Human activity as a factor of disturbance for insect biodiversity – A case study of ants in mango ecosystem

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ABSTRACT

Human activities on land increasingly represent a fundamental source of change in the global environment, the most important being loss of biodiversity. Ant diversity was recorded in two mango orchards with high functional disparity, one undisturbed and other disturbed with human interventions. Fifteen ant species belonging to four subfamilies were recorded in an undisturbed orchard and six species belonging to three subfamilies in disturbed orchard. Human activities in the disturbed orchard showed 60% less species diversity as compared to the undisturbed orchard. Canopy cover showed significant positive correlation with the ant species diversity in mango ecosystem.

KEY WORDS: Ants, biodiversity, biotic, homogenisation species richness

INTRODUCTION

Tropical habitats have a rich store of ant diversity. Unfortunately, data on the ants of both natural and man-made habitats are meagre, especially for the Indian region (Gadagkar et al., 1993). Industrialization and destruction of natural habitats have become common in urban India. The disturbance created by man destroys the habitat of a wide array of unique endemic species and often creates an attractive habitat for relatively few species able to adapt to these disturbed conditions. Urbanization is a major threat to biodiversity (Czech et al., 2000, Sala et al., 2002, McKinney 2002, 2004 and Vitousek et al., 2007). Urban explosion and use of pesticides have deleterious effects on biodiversity especially on insects even in agro-ecosystems. Human activity creates a microclimate that is not environmentally healthful (Einstein, 1999; Olden 2004). This is especially true in peri-urban agroecosystems where a number of human related activities take place.

Arthropods are excellent candidates for studying the effects of human interventions in agroecosystems because they perform a wide range of ecosystem services and serve as important bioindicators of ecological change (McKinney 2008, McIntyre 2000, Kremen et al. 1993). Many insects are useful in the evaluation of biodiversity and ants have been used extensively as indicators of disturbance (Andersen 1997; Holldobler and Wilson 1990; Kim 1993; Kremen 1993). Ants are diverse, abundant, easily found, and can be reliably sampled and monitored (Andersen 1997; Majer 1983). They have restrictive ranges and are responsive to small-scale changes in both space and time (Andersen 1997; Holldobler and Wilson 1990; Kremen 1993; Majer 1983). Ants in particular are important because they represent a variety of trophic levels, have relatively short generation times and therefore respond quickly to environmental change and they are important economic components of human altered habitats (McKinney, 2008, McIntyre, 2000, Stringer et al., 2009).

Remnants of natural vegetation in urban...
settings could be important reservoirs of biodiversity and contribute to the improvement of quality of life in cities (Balram and Suzana, 2005). Hence, a study has been conducted to understand the ant diversity in undisturbed, almost zero-maintained organic mango orchard retained more for its tree value and disturbed orchard with regular horticultural practices.

MATERIALS AND METHODS

Undisturbed orchard: The study site was roughly a 100 x 100 ft orchard in peri urban Bangalore, Karnataka, India (12°57’N and 77°35’E) consisting of 75 year old mature mango trees of mixed varieties like Jehangir, Totapuri, Suvarna Rekha and Banganpalli. The trees were retained more for their ecological value than for the yield. The old orchard had no horticultural or agronomic operations except for peri-urban pressures like low to moderate intensity of vehicular and people movement close by. At harvest, fruits were harvested by two labourers using hand-held harvesters - the only anthropogenic involvement.

Disturbed orchard: A corresponding orchard (about 500 m away) of dimension 100 x 100 ft was selected from within a bigger mango orchard. This was well spaced and maintained organic trees of the Totapuri variety. Here inorganic pesticides and fertilizers were not used for pest/disease management and nutrition. However, weeding, pruning, manuring with FYM and microbial consortia and tilling of soil were done regularly, besides spraying organic botanical formulations, bagging of fruits, clearing of fallen, immature fruits and basin weeding. All these constituted human intervention activities causing disturbance.

Assessment of canopy cover: The canopy cover in each site was assessed by standing in 5 randomly chosen places within each quadrat. Canopy cover was ranked as ‘0’ if there was no canopy directly overhead; ‘1’ if adjacent crowns barely met, ‘2’ when they overlapped but if the sky was visible and ‘3’ when the sky was no longer visible, a method followed by Aravind et al. (2001) and Daniels (1991).

Sampling and study period: Study was carried out from February to August, 2013. Observations were taken starting from the flowering through fruiting, up to harvesting for 28 weeks (ie., three samplings per week). Thus, there were 81 sampling days covered.

Collection and sampling protocol: Ants were collected by hand picking and aspiration. The tree, its branches, crevices of the bark and surrounding ground of radius of two meters at the base of each tree were carefully observed for presence of ants. All ants that foraged in both the orchards were collected. Specimens collected were curated, identified and preserved. Species abundance was calculated as the mean number of encounter of a species on all trees of both orchards. Mature fallen fruits were observed and sampling was carried out for ant activity; (n= 34 fruits/day) during fruiting season.

