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RESEARCH ARTICLE

STUDIES ON BEHAVIOURAL ASPECTS OF ANTS: COMMUNICATION, FOOD COLLECTION AND NEST CONSTRUCTION

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ABSTRACT

Ants are small, insignificant and quite powerful intelligent eusocial insects. The social organization is very remarkable one in ants, so that they cannot be distinguished from one another, it is mysterious for us that ants are able to recognize their companies, of course they don't have ears, some of them are blind, but they have a great sense of smell. Ants interact with one another through chemicals, called 'pheromones'. These chemicals may vary from one species to another species. When they find a food, leave a pheromone trail, which is sensed by other ants, and that in turn leads to the food source. They have the capacity to find the shortest route from food source to colony so that they can collect maximum food. Ants are one of the few groups of animals, which modify their immediate environment to suit their needs. They often build elaborate nests in a range of situations, sometimes, expending huge amount of energy in their construction. Ant nests vary from small, simple chambers under rocks, logs, twigs, branches using leaves or in trunks of tress on the ground to extensive excavations extending a meter or more into the soil. Ants perform tasks ranging from nest building, finding food and shortest route to food source with excellent communication skills and even help in waste management.

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INTRODUCTION

Ants (Hymenoptera: Formicidae) are common, dominant taxa in terrestrial habitat that plays acrucial role in structure and function of ecosystem. However, understanding the behavioural aspects of ants like communication, food collection and nest construction are not understood much and incomplete. Ants are known to play important role as consumers and ecosystem engineers (Holldobler and Wilson, 1990; Del Toro *et al.,* 2012). They can also influence many invertebrates, plants, and soil microbial diversity (Boulton and Amberman, 2006; Sanders and Van Veen, 2011).They have the capability to alter grassland productivity (Dean *et al.,*1997). Ants are dominant members, can serve as an indicator species to monitor conservation and management practices (Underwood and Fisher, 2006; Moranz *et al.,* 2013). The role of ants in various fields such as pest suppression, soil nutrient cycling, plant and microbial community, and plant community regulation etc. were already known (Frouz *et al.,* 2003; Nemec, 2014). Insect colonies especially ants often exhibit "swarm intelligence": adaptive decisions are made by the group rather than the individual one and these decisions are based largely on worker interactions (Schmickl and Crailsheim, 2004). Sean O'Donnell (2006) has also proposed the term worker connectivity to refer communicative interactions that link colony's workers in a social network and affect their task performance. Connectivity may not be inherently advantageous; in fact it involves some costs to workers, relying on direct perception of task needs, for eg. Signaling itself can incur costs to senders, such as time, energy and metabolically expensive chemicals (pheromones) (Detrain *et al.*, 1999; Dechaume-Moncharmont *et al.,* 2005). The goal of this review is to give recent research on ants behavior and their connectivity, such as communication, food collection and nest building etc. that affect task performance in welfare of their colony. Figure 1 represents the interaction of ants, soil and other organisms in the nature. A solid and dashed line represents the direct indirect impact of ants on soil organisms respectively. Red lines represent negative interactions, green lines represent positive interactions and a gray line represents an interaction that can be either positive or negative depending upon the species considered. Ants generally have a positive effect on soil property through their activities such as nest construction, which can maintain and improve soil conditions for plants. Ants foraging can negatively impact on predators and pollinators through direct or indirect interactions.

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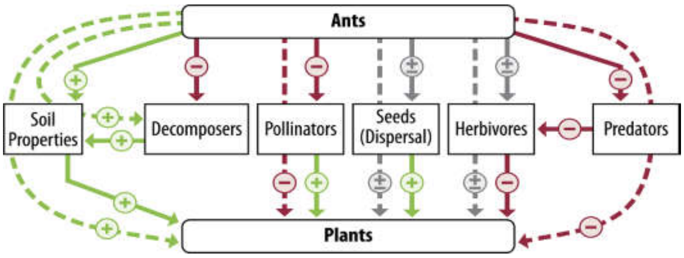

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Figure 1. Diagram representing interaction between ants, soil and other organisms

Seed collecting or seed harvesting ants can serve either seed predators (− effect) or seed dispersers (+ effect) even ants can protect honeydew-producing insects and negatively impacting on plants as they can disrupt herbivores. Altered soils can improve the conditions for decomposers but ants can directly diminish decomposer abundance as consumers.

