

Cue for ant's trail development

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Abstract

Ants collect food either individually or jointly or in a sequential order through a trail tract. It is not clear under what circumstances the ants decide to carry food by developing a trail tract between the food source and the nest. To verify the same different types of food in different quantity were offered to the ants in their foraging ground in Garia, Kolkata, India. It is revealed that the ants *Pheidole roberti*, *Paratrechina longicornis*, *Monomorium pharaonis* did not consider it wise to develop a trail tract to collect the food from the source where offered foods viz. sugar cubes, dry fish fragments, biscuit fragments, nut particles and papad fragments were less than 70 in number without few exceptions. The ants though carried the food particles in different spells in respect to their chance of contact with the supplied food, in cases of deposition of 30-40 food particles at the offered site, occurrence of 120 food particles belonging to four varieties in equal number induced the ants to develop the trail tract to carry the food to the nest.

Key words: Ants, Foraging, Cue, Trail, Food collection

Introduction

Foraging behaviour of ants have drawn the attention of a number of workers (Wehner *et al.*, 1983; Schmid-Hempel, 1987; Goss *et al.*, 1989a, b; Traniello, 1989; Beckers *et al.*, 1990; Vasconcellos, 1990; Nelson *et al.*, 1991; Portha *et al.*, 2002; Jackson *et al.*, 2004; Muser *et al.*, 2005; Vittori *et al.*, 2006; Abril *et al.*, 2007; Domisch *et al.*, 2009; Sengupta *et al.*, 2010; Jayatilaka *et al.*, 2011; Raquel *et al.*, 2013; Schultheiss and Nooten 2013; Schultheiss *et al.*, 2013; Hashimoto and Yamane, 2014; Lixiang *et al.*, 2014; Naskar and Raut, 2014a, b, c, 2015a, b, c, d). It is an established fact that the foragers of an ant colony move in different directions for food searching (Calcott, 2006). The forager, in cases of small amount of food, may pick up the said food and back to home to deposit the same. If the amount of

food is considerably high then the scout-forager returns to the nest to invite the fellow members to collect these foods. Certainly, the ability of forager ant to assess the food volume is the key factor that determines the forager ant's behavioural response either to carry a food particle alone to the nest or to go back to the nest to invite the nestmates to procure the available food from the site concerned. However, this aspect of foraging in ants has not been paid due attention by any workers so far. But, Mailleux and coworkers (2000) and Naskar and Raut (2015b) opined that the ants are able to assess the volume of the food locating at a site. Mailleux et al (2000) have discussed at length regarding the mechanism of communication to the nestmates by the scout regarding volume of the food locating at the site.

However, in spite of availability of ample information on the foraging behaviour of ants nothing is known on the decisive factor i.e. what should be the amount of the food that stimulates the forager ant to inform the nestmates for procuring the said food. Accordingly, we aimed to note the cue that induces the foraging ants occurring in their foraging ground, in and around Garia, Kolkata, West Bengal, India, experimentally by offering different types of foods in different amount irrespective of hours of a day (24h). Our findings as could be revealed from the following descriptions indicate that the ants are intelligent enough to measure the volume of food in respect to cost-benefit effect. Therefore, when the available food source exceeds and/or equalizes with the expected amount to be considered for carrying the same through the recruitment of fellow members, the ants, irrespective of species, inform the same to the nest-mates.

Materials and Methods

We offered sugar cubes, biscuit fragments, dry fish particles, nut particles and papad fragments between 15-45 mg in weight (each cube/ fragment/particle) to the ants in their foraging area at Garia, Kolkata, West Bengal, India in different specifications and numbers (Table 1). In all 38

Table 1. Specifications of the foods, the time and the amount (in number) of food materials offered to the ants at a site in their foraging area in Garia, Kolkata, India in different trials.