RESULTS AND DISCUSSION

Habitat characterization: The undisturbed orchard had 24 trees and all the trees were full of foliage and fruiting. The disturbed orchard had 30 fruiting trees and was clean and well maintained. The trees in the orchard were well spaced, pruned and showed no overlap of lateral branches.

Undisturbed orchard: From observation and collections, 15 ant species belonging to four subfamilies were recorded (Table 1). Canopy cover ranged between 2.5 and 3. This orchard had a variety of grasses, wild shrubs and weeds, within the orchard.
The most common ant species were *Camponotus compressus* Fabricius, *Oecophylla smaragdina* Fabricius, *Crematogaster ransonneti* Mayr and *Monomorium pharoanis* Linnaeus and these were found on majority of the trees (up to 45%). These ants were observed to actively forage both on the trees and on the ground. Ants of the sub family Myrmicinae were the most common up to 42.8% (Figure 1).

**Fig.1: Percentage of ant subfamilies found in the undisturbed mango orchard**

Ant nests of thirteen species, both terrestrial and arboreal were found in the undisturbed orchard. The nests of *Camponotus irritans* and *Monomorium carniceps* were not found in the orchard and they may be immigrant foragers from the colonies found around the subject orchard vicinity. Due to limited harvesting of fruits the ones that fell to the ground served as food for the ants. Approximately 38.23% of the fallen fruits in the orchard were used as food source by the ants. Foraging activity of *Myrmecaria brunnea* (53.2%) and *C. compressus* (41.7%) on the fallen mangoes was the highest. The pulp was seen to be consumed by the ants. The larvae of fruit flies (*Bactrocera dorsalis*, Diptera: Tephritidae) infesting the mango fruits were seen in fallen fruits and these were carried back to the ant nests. The other ants that were seen feeding and foraging on the fallen, decaying mango fruit were *Tapinoma melanocephalum* (1.85%), *M. pharoanis* (0.83), *T. albipes* (1.04%), and *O. smaragdina* (0.38%). Anderson (1995) mentions that the Dolichoderines are open habitat species, highly active and aggressive and exert a major competitive influence on other ants. Ant species like *Solenopsis geminata* being indicators of disturbance were found in the orchard despite being away from direct disturbance. Species richness was high with an average of 7 ants per tree. Tree 16 showed the highest species richness through the study span with 12 species encountered on it followed by tree six and 23 with eight species each (Fig 3a).

**Disturbed orchard:** There were no overlapping of trees and hence the canopy cover was ranked 0 or 1 throughout. Six species of ants belonging to three subfamilies were recorded (Table 2). The
most common of them are the *C. compressus* followed by *O. smaragdina* and *C. sericeus*. Ants belonging to sub family Formicinae ranked highest up to 50% (figure 2). As the orchard was cleaned regularly, there was rare encounter of fallen fruits. Every tree harboured an average of one ant specie each (fig 3b). The highest number of species observed on any of the trees was two with nine trees showing no ant encounters at all.

![Pie chart showing ant subfamilies](image)

**Fig.2: Percentage of ant subfamilies found in orchard with disturbances**

The undisturbed orchard with habitat complexity and heterogeneity showed an immensely high species richness in comparison with the other orchard (Fig 3a). Species richness showed a reduction of 60% in disturbed orchard. Figure 4 shows the comparison of encountering a recorded ant species in both the orchards. The disparity in function that was seen in the orchards was responsible for the decrease in species richness. Counts have been ranked based on their encounters (24x81 observations).

Canopy cover and the number of species of ants on a particular mango tree showed positive significant correlation of $r=0.71$ at $p=0.05$. Further a linear regression analysis showed the influence of canopy cover over higher species richness to be 75.1 percent ($y = -1.1698x^2 + 7.8556x - 6.2987; R^2 = 0.753$). The high occupancy of *C. compressus* (68%) in the disturbed sites might be due to their high potential and adaptability to varying environmental conditions. As they are found in different types of habitats worldwide, they are classified as Generalized Formicinae (GF) functional group by Bestelmeyer and Wiens (1996), Andersen (2000). Similar results were drawn by Savitha et al., in 2008. The six species found in disturbed orchard were also recorded in orchard and hence proved their resilience. Formicines established best and were seen in both the orchards. Pseudomyrmicines showed least resilience and probably were vulnerable to disturbance and hence absent in disturbed orchard. The most number of species were seen during the flowering seasons in both the orchards (fig 5) and this may probably be due to the availability of nectaries and presence of homopteran pests that excrete
honeydew on the inflorescence. The initial fruiting season showed the highest number of species in both the orchards. The growth phase and maturity of mango in undisturbed orchard and the lime, marble and maturity stages in orchard two showed high species richness. Thick canopy cover provides more shade and low penetration of sunlight. This may have served as an ideal condition for the ants. Further studies on this are required to throw light on such microclimate influence on ants.