Ant Colony

All ants are social insects, most of the ant colonies contains three castes i.e. queen, male (drone) and worker. If ant colonies contains only one queen then it is called ‘monogynous’, if many, it is referred to as ‘polygynous’. When all the workers in a nest are of same size, they are called as ‘Monomorphic’ (Ponerians, Dolicoderiles). When there are two distinct size and classes of workers, they are known as ‘Dimorphic’ (Oecophylla, Pheidole). If the variation is continuous from small to large workers in a colony, they are called as ‘Polymorphic’ (Componotous, Monomorium). Larger colonies may contain more than two to three types within each caste, varying in their size, shape and other morphological characters. In an ant colony, queens are usually winged and larger compared to other castes. Males are also winged and usually smaller than the female queen and they live for shorter period because their death within a few days after mating. All workers are sterile wingless females, they manage all works efficiently such as search of food, nurse the young ones, construction of nest, bring food for colony, look after the queen, defend the colony and keep the nest clean etc. Soldiers are modified workers with disproportionately large head. Foraging may be either diurnal or nocturnal or both, sometimes swarming also take place in some ants too.

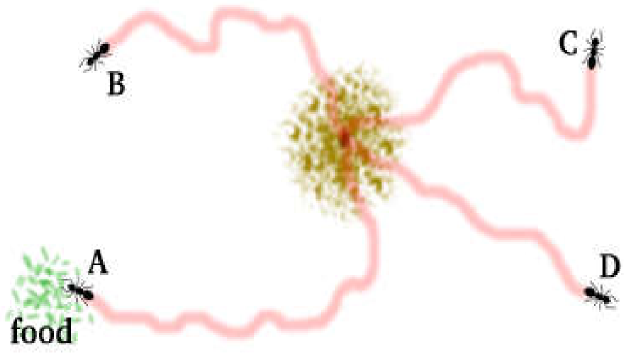
1. Communication

Another wonder activity in ant colony is their communication between different castes. They lead their life in a very well organized and disciplined manner. Ants communicate with each other using scented chemical known as ‘Pheromones’ and touch. Like other insects, ants also perceive smell with their long, thin and mobile antennae. Communication serves to acquire, share and distribute information about the current state of the colony and the surrounding environment. It is the invaluable thing in coordinating and organizing the work in between several colony members. Communications are usually classified by the nature of the signal carrier such as chemical, acoustical, mechanical and visual. They are also classified by the function, they serve alarm, attraction, recruitment, grooming, trophallaxis, recognition, etc. (Holldobler and Wilson, 1990). The trail-laying behaviour of forager ant *Lasius niger* was observed in the laboratory by Beckers *et. al.,*(1992). They measured frequency of trail-laying, as defined by the proportion of trips during which trail-laying occurred and its intensity, which is defined by the number of marks laid during one bridge crossing. Foragers did not exhibit trail-laying behaviour until a food source is discovered. Later, trail-laying occurs more or less equally both to and from the nest, and then its frequency and intensity decreased as the recruitment proceeds. Foragers of very small and less than a year old colony appeared to have quantitatively the same trail-laying behaviour as those of larger and much older colonies. The trail-laying intensity is found to be similar for both trips to and from the nest for ant's first, second, third and fourth trip. The frequency diminished rapidly with the number of trips made by each individual. Even though foragers stop marking after a variable number of passages, they continue to move between the nest and the food source, and other ants start marking. Different foragers appear to have widely different levels of trail-laying, although they couldn’t say whether these differences are stable between different recruitments. Trail-laying was strongly affected by the forager’s position on the bridge, especially for ants returning to the nest, which lay-up to five times more on the segment closest to the food source than that to the nest. However, the effect was weak and could partly be attributed to their lower speed. Finally, a model using the experimental data gathered on the individual’s trail-laying behaviour reproduced satisfactorily by the colony's overall trail laying. One of the well-known examples of social co-operation is described in nature, which occurs in the weaver ants. The workers of these species build nests utilizing the silk produced by their larva, due to this particular behaviour it is believed that the social aspects of this group is one of the most advanced one within the order Hymenoptera (Holldobler and Wilson, 1977; Holldobler and Wilson, 1990).