Trial No	Food offered		
	Type	Number	Time (h)
1	Sugar cube	10	06:25
2	Sugar cube	10	11:05
3	Nut particle	10	18:20
4	Biscuit fragment	10	09:00
5	Dry fish particle	10	07:45
6	Sugar cube	20	19:00
7	Nut particle	20	06:30
8	Dry fish particle	20	09:50
9	Sugar cube	30	20:30
10	Biscuit fragment	30	07:15
11	Nut particle	40	11:05
12	Sugar cube	40	18:00

13	Biscuit fragment	40	09:00
14	Sugar cube	50	06: 45
15	Biscuit fragment	50	19:05
16	Dry fish particle	50	07:40
17	Nut particle	50	09:05
18	Sugar cube	60	09:00
19	Dry fish particle	60	08:40
20	Nut particle	60	11:05
21	Biscuit fragment	60	06: 40
22	Sugar cube	70	08:36
23	Biscuit fragment	70	19:05
24	Sugar cube	80	09:05
25	Sugar cube	90	08:30
26	Sugar cube	100	07:55
27	Sugar cube	100	07:47
28	Biscuit fragment	100	07:55
29	Sugar cube	110	07:58
30	Sugar cube	120	06: 40
31	Sugar cube	130	08:05
32	Sugar cube	140	07:30
33	Sugar cube	150	07:15
34	Sugar cube	160	10:20
35	Sugar cube	170	08:23
36	Sugar cube (30)	120	18:55
	Dry fish particle (30)		
	Papad fragment (30)		
	Biscuit fragment (30)		
37	Sugar cube (40)	140	22:05
	Dry fish particle (30)		
	Biscuit fragment (30)		
	Nut particle (40)		
38	Sugar cube (40)	180	23:08
	Nut particle (50)		
	Biscuit fragment (50)		
	Dry fish particle (40)		

trials have been made on different dates. In all cases due attention was paid to note the time of arrival of forager ant at the food-offered sites and the subsequent behavioural manifestations in respect to checking food matters, information-communication to the nestmates and the food-carrying phenomena.

Results

Results of experimental trials have been shown in Table 2. It is evident that in all trials

Table 2. Results of experimental trials in respect to supply of different varieties of food in different number either singly or in combination in the foraging ground of the ants locating at Garia, Kolkata, India.

Trial No.	Results
1	At 06:29 h a <i>P. roberti</i> forager appeared at the site and took away a sugar cube. Within next few minutes few more foragers of the said species came across the supplied sugar cubes and the same were carried by them to the nest.
2	After 2 minutes of supply of the sugar cubes one <i>P. roberti</i> forager was seen to check the sugar cubes. Within next few minutes many more foragers of the same species assembled at sugar cube supplied site. All the sugar cubes were carried to the nest individually.
3-4	<i>P. roberti</i> appeared at the site after 6 and 11 minutes of the food supply. They checked few particles and started procuring those one after another to the nest individually.
5	Just within one minute a <i>P. longicornis</i> forager was seen to check the fish particles. Within next 3-4 minutes few more <i>longicornis</i> foragers assembled at the site. They carried all the fish particles to the nest at different time intervals.
6	At 19:03 h a <i>P. longicornis</i> forager was seen to check the sugar cubes. Within a few minute it took away one sugar cube. Then few more foragers of <i>P. longicornis</i> were seen to collect these sugar cubes individually.
7-9	<i>P. roberti</i> foragers came across the supplied food materials after 2, 1 and 6 minutes of the supplied time. All the food particles were carried by these ants individually, sometimes jointly to the nest.
10	Within a minute of food supply <i>P. longicornis</i> foragers encircled the site and started checking as well as procuring the biscuit fragments to their nest.
11	After one minute of supply of the nut particles a <i>P. roberti</i> appeared at the site and taken away a nut particle. Within next 2-3 minutes many more foragers of <i>P. roberti</i> were seen to procure the nut particle individually almost in a isolated manner to the nest.
12	At 18:05 h i.e. after 5 minutes of food supply a forager of <i>P. roberti</i> came across these sugar cubes. Soon after, two more <i>roberti</i> and subsequently many more foragers of the said species paid a visit to the site and took away a sugar cube from the site, individually, on the basis of almost first come first serve.
13	After 5 minutes i.e. at 09:05 h one <i>Monomorium pharaonis</i> was seen to check the biscuit fragments. Soon after few more <i>pharaonis</i> foragers assembled at the site. They were seen to disintegrate the biscuit fragments into very small granules. Some of the granules were fed by them while many other granules were seen to carry by the foragers almost in an order of row to the nest.
14	At 06:51 h one <i>P. roberti</i> forager appeared at the site. It was seen to verify the sugar cubes. Within next 3 minutes 2 more <i>roberti</i> foragers and one <i>Paratrechina longicornis</i> forager reached at the site. <i>P. longicornis</i> forager checked few sugar cubes and returned to the nest. In the mean time few more <i>roberti</i> foragers assembled at the site. Some of them were seen to carry the sugar cubes to the nest. Suddenly 21 <i>P. longicornis</i> appeared at the site. They started fighting with <i>P. roberti</i> . But, in course of fighting some individuals of both the species took the