Ants can be effectively used in indicator studies because they immediately respond to any alteration in the surrounding environment. When assessing different taxa as disturbance indicators ants perform better as compared to other invertebrates such as spiders and hemipterans (Crist, 2009). The number of certain ant species in disturbed habitat considerably increased because they had ideal conditions such as nesting sites, food availability, open grounds for foraging etc. Considering the large difference in species numbers we can understand that habitat variables such as dense canopy cover live and dead trees, litter accumulation during flowering and fruiting season can provide ideal habitats for ants. Habitat complexity provides hiding, nesting and foraging grounds to ant species. Hence the less disturbed orchard promoted higher species richness. Detailed studies of disturbed habitats based on extent of disturbance, type of disturbance, physicochemical properties of soil, climatic factors, flora and fauna are the need of the hour to understand establishment of the organism. Natural gardens, organic orchards and zero-tillage fields (Benites et al 2002), should be encouraged and maintained for enhancing biodiversity.

Organic integrated pest management should be encouraged to bring down use of harmful pesticides that pose a threat to the dwindling faunal richness. Since the undisturbed plot showed presence of much higher species diversity, it is necessary to encourage more patches of land where litter is allowed to recycle. Studies from different regions of world have shown that habitat degradation, disturbance and fragmentation have a negative effect on ant diversity and abundance whereas undisturbed forests have higher species richness than those in disturbed habitats (Greenslade and Greenslade, 1977) Thus, habitat variables such as canopy cover and organic litter content in the soil coupled with lower human intervention can provide an appropriate habitat for more species, contributing to their enhanced biodiversity.

ACKNOWLEDGEMENTS: The first authors is thankful to DST-Inspire fellowship programme, for funding the research, and Dr. Pratheepa M, Senior Scientist, NBAIR, Bangalore for helping with statistical analyses. We are greatly thankful to the Insect identification service, Division of Entomology, IARI, New Delhi for identifying the ant specimens.

Table 1: Species of ants found in the undisturbed mango orchard

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Common name</th>
<th>Scientific name</th>
<th>Sub family</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Odour ant</td>
<td>Tapinoma melanocephalum</td>
<td>Dolichoderinae</td>
</tr>
<tr>
<td>2</td>
<td>White footed ghost ant</td>
<td>Technomyrmex albipes</td>
<td>Dolichoderinae</td>
</tr>
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<td></td>
<td>Species Name</td>
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<td>Subfamily</td>
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<tr>
<td>3</td>
<td>Godzilla ant</td>
<td><em>Camponotus compressus</em></td>
<td>Formicinae</td>
</tr>
<tr>
<td>4</td>
<td>Giant honey ant</td>
<td><em>Camponotus irritans</em></td>
<td>Formicinae</td>
</tr>
<tr>
<td>5</td>
<td>Golden backed ant</td>
<td><em>Camponotus sericeus</em></td>
<td>Formicinae</td>
</tr>
<tr>
<td>6</td>
<td>Black crazy ant</td>
<td><em>Paratrechina longicornis</em></td>
<td>Formicinae</td>
</tr>
<tr>
<td>7</td>
<td>Weaver ants</td>
<td><em>Oecophylla smaragdina</em></td>
<td>Formicinae</td>
</tr>
<tr>
<td>8</td>
<td>Glossy slender acrobat ant</td>
<td><em>Crematogaster ransonneti</em></td>
<td>Myrmicinae</td>
</tr>
<tr>
<td>9</td>
<td>Common broad acrobat ant</td>
<td><em>Crematogaster subnuda</em></td>
<td>Myrmicinae</td>
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<tr>
<td>10</td>
<td>Spineless harvester ant</td>
<td><em>Monomorium cariniceps</em></td>
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</tr>
<tr>
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<td>Pharoah ant</td>
<td><em>Monomorium pharoanis</em></td>
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</tr>
<tr>
<td>12</td>
<td>Short legged hunch back ant</td>
<td><em>Myrmecaria brunnea</em></td>
<td>Myrmicinae</td>
</tr>
<tr>
<td>13</td>
<td>Common red fire ant</td>
<td><em>Solenopsis geminata</em></td>
<td>Myrmicinae</td>
</tr>
<tr>
<td>14</td>
<td>Miniscule house ant</td>
<td><em>Tetramorium smithi</em></td>
<td>Myrmicinae</td>
</tr>
<tr>
<td>15</td>
<td>Arboreal bicolor ant</td>
<td><em>Tetraponera rufonigra</em></td>
<td>Pseudomyrmecinae</td>
</tr>
</tbody>
</table>

**Fig 3a: Species richness of ants in undisturbed orchard**
Table 2: Species of ants found in the disturbed mango orchard

<table>
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<tr>
<td>6</td>
<td>Short legged hunch back ant</td>
<td><em>Myrmecaria brunnea</em></td>
<td>Myrmicinae</td>
</tr>
</tbody>
</table>

Fig 3b: Species richness in disturbed orchard

Fig. 4: Comparison of the frequency of sighting of the ant species in both orchards

Ranks: 0=0; 1=1-100; 2=101-200; 3=201-300; 4=301-400; 5=401-500.
Fig. 5: Number of species during various stages of mango fruit growth

REFERENCES


[MS received 11 March 2015; MS accepted 27 June 2015]