RESEARCH REVIEW JOURNALS
Volume-04
Issue-04
April-2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Ants on plants: a study on diversity of ant

[1]Bharatbhusan Nemichand Baghele and [2]Dr. Ramdas Rajaramji Kamdi

[1]Research Scholar , Department of Zoology, Sri Satya Sai University of Technology & Medical Sciences, Sehore, M.P.
[2]Research Guide, Sri Satya Sai University of Technology & Medical Sciences, Sehore, M.P.

ARTICLE DETAILS

Article History
Published Online: 15 April 2019

Keywords
Ant–plant interaction, abiotic impact, biodiversity indices

ABSTRACT

We studied the insight into the role of ants as plant biotic defences by performing meta-analyses on plant for the effects of ants removal experimentally. Removal of a single ant species increased herbivory of plants by nearly three times compared with removal of multiple ant species. Overall, these findings indicate that ants serve as plant biotic defences but the effects of their presence in tropical systems are more pronounced. Therefore, it is as important to consider the vulnerability of ants to abiotic parameters as to take steps to preserve them in the light of climate change.

1. Introduction

"Ants depict the greatness of the evolution of insects in the same way as humans represent the height of vertebrate evolution. They use the most complex modes of chemical communication and their social organisation offers an enlightening comparison to that of humans, but only one biologist in one hundred can thoroughly explain the life cycle of any animal (Hölldobler and Wilson, 19).

The word ant comes from 'ante' which means 'the biter.' Formicidae is a family name derived from the Latin word Formica which means bug. Ants developed from wasp-like ancestors between 110 and 130 million years ago during the Cretaceous era, and diversified to alter the growth of flowering plants. They are easily recognized by their elbowed antennae and their distinctive anterior node-like structure to the abdomen that forms a slender waist (Forel, 1978).

All living ants are eusocial species and form highly cooperative communities (Oster and Wilson, 1978), generally known as colony. They form colonies ranging from a few dozen predatory people to highly structured colonies that can occupy vast territories and consist of millions of people. The colonies are often characterized as super-organisms, since the ants seem to behave as a single group, working together to support the colony (Wheeler, 1910).

Ant species vary between 0.75 mm and 52 mm in length. They differ in colour; most of them are reddish brown or black with metallic clarity, while others are green and non-metallic (Wheeler, 1910). Currently there are over 14,700 species recognized with the greatest diversity in tropics. Ants are also very useful in ecological studies as indicator species. Interactions with ants have influenced the evolution of a number of other species to an extraordinary degree, for example a few trees such as Acacia (Hölldobler and Wilson, 1990 and Ali et al., 2013).

Ants are one of the great success stories of life on Earth in its history. Ants have colonized almost every landmass on Earth except the Antarctica, and can survive in most habitats. Their success in many environments was due to their social organisation and ability to alter ecosystems, access resources and protect themselves. Ants have been dubbed keystone organisms because of their position in an ecosystem. Keystone species are organism species which have a strong influence on an ecosystem's character or structure. When these are missing or damaged or have disturbed their operations, the environment has a significant impact. They have the distinction of having influenced the evolution of a number of other species to an amazing degree, because ants act as predators and are mutualists with various organisms (Robert, 2003).

Ants are predated on by humans, birds, fish, amphibians, reptiles and even mammals like any other species. Chances may occur that a specific species of stronger ants can have a detrimental impact on a weaker ant colony. Trophic associations are the basic unit of any food chain; they are of great significance for some species of ants (Hölldobler and Wilson, 1990 and 2009). In general, anti-colonies are resistant to other arthropod attacks because they club a large-scale defense against any predator by releasing pheromones of alarm, aggregate or protection.

Savitha et al. (2008) clarified how ant species are spread and abundant through a disturbance gradient, as man-made gardens are an area of concern to many ecologists. An urban or peri-urban garden with various horticultural plants is one such 'disturbed' ecosystem. These included urban parks, lawns, fields, medicinal gardens etc. These characteristically are also kept organic and can be a residence for variety of insects. Preliminary studies before the literature analysis and review showed that Bangalore supports about 95 species of ants belonging to seven subfamilies (Varghese, 2003). Increasing urbanization and changes in land use patterns lead to significant destruction of the natural environment in tropical rich biodiversity countries. Nevertheless, several species are not only able to adapt to man-made habitats, but also in comparison to native species will proliferate and become locally invasive (Thompson and McLachlan, 2007).