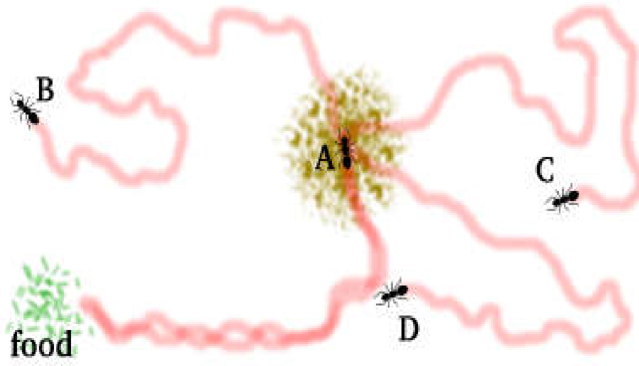
2. Food collection

The food collection is usually called as “foraging” as ants are voracious feeders, breeders and very hard working animals, several ants feed on dead and decaying animals, plants even on animal wastes helping in degradation process and recycling of nutrients. They play a little role in food chain, but which has great impact as they usually feed on small insects and helpless terrestrial arthropods. Another food source for certain species of ants are the different plant products, such as sweet liquid excluding from the floral and extra floral nectarines and leaf hoppers (Membracids).Ants communicate with each other very cautiously, while collecting food. This communication is very interesting and surprising phenomena in class-Insecta especially in ants. They communicate with their nest-mates by using chemical scents known as “Pheromones”, which can be used in many ways by different animals. Consider a colony of ants searching for a food, casual observation of a colony will reveal that they often walk in a straight line between their nest and food source, which is usually the shortest route, seems like an obvious solution for the problem of efficient food transportation and collection. The concept of an ‘army’ of ants marching in file has permeated or spread out a popular culture. To solve “finding home” problem, each ant leaves a trail of pheromone as it looks for food. In the following pictures (1-5), the pheromone trail left by each wandering ant is shown in transparent red color.

In picture-1, when an ant finds a food source, it can follow its own pheromone trail back. On the way back to the nest, the ant solves the problem by laying down more pheromone, creating a trail with even stronger scent.

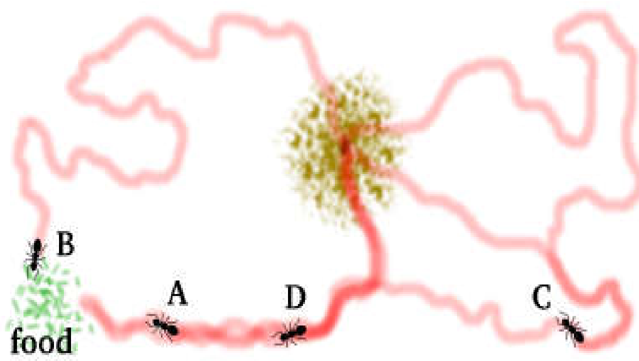


Picture 1.



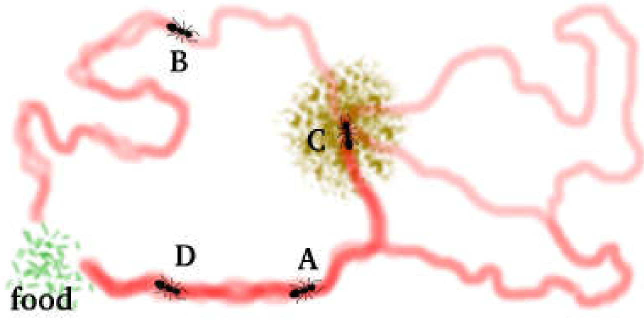
Picture 2.

In picture-2, Ant **A** reaches the food first and then follows its own trail back to the nest, while the other three ants keep wandering until they find food. When other ants run into a trail of pheromone, they give up their own search or trail and start following the same trail.



Picture 3.