	opportunity to procure the sugar cubes from the site.
15	Just after 10 minutes of supply of the biscuit fragments a <i>P. roberti</i> forager had the chance to come in contact of the same. It was seen to check the fragments. Subsequently, other foraging members were seen to participate in checking process. Thereafter, these fragments were taken to the nest individually or jointly at certain intervals.
16	After 3 minutes a <i>P. roberti</i> forager was seen to check the fish particles while after next 3 minutes one <i>P. longicornis</i> forager was seen to chase the said <i>P. roberti</i> forager. Subsequently, on arrival of few more foragers of both the ant species fighting between the species was inevitable and two <i>P. roberti</i> individuals were killed by <i>P. longicornis</i> . Thus, within next 2-3 minutes <i>P. roberti</i> foragers were compelled to leave the site though one of them was seen to carry a fish fragment alone. After 6 minutes a row of <i>P. longicornis</i> was developed and the fish fragments were carried to the nest.
17	After 6 minutes a forager of <i>P. roberti</i> and after 12 minutes a forager of <i>P. longicornis</i> were seen to move around the nut particles. Within few minutes many more <i>P. roberti</i> and 3 <i>P. longicornis</i> assembled at the site. Some of them irrespective of species started carrying the nut particles to the nest, individually.
18	Immediately, after the supply of sugar cubes <i>P. roberti</i> appeared at the site and the sugar cubes were taken to the nest within next few minutes depending upon the arrival of foragers.
19	Within a minute <i>P. roberti</i> forager came across the fish particles while <i>P. longicornis</i> appeared at the site just after 9 minutes of the offered time. Only a few dry fish particles were procured by the <i>P. longicornis</i> foragers while the remaining fish particles were carried by <i>P. roberti</i> in due course of time in respect to arrival of foragers at frequent intervals.
20	At 11:08 h i.e. after 3 minutes a <i>P. roberti</i> forager was seen to touch the nut particles while a <i>P. longicornis</i> forager reached at the site at 11:26 h. Subsequently more foragers of both the species were seen to come in contact of the nut particles. Thus, the nut particles were carried by both the species at frequent intervals but in all cases individually.
21	<i>P. roberti</i> forager appeared first at the site. This was followed by <i>P. longicornis</i> after few minutes. Subsequently, many foragers had the chance to visit the site and to carry the biscuit fragments to the nest, individually.
22	With the supply of sugar cubes at the site a <i>P. roberti</i> forager started checking the sugar cubes instantly. After 13 minutes a <i>P. longicornis</i> forager appeared at the site. It checked 5 sugar cubes and hurriedly left the site. In the mean time another <i>P. roberti</i> forager reached at the site and took away a sugar cube. Within next 3 minutes many <i>P. longicornis</i> foragers were seen marching towards the sugar cubes supplied site. They checked the sugar cubes here and there. Within a minute they started carrying the sugar cube individually in a row. Also on the same trail many more members of their colony were seen to marching to food source side by side. Thus, a distinct row was developed and all the sugar cubes were procured by <i>P. longicornis</i> .
23	Within two minutes of supply of the biscuit fragments <i>P. roberti</i> foragers assembled at the site. They were seen to carry the biscuit fragments at irregular intervals depending on their arrival at the site. Moreover, some of the foragers were seen to move elsewhere perhaps, in search of other kind of food materials. However, ultimately within a period of 4 hours these biscuit fragments were taken to the nest.
24	At 09:06 h a <i>P. longicornis</i> appeared at the site. It started checking the sugar cubes. It left the site. After that a <i>P. roberti</i> forager reached at the site, checked the sugar cubes and took away a sugar cube. A total of 21 <i>P. longicornis</i> foragers were seen marching towards the site in a row. They took the sugar cubes and moved towards the nest. Soon after many more <i>longicornis</i>