Ants are numerous, plentiful, easily discoverable and can be sampled and visually tracked reliably. They are fairly sedentary, with most of them wingless in a group, with limited ranges but responding to small-scale ecological changes in both space and time (Ward, 2000). Since ants can be a source of information for communication behaviour, foraging behaviour, breeding, growth, division of labor and control of various castes etc., many have used ants as model organisms for their studies, as they can be easily cultivated and controlled

in the laboratory (Stadler and Dixon, 1998). To summarize , ants exhibit impressive adaptive strategies and specializations; increasing fungal crops, harvesting of seeds, herding and milking of other invertebrates, weaving of communal nests, packing cooperatives, social parasitism and slave-making (Hölldobler and Wilson, 2009; Lach et al., 2010).

2. Status of ants

The endemic Indian ant species are in process of red classification. Cataloged species are mainly of Indo-Malayan origin. Tramp / invasive ant species such as Paratrechina longicornis, Tapinoma melanocephalum, Anoplolepsis gracilipes and other species of Myrmicine pests such as Monomorium indicum and Monomorium pharoanis have already infiltrated Indian habitats, with *Solenopsis invicta* as potential future threat. In this Indian sub-continent, Gadagkar et al . (1997) reported 632 ant species from 81 genera and 13 subfamilies.

India, within its total land area of about 3,287,263 square kilometers, harbours a variety of eco-zones ranging from deserts to high mountains and tropical to temperate forests (Anon, 2006). Currently, the country harbours 797 valid species from 96 genera. Ant fauna is representative of India's vast diversity of habitat (Bharti, 2012).

Bharti *et al*. (2013) described the ant species of the Himalayan region, ranging about 3,000 kilometres long, and harbouring more than 202 species of ants, with 45% being endemic to the region. Common ant species belonging to the genera *Lasius*, *Myrmica*, *Aphaenogaster*, *Formica* and *Temnothorax* were found to dominate the higher Himalayan ranges. They were reported to have nests under stones but do not penetrate into lower temperatures and lower elevation areas. The other genera found in the area were *Cardiocondyla, Crematogaster, Lophomyrmex, Mayriella, Meranoplus, Messor, Monomorium, Myrmicaria, Pheidole* and *Tetramorium.* Formicines like *Camponotus, Cataglyphis, Lepisiota, Nyl anderia, Oecophylla, Paratrechina, Plagiolepis* and *Polyrhachis* were reported. Ponerines like *Harpegnathos, Leptogenys, Odontomachus, Odontoponera* and *Pachycondyla* (Sharma, 2012). Himalayan ecology was termed temperature-dependent and altitudinal gradients were recorded to have remarkable effect on ant species composition and abundance (Bharti *et al*., 2013)

Ponerines. Kharbani and Hajong (2013) in their study quoted that tropical and subtropical forests marked by agricultural fields and grasslands forming a mosaic environment provides excellent habitats for ants. Ant taxonomy in India is not complete, perhaps due to the complexity of the fauna and other taxonomic problems that occur at a large scale geographical study (Varghese, 2003).

3. Ants Role In Environment

Ants form a major component of soil organisms and also on litter in the forest floor. Ants have the peculiar habit of manipulating and modifying their immediate surroundings. They change physical and chemical parameters of the soil by bioturbation and by accumulation of organic material (Dostal *et al*., 2005). Ants are phytophagous, ominivores, carnivores, granivores and also saprophytic in feeding (Hölldobler and Wilson, 1990). Ants participate in symbioses, both facultative and obligate, with more than 465 plant species in over 52 families (Jolivet, 1996); with thousands of arthropod species (Kistner, 1982; Hölldobler and Wilson, 1990 and 2009) and with as-yet unknown numbers of fungi and microorganisms (Schultz and McGlynn, 2000; Hölldobler and Wilson, 2009 and Lach *et al*., 2010).

Ants are mainly attracted to Hemipteran honeydew as it consists of a mixture of nutrients such as sugars, amino acids, amides, and proteins (Auclair, 1963; Narendra and Kumar, 2006). Oudhia (2002) had described interesting aspect of the *O. smaragdina* being used in Chinese drugs, in soup and in some parts of South – East Asia their dried powder is considered as aphrodisiac.