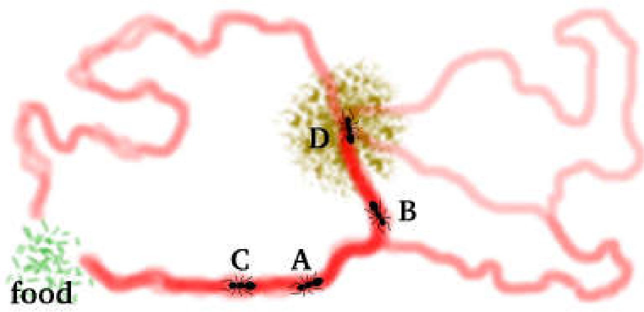
In picture-3, Ant D discovers the double strength trail left by Ant A and starts following it. Ant C encounters the single strength trail left by Ant D and follows that trail that eventually leads to Ant A's trail as well. Ant B eventually discovers its own route to find a food source that is completely disconnected from the route used by ant A. If a pheromone trail lead by an ant back to the nest with empty jaws, it turns around and follows the trail in the opposite direction. Once, if it reaches the food source, it grabs a small piece of food and follows the same trail back to the nest. While coming back, ant reinforces the trail by laying down more pheromone.



Picture 4.

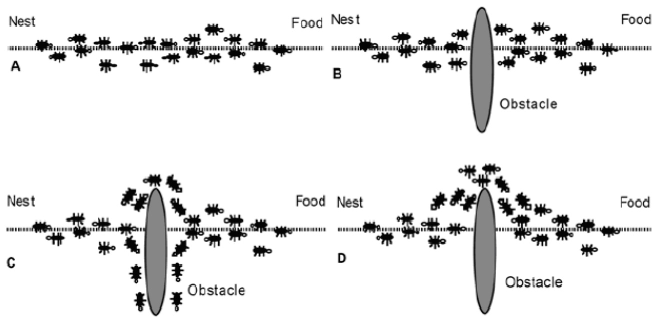
In picture-4, above Ant C joins the Ant A's trail, but follows the wrong direction, reaching the nest with empty jawed. Ant B follows its own trail back to the nest it never comes in contact with the direct trail that the other ants are using Ant A and Ant D trail to carry food back to the nest along the more established route. This is how, ants find a food but how do they find the shortest route to the food source?

Ants prefer to follow the trails with strongest pheromone scent; shorter routes between the nest and food are completed faster than the farthest one by each ant. For example, if Ant X is travelling along a 10m path to the food source repeatedly and Ant Y is travelling along a different 20m path repeatedly, Ant X will make twice as many as trips in an hour as that of Ant Y. If given the choice, ants will prefer the strongly scented 10m path over the more weakly scented 20m path. Like this way they prefer and find shortest route to the food and nest.



Picture 5.

For example in picture-5demonstrates the same concept, when Ant B deposits food at the nest and sets out for another trip it discovers the strongly scented path used by the other ants and abandons its own path. At this point, all 4 ants are using the path discovered by Ant A to carry food between the food source and the nest. Over the time, many more paths between the nest and the food source are explored, but on shortest the scent path is reinforced more than that of other paths, so it quickly becomes the most popular path and all the ants prefer to walk in file along with it. Ants are capable of finding shortest path from a food source to the nest without using visual cues. They are capable of adapting themselves to changing environment conditions. For example finding a new shortest path once the old one is no longer feasible due to a new obstacle, consider the following picture-6,where in, figure-A represents ants are moving on a straight line, which connects a food source to the nest. Ants deposit a certain amount of pheromone while walking, and each ant probabilistically prefers to follow a rich pheromone direction rather than the poorer one. Ants are able to find the shortest path, if the appearance of an unexpected obstacle that interrupted the initial path (figure B). Once the obstacle has appeared, the ants, which are just in front of the obstacle, cannot continue to follow the pheromone trail and therefore they have to choose between turning right or left. In this situation, we can accept half the ants to choose to turn right and the other half to turn left (figure-C). It is interesting to note that those ants which choose, by chance, the shorter path around the obstacle will more rapidly reconstitute the interrupted pheromone trail compared to those which choose the longer path. Hence, shorter path will receive a higher amount of pheromone by the time and this will in turn attract higher number of ants to choose the shorter path. By this positive feedback (Autocatalytic process) soon all the ants will choose the shorter path (figure-D).



Picture 6.