	foragers assembled at the site almost in a row but the row was discontinuous. All the sugar cubes were procured by <i>P. longicornis</i> .
25	Sugar cubes were supplied at 08:30 h but a <i>P. longicornis</i> visited the said food supplied site at 08:47 h. It was seen to check 6 sugar cubes occurring at different locations of the spot. It then moved to the nest. Suddenly, two <i>P. roberti</i> foragers appeared at the site. They were seen to check the sugar cubes. One of them was seen to carry a sugar cube to the nest. By this time <i>P. longicornis</i> foragers reached at the site one by one. A good number of <i>P. longicornis</i> were assembled at the site and within few minutes they were seen to carry the sugar cubes one by one in a row and some other individuals were seen to march towards the site along the same tract. Finally, a row became prominent and all the sugar cubes were taken to the nest by <i>P. longicornis</i> .
26	The sugar cubes were supplied at the site at 07:55 h. One <i>P. longicornis</i> forager came in contact of these sugar cubes by 08:22 h. It was seen to check 5 sugar cubes here and there and promptly returned to the nest. Within next 8 minutes several <i>P. longicornis</i> were seen marching towards the site in a row. After coming in contact of the sugar cubes the ants took individually one sugar cube, and moved to the nest in a row while few more individuals were seen approaching the sugar cube supplied site along the said tract. After the development of row, within 48 minutes all the sugar cubes were carried by <i>P. longicornis</i> to the nest.
27	Just after one minute a <i>P. longicornis</i> forager appeared at the site and checked few sugar cubes hurriedly. Then, it moved to the nest. Within a short time many <i>P. longicornis</i> were seen marching towards the site. After reaching at the spot they instantly started picking up one sugar cube individually and took their way to the nest along the same tract through which they crawled to the sugar-cube supplied site. Thus, coming to collect the sugar cube and going of the foragers with the sugar cubes were become the events of the ants until the sugar cubes were taken to the nest.
28	Biscuit fragments were supplied at the site at 07:55 h. A <i>P. roberti</i> forager appeared at the site by 08:01 h. Following checking of few biscuit fragments here and there at the deposited site it moved away. Within next 6 minutes a good number of <i>P. roberti</i> were seen marching towards the site. After coming in contact of these food matters they were seen to verify this and that fragment of biscuit perhaps to consider which one is more suitable to carry to home. Thus, within 2 minutes a trail was established where coming of individuals to the site and going towards the nest with a sugar cube by some other individuals of <i>P. roberti</i> became a distinctive feature.
29	A <i>P. longicornis</i> forager came across the supplied sugar cubes after 5 minutes of supply. Following examination of the deposited sugar cubes it moved away. Within next 2 minutes a forager of <i>P. roberti</i> was seen to check the sugar cubes. It took a sugar cube and moved away. In the next moment several <i>P. longicornis</i> reached at the site. They individually procured a sugar cube and moved towards the nest in a row by the side of the fellow members of the colony crawling towards the sugar cube supplied site. Thus within 19 minutes, after contact with the sugar cubes, a row of <i>P. longicornis</i> was well established.
30-35	Irrespective of times and numbers of the sugar cubes supplied at the site foragers of <i>P. roberti</i> and <i>P. longicornis</i> had the chance to come across these sugar cubes within 2-19 minutes. In all cases initially <i>P. roberti</i> forager took a sugar cube and moved away while <i>P. longicornis</i> following collection of information regarding the food source moved away without procuring a sugar cube, to the nest. In all cases a large number of <i>P. longicornis</i> foragers assembled at the site and took away the sugar cubes individually along a trail to the nest. The trail was also used by the ants coming from the nest for procurement of these sugar cubes. Finally, a row of ants

	<i>P. longicornis</i> was well established in all the trials.
36	Within 3 minutes a <i>P. roberti</i> forager visited the site and took away a dry fish fragment to the nest. At 19:18 h a <i>Paratrechina longicornis</i> was seen to examine the food materials occurring at the site. In the next moment it moved to the nest. In the mean time 8 <i>P. longicornis</i> appeared at the site. Some of them were seen to procure a sugar cube individually and moved away. Within a few minutes many <i>longicornis</i> ants were seen crawling towards the food source. Finally, a row of <i>P. longicornis</i> was developed and all the remaining food materials were collected by these ants.
37-38	Within 10-15 minutes of food supply the foragers of both the ants <i>Pheidole roberti</i> and <i>Paratrechina longicornis</i> had the chance to note the occurrence of the food materials at the sites. <i>P. roberti</i> instantly took away few food particles in respect to their contact with these foods while <i>P. longicornis</i> hurriedly moved to the nest to invite the nestmates to carry these foods. Thus within a sort time a row of <i>P. longicornis</i> was developed and the food matters were carried to the nest.

