerinae is represented by two genera in Vadodara- *Leptogenys (one species L.chinensis)* and *Diacamma (2 species D. ceylonense and D.rugosum).* The biology of the 'queen less *Ponerine* ant' *Diacamma ceylonense* has been described by Karpakakunjaram *et al.*, (2003).

Subfamily Pseudomyrmecinae has been represented by a single genus *Tetraponera* in Vadodara. Two species, the uniformly black coloured *T.allborans* and the bicoloured *T. rufonigra* are being reported in this study. *Tetraponera* are easily recognisable due to their elongate, slender bodies, oval eyes, and short antennae and well developed sting. They are reported from a wide range of habitats from forests to urban areas (Ward, 2001). In Vadodara, they were conspicuously found in all urban areas and some agricultural habitats.

Ant Community Structure and Composition

The study of ant diversity has been done keeping in mind the major objective of examining the capacity of urban and agricultural habitats of Vadodara to support ant diversity. For this eight urban habitats and four agricultural habitats were selected.

In order to conduct a thorough study of Urban ecosystems, community gardens, residential areas and fragmented sites were sampled. The results reported maximum capacity of urban habitats to support ant species. Fragmented habitats when compared with forest habitats as in the studies of Amazonian ants have been reported to have suffered a decline in ant species numbers (Suarez *et al.*, 1998). But Fragmented habitats (e.g. the Laxmi Vilas Palace of Vadodara and The M.S.University of Baroda), that are a part of Urban ecosystem, compared with other urban habitats (e.g. the community gardens and residential areas); show maximum ant species diversity as reported in this study.

Agricultural study sites of Vadodara show the presence of 25 species of the total 28 species reported from this region. There is a comparable diversity seen in all agricultural sites. Waghodia (ASite 3), however, yielded a slightly lesser number of species. The probable reason is the on-going large scale construction in this area.

Ant species richness has been found to be greater in field margins than in the cultivated portions due to the margins being safer from disturbance caused due to tillage and insecticides. Suvak (2007) in his study of ant fauna of East

Slovakia, Russia, also confirms that ant species are usually numerous in the immediate vicinity of ploughed area but not within cultivated soil. Intensive agricultural practices, human and cattle activities all play an important role in limiting the ant species richness of Agricultural fields.

Results of Ant Community structure and Composition study have been discussed in detail in Chapter4.

Nesting and Foraging Ecology of Ants

Nests provide shelter, security and a micro-environment for ants to survive. A large variety of nests were observed during the study period as ants chose various types of habitats for nest building. The plan of construction is generally specific for a specific species. The size of the nest is strongly proportional to the population of the workers within as reported by Tschinkel (2005) in his extensive studies on ant nest architecture.

Nests of ants have been found on in every imaginable place in all study sites. Ants prefer different habitats for constructing their nests. *Lasius* ants construct nests on loose and moist soil, *Formica* choose damp wood, *Pheidole* ants nest in all possible areas like homes, gardens, roads, fields etc. The ant genus *Polyrhachis* demonstrates a significant diversity in nesting habits, their nests range from subterranean localities to arboreal nests incorporating silk produced by the ants' own larvae (nest weaving) as reported by Robson and Kohout (2007). *Oecophylla smaragdina* has received immense attention for their nest weaving behaviour.

Foraging patterns have been studied with great interest as ants and other social insects use pheromones very successfully to mark trails connecting the nest to food sources (Hölldobler and Wilson, 1990) and to recruit other ants to the foraging task. This capability of pheromones is being explored as a guide for developing algorithms for artificial agents and robots (Panait, 2004).

In this study however, foraging behaviour has been reported purely based on observations of whether the foraging in a species is solitary or in trails. Foraging behaviour of a number of ant species has been studied by different workers.

Mody and Linsenmair (2003) have reported systematic and directed foraging behaviour in *Camponotus sericeus.*

Ecological Significance of Ants

The ecological roles of ants make them an important part of the ecosystem. During this study ants have been observed offering various ecosystem services. The mutualistic ant insect associations between *Camponotus* ants and leafhoppers, scale insects and mealy bugs have been observed at all study sites. Ant plant associations were conspicuously seen between *Acacia nilotica* plants and *Camponotus compressus.* Various studies have been conducted to study the interdependence of ants and *Macaranga* plants (Heil *et al.*1998).

There are different speculations regarding role of ants as pollinators. While Hölldobler and Wilson (1990) have considered ants as unlikely pollinators, Hickman (1974) had proposed that ants may act as pollinators in dry and hot habitats to reduce energy and water costs for the plant. In this study many ants like *Crematogaster subnuda, Camponotus sericeus, Lasius sp., Crematogaster spp.,* etc. have been seen frequenting flowers. Also pollen grains have also been noticed sticking to the body of *C. sericeus* ants suggesting their possible role in pollination.

The scavenging nature of ants makes them survive successfully in most habitats. As ants are omnivorous they feed on anything ranging from seeds to dead organisms. They clear the environment of the debris. This role of ants has not been specifically studied and ants continue to be looked upon as household pests.