4. Influence of ants in agriculture

All over the world, study of ant distribution on horticultural crops and related investigations are held as to assess the impacts of ants. For example of one such study, the risk assessment for Argentine ants in New Zealand horticultural crops was carried out in the year 2002. Farmers were asked to report the occurrence of any ants in their farms and the data obtained was documented. Advertisements were published in newspapers as a source for communications. Argentine ants were observed in a total of 15 different horticultural products, ranging from apples to walnuts. The crops were given a "high risk", "medium risk" and "low risk" ratings. Argentine ants are recorded to be of economic importance in many crops in Australia, South Africa, and USA due to their associations with the sap sucking insects like aphids and mealybugs. These ants were recorded along with many others on the crops in commercial and non-commercial settings in New Zealand. And were termed to be of significant economic importance on citrus and grape crops (Lester *et al*., 2003)

Lester *et al*. (2003) stated that, ants benefit a crop by keeping pest counts in check as well as promote the pest inhabitation on a crop that might also lead to the complete loss of the crop or yield. The *Oecophylla smaragdina* are predatory, tree-dwelling ants that combined with other ant species contributes to the eco-dynamics of perennial tree ecosystems (Verghese *et al.*, 2013). Their nest can be removed and replaced on the desired trees to establish efficient pest control (Bharti, 2012)

5. Negative impacts of ants

Solenopsis geminata causes chewing damage to PVC coatings of electrical wiring (Prins, 1985). Ants tend Hemipteran insects to obtain sugary excretion or honeydew and this in turn causes extreme losses to farmers worldwide The harmful nature of ants not only lies in pest status but also in their biting and stinging habits. Not all ants have stings or bite. It is when the other seems a threat do they attack the intruder (Hölldobler and Wilson, 1990). Some ants spray acid on the body of the intruder when they are disturbed (e.g.:- *Oecophylla smargdina* (Fabricius), *Anoplolepis gracilipes* (Smith). Naik *et al*. (2012) have described the effects of ant bites. They explained that *Solenopsis geminata* injects toxic alkaloid venom, Solenopsin which causes a sensation similar to what one feels when burned by fire. The bite area often shows high inflammation, redness and pustules. *Camponotus compressus* (Fabricius) is notorious for its painful bite in the coastal regions of India which rarely results in anaphylaxis (Naik *et al*., 2012).

Ant species that attack the plant shoot parts include *Myrmicaria brunnea* which feeds on the flowers and flower buds of *Abelmoschus esculentus* L (Veeresh and Ali, 1987) and *Monomorium indicum* Forel nibbles on leaves of *Cajanus Cajan*. In addition to causing damage to plant parts, several species of genera *Solenopsis, Monomorium, Pheidole, Meranoplus, Myrmicaria, Camponotus* and *Dorylus* harvest grass seeds, remove tobacco seeds from nursery beds (Veeresh and Ali, 1987) and removal or transfer of grains from sown agricultural areas are direct causes for poor germination (Srivatsa *et al*., 1969). Woodwork and carved wooden frames near foundations and buildings provide a good shelter for ant colonies of *Monomorium indicum* (Pruthi and Singh, 1950).

6. Significance of biodiversity indices

Biodiversity is the variety of life among the living organisms, biological system and biological process found on Earth". In every ecosystem, living organisms are part of a whole; they interact with one another and as well as with the air, water, and soil that surround them (Schultz and McGlynn, 2000). Malhotra (2011) describes that rich biodiversity has been instrumental in providing food security, health care, and consumer goods to humanity that have contributed to a high standard of living in the modern world. It has also unfortunately created the current consumerist culture that adversely affects the diversity of biological resources on which it is centered. Diversity study has environmental, environmental and social benefits.

Biodiversity is intrinsically important as a way to enhancing our understanding of the nature and functioning of ecological ecosystems, according to McArthur and Kitchen (2000).The factors assessing a community's diversity are extraordinarily complex. Environmental factors, such as temperature, precipitation, sunlight and the availability of inorganic and organic nutrients are very important in shaping communities and ecosystems (Hunter and Kidd, 1964).