3. Nest construction:

Ants are one of the few groups of insects, which modify their immediate environment to suit their needs. They often build elaborate nests in a range of situations, sometimes expending huge amount of energy in their constriction. Ant species form nests in the soil fields where soil must be fertile, slightly acidic or basic. Some ant species, nest in ground, under concrete slabs and some nests are found in wood (Such as fence posts, dead logs and hollow trees).

a. **Nesting in soil:** These are sub-terranean nests, vary from small to simple chambers under rocks, logs and other objects on the ground to extensive excavations up to a meter or more into soil. The exact structure of the nest varies with the species, soil type and habitat. The entrances to these nests show a wide range of styles. Many are having not more than a cryptic hole, just large enough for a single worker to squeeze through. Others have a single entrance surrounded by soil, which varies from a low and broad mound to a tall and narrow turret. A large number of ant species assemble soil and leaves around their nest entrances to form large piles with well defined, vertical sides and concave tops. Ant activities within the soil have important consequences on biodiversity, nutrient content, and physico-chemical properties. Nest mounds often represent with high amount of total nitrogen, phosphorous content and neutral pH quite different from the surrounding soils (Umbanhowar, 1992; Frouz and Jilkova, 2008), but they generally do not harbor more plant species compared to the surrounding soils (Culver and Beattie, 1983; Dean *et al.,* 1997). Some ant species (seed harvesting ants) will directly remove or clip plant vegetation in and around their nests, maintaining vegetation free islands (Mac Mahon *et al.,* 2000). However, in north temperate regions, mounds often do maintain small scale patchiness in grasslands (King, 1977b) because they contain relatively less moisture than that of the surrounding soils. Therefore, ant nests tend to harbor more xeric tolerant plant species (King, 1977a), or other such species, which cannot compete with dominant plant species (Dostal, 2007). In drier grasslands, nests of seed-harvesting ant species often serve as an important island for plants by increasing soil moisture and nutrient concentration compared to the surrounding soils (Mac Mahon *et al.,* 2000).

b. **Nesting on plants:** Nesting on plants is done by arboreal species such as *Oecophylla smaragdina*, commonly called as ‘weaver ants’. They use plant materials like leaves, fibers etc. and their own secretions to construct a protective covering over the nests. Weaver ants use their silk threads (whitish) secreted from salivary glands of larvae, they attach one leaf with another leaf by stitching and they expand the colony both by enlarging existing leaf nests by adding new satellite nests. Other arboreal species use plant fibers to construct coverings, which are attached to the surfaces of leaves. The ants live comfortably within the chamber/compartments formed by their secretions and leaves.

Conclusion

Ants are the most diverse and successful creatures among insects in terrestrial ecosystems. Their abundant biomass and diversity make them important consumers and also ecosystems engineers (Del Toro *et al.,* 2012). Therefore, ants appears to play a positive role in an ecosystem as consumers by protecting plants from herbivores (Styrsky and Eubanks, 2007; Rosumek *et al.*, 2009). Ants also play as ecosystem engineers in a variety of systems, improving soil conditions so as to support greater plant diversity (Del Toro *et al.,* 2012; Nemec, 2014). Ants communicate, partly, through chemical scents called pheromones, which can help them to follow one another for a piece of food in order to bring it to their nest. Sometimes, groups of ants moving the food together loose the track most possibly because the food may block their antennae, making it difficult for them to navigate properly but, Individual ants moving freely with a better sense of the nest’s location, and they come into correct path. The type of nests on varies with the species, soil type and situation, some nests are arboreal, frequently found in twigs, on branches or on the trunks of tree. In a few arboreal ant species nests are constructed using leaves. Many of the ant species found in rotten wood do little more than to remove loose wood fibers to construct simple chambers for workers and brood. These chambers can be small or very extensive but often lack the complexities of nests found in soil or arboreal. Some species (Leptogenys) lack a nest and are found in small groups, clustered on the ground in leaf litter or among the roots of plants. These species move their "nests" frequently and can be found in a wide range of suitable sites. Antagonistic behaviour in ants deserves attention and specific study regarding its function. Conflicts between queens, queens & workers and workers & workers are observed in some ant species colonies (Bourke, 1991). This might be related to the establishment of the hierarchy of dominance (Oliveira and Holldobler, 1990). Cannibalism, although not yet well understood, was observed in some ant species (Wilson, 1976; Bourke 1991) and might be related, for example, to dominance or stress in the colony (Carlin, 1988; Holldobler and Wilson, 1990).

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