In agricultural fields ants are not major pests, some species like *Oecophylla smaragdina, Solenopsis* spp., are termed as pests due to their aggressive behaviour and stings. However, farmers in their interviews maintain that these ants are a minor nuisance in agricultural fields because of only two reasons: they transfer insect pests like aphids and mealy bugs from plant to plant thus helping in their spread and they sting when disturbed.

Ants are termed as ecosystem engineers because of the profound effect they have on soil and its properties (MacMahon *et al.,* 2000).along with overturning

Large quantities of soil while constructing nests, ants also collect and consolidate organic (Dauber *et al.*, 2001) and inorganic material (Whitford, 2003) in their nests.

Various other animals are seen in association with ants in the agricultural fields. Ants are bird prey and bird competitors (Philpott *et al.*, 2004). Birds like *Bubulcus ibis* (cattle egret), *Acridotheres tristis* (common myna) etc. consume ants. On the other hand reduced bird activity in trees may be a direct result of ant aggression (Haemig, 1996).

Several other ecological roles of ants have been described in studies conducted all over the world. *Oecophylla smaragdina* ants have been used as biocontrol agents since ancient times (Way and Khoo, 1992). In several Asian countries *Oecophylla* ants are harvested and sold at local markets as a pricey human delicacy), for traditional medicine (Oudhia, 1998), or as a valued feed for pet birds (Cesard, 2004).

Ants as bioindicators of environmental disturbance have been documented for their use in mine site restoration in Australia (Andersen *et al.*, 2004).

The ecosystem functions of ants need to be explored further so that their importance in the ecosystem can be established with greater force and adequate steps are taken to conserve them.

This can be achieved if the functional grouping of ants as described by Andersen (1995) is applied at regional levels also.

Conclusions

The number of ant species recorded in this study seems to be considerably less. These points towards two possibilities. One, only agricultural and urban sites of Vadodara have been explored and no forest site has been studied .Forests are free from human disturbance and always yield greater numbers of ant species. Second, the pronounced effect of urbanisation, industrialisation and extensive agriculture all has taken its toll on the ant species of Vadodara decreasing the species diversity of ants in this region. However, as no previous records exist, this is difficult to prove.

The species inventory given in this thesis is to present the first ever record of the number of species present in Vadodara along with providing necessary information about the functional morphological characters of ants, their food habits, nest-site preference, colony size, etc.

Community gardens have a capacity to provide a significant opportunity to retain some of the biodiversity. Fragmented habitats in Urban landscapes show maximum ant species diversity. Hence, the most effective strategy to conserve ant diversity is to preserve as much remnant natural habitat as possible so that native generalist species of ants (e.g. Formicines and Myrmicines) flourish.

Ant species like *Camponotus compressus*, *Paratrechina longicornis*, *Monomorium minimum*, *Lasius* sp., *Pheidole watsoni,* etc. have adapted to anthropogenic disturbance and form the ant community of urban habitats.

Urban habitats face greater challenges to conservation of ant diversity. Measures like implementation of water-harvesting systems in gardens, features such as hedgerows, uncultivated field margins, small woodlands and patches of scrub can enhance the bio diversity of urban spaces (Gove *et al.*, 2005). Restoring modified habitats can also promote native species conservation thereby helping to reduce the impacts of urbanization on native ecosystems. Because the capacity to increase the number and area of urban parks and green spaces is limited, other options for optimizing biodiversity must be utilized. Existing green areas must be developed with native vegetation and maintained. Removal of dead trees and litter must be avoided and garbage dumping should be prohibited as these provide nesting places for ants. Artificial nests could be used to increase ant diversity and abundance for biological control.

Agricultural ecosystems suffer biodiversity loss of ants due to intensive agricultural practices like greater mechanisation, more pesticides and heavy tillage. These practices reduce the number of species drastically. Heavy tillage robs the ants of their nesting sites.

Agricultural practices should be compatible with biodiversity. Traditional or less intensive systems (i.e. with fewer agrochemicals, less mechanisation, more crop species) have the ability to provide a refuge for ant species and may also enhance certain ecosystem functions (i.e. predation). Also, agricultural systems should be simplified by reducing practices like agricultural soils subject to tillage, herbicides and weed removal.

A more ecologically informed public with greater sensitivity and better understanding of the role of the ants in the ecosystem will help to provide better opportunity for these small creatures to thrive in nature.

As the city is growing, there is a surge in housing complexes with large expanse of green spaces, which actually do not support any biodiversity as they largely comprise of manicured lawns. If these small green spaces are converted into biodiversity friendly patches, they could serve as green corridors connecting larger patches in and around the city. This can only be done by conducting large scale awareness programs and educating the public.

Existing natural areas within urban zones play a critical role in safeguarding biodiversity. In order to conserve and protect these remaining green spaces within the city, strict management policies and local stewardship associations must be put into place.