Storch *et al*. (2007), in their study claimed that, though years of research have yielded into volumes and archives of literature, findings and research outcomes, we are only beginning to understand in depth the processes that generate and maintain the global biodiversity. Recent studies indicate that more diverse ecosystem has greater capacity to withstand environmental stress and consequently is more productive. Further they state that, the total loss of species is thus, likely to decrease the ability of the system to maintain itself or to recover from damage or disturbances. Almost like a species with high genetic diversity, an ecosystem with high biodiversity may be more able to respond to changes in the climate (Schultz and McGlynn, 2000).

Biodiversity, for ecologists, means the variety of lasting interactions between organisms. This refers not only to animals but also to their immediate environment (biotope) and the eco-regions in which the organisms live.Diversity assessments are used as markers of ecological system well-being (Magurran, 1988). Nevertheless, any attempt to quantify biodiversity quickly runs into the question of being a inherently multidimensional concept: it can not therefore be reduced to a single number sensibly (Whittaker, 1972 and Magurran, 1988).

Diversity Alpha can be quantified in several respects. Another is richness which is defined in a sampling unit as the number of species (Magurran, 2004). Hurlbert (1971) and Peet (1974) interpreted that, since richness depends on sample size, it is not always straight forward. A second index of alpha diversity is equality measures; these show how species and diversity or heterogeneity indices are distributed among individuals in a group and are widely used to calculate the dimension of alpha diversity. While biodiversity is known as the variety and abundance of species in a given unit, the real biodiversity is associated with species richness and relative species abundance in space and time (Hubbell, 2001 and Diaz *et al*., 2005).

Species richness is just the number of species within the study unit. Evenness outlines the variability in the abundance of species. This is known as the Diversity Index (Good, 1953) if both richness and evenness are integrated into one statistic. This blend is often termed heterogeneity (Hulbert, 1971). A good diversity index should encompass both diversity (Example, Simpson index) and information indices (Example, Shannon-Wiener index). To comprehend such diversity it is advantageous to investigate the combined uses of species richness and diversity as well as to estimate the combinatorial effect of species richness and frequency distribution in order to understand their role and distribution in their habitat (Magurran, 1988).

Many methods are scale-dependent and thus, hard to interpret in a comparative context. Hilton and Taylor (2000) stated that the most widely used indicators are based either on risk of extinction or on land area under conservation protection (IUCN and UNEP, 2003).

Lob (2002) and Sanderson *et al*. (2002) offered several indices that have been combined either as a sparse or selective set of population estimates for indicator species, or combine a number of factors that are thought to relate to biodiversity status.

7. Ants Biodiversity Status

Ants are highly social insects, live in colonies and display highly coordinated division of labour (Veeresh *et al*., 1990). Their social organization is orchestrated by intricate chemical communication. Alonso (2009) stated that, for an organism to be a successful indicator of ecosystem health, it should fulfil basic criterions like being easy to sample and monitor, represent a fairly diverse group of biological importance in its ecosystem, act in response to its environmental changes and interact with organisms of other taxa. Even so, most groups selected as potential indicators, do not fulfil all the above mentioned criteria. (Landres *et al.,* 1988 and Wilson *et al.,* 1996).

Crist, in the year 2009 reviewed that biodiversity, species interactions and functional roles of ants in fragmented landscapes and analyzed that shifts in ant species composition, relative abundance due to habitat fragmentation have direct and indirect effect on species interactions of ants, including sap feeding insects, seed dispersers and vertebrate mutualists. The loss of some ant species from small habitat fragment may have widespread effect in ecosystems because of their functional role as keystone mutualists. Under the current scenario of biodiversity loss, and in order to preserve it, it is essential to achieve a deep understanding on all the aspects related to the biological interactions, including their functioning and significance (Khot *et al*., 2013).

According to Quadros *et al*. (2009) the studies on biodiversity of ants have now assumed greater significance as ecologists try desperately to document global biodiversity in the face of unprecedented perturbations, habitat loss and extinction rates. Cardinale *et al*. (2012) explains how in the past 20 years remarkable progress has been made towards understanding how the loss of biodiversity affects the functioning of ecosystems and thus affects society. They also explained that organisms that control ecological processes at any single location, or in any particular year, often differ from those that control processes in other locations or years. Ant diversity at the coasts is different from those at high altitudes. Though a few species might be common they may depict different status and functionality of the environment in which they are found (Bharti, 2013). As such, more biodiversity is required to maintain the 'multi-functionality' of ecosystems at multiple places and times.

Hence there is a risk associated as some introduced species have been shown to increase suddenly and spread, despite having remained localized for a substantial period of time (Crooks and Soulé, 1999).