supplied foods, irrespective of types and numbers were procured either by *Pheidole roberti* or by *Paratrechina longicornis* or by *Monomorium pharaonis*. However, in most cases, in a trial supplied foods were shared by the ants *Pheidole roberti* and *Paratrechina longicornis*. Therefore, in certain cases fighting between these two species was inevitable. Though, in cases of small number of food particles ant individual procured the food particle at per will in respect to contact with the offered food matters development of a trail was initiated when the number of offered food particles was high.

Discussion

From the results it appears that the ants irrespective of species are adapted to collect their food from the foraging grounds by different means in respect to the amount of the food present at the source. In the present study it is evident that the ants *Pheidole roberti*, *Paratrechina longicornis* and *Monomorium pharaonis* occurring in Garia area of Kolkata are habituated to use the same foraging ground to meet up their need for food. Though the area is dominated by the ants *Pheidole roberti* the long horn ants *Paratrechina longicornis*, in course of competition for food, almost in all cases, succeeded to chase away the competing ants *Pheidole roberti*.

It is evident that the food-carrying strategy in ants depends on the amount of food present at the source. Because, the ants considered it wise to develop the trail for collection of food when the amount of deposited food at the site was close to 70 cubes/particles/fragments and/or more. Prior to that, in all other trials food particles were procured by the ants in different spells depending on the arrival of the foragers in contact of the supplied food particles. Of course, in cases of competition between *Pheidole roberti* and *Paratrechina longicornis* in respect to collection of dry fish particles *P. longicornis* applied their intelligency by developing a trail hurriedly, at the end of battle with *P. roberti* to procure the food particles as early as possible. However, in all other instances trail was developed either by *Paratrechina longicornis* or by *Pheidole roberti* when the amount of deposited food was a mass of 100-170 cubes/fragments/particles. Thus it is evident that the ants are enough intelligent to estimate the volume of food occurring at the site.

As there exists every possibility of procuring these foods by the foragers of competing ant and and/or other species development of a strategy to collect these foods at the earliest opportunity by applying the best possible means, by the stronger ant species is inevitable. For this reason, keeping in view of the cost-benefit effect regarding energy spent to communicate the information to the nestmates and to recruit a large number of individuals to move to the site for collection of the food, the scout ants are adapted to assess the food volume at the source. Though the selection of food by the ants varied to a great extent with the need of the colony (Portha *et al.*, 2002) it is evident that the ants, neither *Pheidole roberti* nor *Paratrechina longicornis* considered it wise to inform the colony members for procurement of food when 30 or 40 sugar cubes and/or other food particles were at the site. But, surprisingly, when the deposited foods were 120, 140 and 180 of four different varieties with a combination of 30-50 particles of each variety, then the ants decided to collect these foods through the development of a trail.

Thus, it is clear that food collection by the ants through the development of a trail between the source and the nest is a function of the volume of the food locating at the source. Therefore, movement of ants in a row is related with the food-procurement success. Hence, development of a trail is prerequisite for collection of food if occurring in large quantity at the source. Undoubtedly, trail is regulated by the trail-tract by the aid of pheromones (Blum, 1966; Ritter *et al.*, 1973; 1977; Vander Meer, 1986; Pasteels *et al.*, 1987; Holldobler *et al.*, 1995; Jeanson *et al.*, 2003; Jackson *et al.*, 2004, 2006).

From the present findings it can be said that the volume of the food is cue for construction of row by the ants for procurement of foods from the source. However, under competitive situation stronger ant species may develop row hurriedly with a view to procure all the foods as quickly as possible. As we have noticed almost similar behavior in cases of different types of foods offered at the site the influence of chemical composition of food on the trail-laying behaviour of *Pheidole roberti* and *Paratrechina longicornis*, as have been advocated for other ant species by Verhäghe (1982), Beckers *et al.* (1993) and de Biseau and Pasteels (1994) is questionable.

Acknowledgement

The authors are thankful to the Head of the Department of Zoology, University of Calcutta for the facilities provided. The ants specimens were identified by the Zoological Survey of India, Kolkata, India.

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