8. Ants -Plants Interaction

Mayer *et al*. (2014) have quoted that, plant-ant relationships in particular offer an outstanding array of interactions, being both among the most diverse and dominant multicellular organisms on Earth that coevolved for over one hundred million years. In plant-ant interactions mutualistic interactions both parties gain benefits from the association (Davidson and McKey 1993; Byk and Del-Claro, 2011).

A lot of findings on the association of plants and ants have been studied. True ant-plant associations or myrmecophytes represent a coevolutionary complex where plants undergo modifications such as domatia, hollow twigs and sugary nutritious secretions or exudates, in order to attract ants (Buckley, 1982 and Koptur 1991). Plants like *Acacia* have beltian bodies that are huge thorns or pinnules that accommodate ant nests in them. Plants like *Cercopia* harbours ants in hollow petioles (Beatie, 1985). Mullerian bodies that provide proteins to the ant visitors at the base of *Cercopia* sp, pearl bodies in Balsa and *Ochroma* plants, and elaiosomes that are lipid based extensions between fruit-pulp and seed are some plant adaptations to encourage ant visitation and nesting in them (Benzing, 1991). Ants are reported to keep the plant free from other insects, vertebrate herbivores and also from invading fungi and other plants (Rico-Grey and Oliveira, 2007). Vega and Herrera (2013), have reported that ants carry certain microorganisms (yeasts in their case); and they can alter nectar composition.

In India, *Humboldtia brunonis* (found in the Western Ghats) bear domatia on some of their branches, while all other individual branches produce extrafloral nectar. Each domatium is formed by modified swollen and hollow internodes. These domatia have a self-opening slit that allows access to the domatium interior and are prone to interloping residents (including many species of non-protective ants and the arboreal earthworm *Perionyx pullus*) in addition to the protective ants (Chanam *et al*., 2014).

Ants are relatively immune from the attacks of most predacious arthropods except for a few species of myrmerachnae (spiders), tiger beetles, carabids, reduviids, antlion larvae, fussorial wasp's etc. Among vertebrates, amphibians like frogs and toads, reptiles like lizards and the blind snakes, birds like woodpeckers feed on ants. Among mammals, moles, shrews, monkeys, scaly ant eaters, pangolins and a few humans eat ants (Hölldobler and Wilson, 2009).

9. Ant- Hemipteran Interaction

Many Hemiptera, such as aphids, excrete a carbohydrate-rich waste product, called honeydew, which is used by ants, bees, and even human beings (Waldbauer, 1996); (Sreedevi and Verghese, 2007). While many ants forage for honeydew from the plant surfaces or ground where hemipterans have deposited their faeces, some ants solicit honeydew directly from hemipterans, having evolved a more intimate, mutualistic relationship (Hölldobler and Wilson, 1994). In direct honeydew collection, ants often approach hemipterans by antennating the Hemipteran's abdomen, thus stimulating the release of a droplet of honeydew that ants then ingest (Way, 1963); (Sreedevi and Verghese, 2007). Ants continue to collect the honeydew and return to the nest with distended abdomens to regurgitate the honeydew to nest mates (Hölldobler and Wilson, 1994). Between 0.2% and 1.8% of honeydew's dry weight consists of amino acids, while 90% to 95% consists of carbohydrates (Hölldobler and Wilson, 1990).

In Malaysia, honeydew derived from their myrmecophile mealybugs is the only source of nutrients for the ant *Dolichoderus cuspidatus* (Smith) (Hölldobler and Wilson, 1994). The majority of ant species, however, tends and/or attacks a wide range of Hemipterans (Buckley, 1978). Ant-tending can also have an impact on the amount and proportion of melezitose produced in honeydew. Fischer and Shingleton (2001) found *Chaitophorus populeti* and *C. populialbae* had higher levels of melezitose in their honeydew when they were reared in the presence of the ant *Lassius Niger* than when reared in the absence of ants. Hence more the excretion more is the possibility of sooty mould on the plant obstructing photosynthesis.

10. Effects of abiotic factors on insects

Organisms are influenced physiologically and behaviourally by abiotic factors and this in turn may influence the outcome of biotic interactions and therefore community organizations. It is more appropriate to consider how the relative importance of competition and predation changes as abiotic conditions change (Dunson and Travis, 1991). Processes of climatic change and habitat loss which concurrently happen are an important example where synergistic effects may occur. Yet most studies reporting effects of climate change (Parmesan, 2006) or habitat loss and fragmentation on biodiversity (Brooks, 2002; Mantyka and Pringle *et al*., 2012) have examined each in isolation.

Narendra *et al*. (2010) analysed the structure of ant assemblages in Western Ghats, India and worked out the role of habitat disturbance and introduced species. They sampled 84 species representing 30 genera from 5 subfamilies. Myrmicinae was most widely represented with 44 species and 11 genera. Genus *Monomorium* was most rich, represented by 12 species and genus *Pheidole* was most abundant followed by *Camponotus compressus* and *Diacamma rugosum* was most frequently occurring species. Maleque *et al*. (2009)

investigated the role of arthropods as indicators of sustainable forest management, with a focus on plantation forests. They found that different arthropod groups respond differently to forest management. Ants, carabid beetles and spiders respond to local-scale disturbance-induced vegetation development caused by thinning and can be used to infer the ecological suitability of forest management treatments.

Sustainable agriculture and climate changes are largely interlinked. Temperature fluctuations, green house gases and other climatic changes will have profound effect on crop health, photosynthetic rate, and agro diversity to mainly carbon dioxide, methane and nitrous oxide. Environmental changes are evident through their affect on dynamics of populations of living organisms i.e. flora and fauna directly and indirectly. Insects being poikilothermic, their development is largely determined by temperature. Elevation of temperature induces the shift of distribution range, reduction in winter mortality, earlier occurrence in spring and increase in the number of annual generations. Increased CO_2 levels would leave greater impact on C_3 plants (rice, wheat and cotton) as compared to C_4 (corn, sorghum etc.). Elevated Co_2 levels are likely to influence the crop physiology through increased photosynthetic activity. This would, in turn, affect insects indirectly through the changes of plants and vegetation in quantity as well as in quality (Suneet *et al*., 2011).

11. Conclusion

Existing literature provides convincing evidence that ant – plant interactions can serve as 'keystone interactions' that significantly alter the structure of plant arthropod communities. We have shown here that ant existence on plants, regardless of the type of ant attractor or geographical location, has a large effect on the local abundance and distribution of predators and insect herbivores, which in turn affects herbivory levels and plant fitness. Thus, in many cultures, ant–plant interactions may represent 'keystone interactions.' Even then, the impact of ant presence is better in tropical environments, and despite the fact that selection has only rarely favored compulsory mutualism, the positive outcome in domatia-bearing plants associated with single dominant ant species is also stronger.

References

1. Benzing, D. H., 1991, *Myrmecotrophy: origins, operation and importance.* in Huxley, C. R. and Cutler, D. F., Editors. Ant-plant interactions. Oxford University Press, New York. 353-373
2. Wheeler, W. M., 1910, Ants : their structure, development and behaviour. New York : Columbia University Press, xxv + 663. 135,
3. Hölldobler, B. and E. O. Wilson, 1990, The ants.- Springer-Verlag, Berlin. xii + 732
4. Holldobler, B. and E. O. Wilson, 1994, *Journey to the Ants*. The Belknap Press of Harvard University Press, Cambridge, MA.
5. Robert Davie D., 2003, "Linking Keystone Species and Functional Groups : A New Operational Definition of the Keystone Species Conceptǁ. Conservation Ecology.
6. Dostal, P., M. Breznova, V. Kozlfckova, T. Herben and M, P. Kov. 2005, Ant-induced soil modification and its effect on plant below-ground biomass. *Pedobiologia*, **49**:127-137.
7. Holldobler, B. and E. O. Wilson, 1994, *Journey to the Ants*. The Belknap Press of Harvard University Press, Cambridge, MA.
8. Savitha S., Bharvey Narayani and Davidar Priya, 2008, Response of ants to disturbance gradients in and around Bangalore, India. *TropicalEcology,* **492** : page 235-243
9. Varghese, T. 2003, Ants of the Indian Institute of Science Campus. Technical report No. 98., Centre for Ecological Science, Indian Institute of Science, Bangalore.
10. Thompson B. and McLachlan S., 2007, The effects of urbanization on ant communities and Myrmecochory in Manitoba, Canada. *UrbanEcosystems* **10** : 43–52.

