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GENESIS AND SIGNIFICANCE OF COOPERATIVE TRANSPORT IN ANTS

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ABSTRACT
Food particles of different sizes and weight were offered to the ants in their natural foraging area at Garia, Kolkata, West Bengal, India to note the strategy being applied by the ants to carry the food to the nest and possible significance of such behavioural act. It is revealed that the ants did not bother for assistance of other members if the said food particle is manageable for transport individually, by keeping the food high at the head level following mandibular biting. But little heavier food particle induced the ant individual to apply either pushing or pulling or both the acts to carry a food particle. However, with the increase size and/or weight of the food particle the ants were seen to develop the cooperative transport system with a view to ensure procurement of the targeted food matter to the nest. To make the cooperative transport effective the ants apply any and all kinds of options viz. pulling and pushing by changing their position at frequent intervals on way of carrying act, perhaps to meet the requirement of quality food at the first instance though quantitative need could not be ruled out.

KEY WORDS: Ants, cooperative transport, genesis, significance.

INTRODUCTION

The act of simultaneously moving an item by two or more individuals is defined as cooperative transport (Czaczkes & Ratnieks, 2013). Except humans this sort of behaviour is almost confined to ants. It is also stated that the ants follow the cooperative transport mechanism to carry a food item which is unmanageable individually (McCreery & Breed, 2014). Though cooperative transport in ants have drawn the attention of various workers (Hölldobler & Wilson, 1990 ; Moffett, 1992 ; Czaczkes & Ratnieks, 2013) the genesis of the said behaviour is still unknown. However, according to McCreery & Breed (2014) cooperative transport of food is a proximate behavioural mechanism that increases the size range of food available to a colony. It is also stated that the ant species who have developed the art of cooperative transportation are able to increase the amount of food accessible to them (Berman et al, 2011; Czaczkes & Ratnieks, 2013). Keeping these findings in mind we designed some experiments in view of our earlier findings (Naskar & Raut, 2014a, b, c, 2015a, b, c, d, e, f, g, 2016a, b, c, 2018) by offering food of different sizes to the ants occurring in their natural habitats at Garia (Kolkata), West Bengal, India to determine the genesis behind the manifestation of such behavioural act.

MATERIALS & METHODS

We offered different types of foods viz. biscuit fragments, sugar cubes, nut fragments, papad fragments, dead mosquito, fish fragments (both fresh and dry) and fragmented parts of animal's body like cockroach and other insects larvae of certain insects of different sizes to the ants on the ground floor of a house locating adjacent to a garden at Garia, Kolkata to note the collection strategy being applied by the ants irrespective of species. The experimental trials were made both in day and night hours during post-winter and summer months (February-June). Due attention was paid to note the strategy the ants applied to carry the offered food materials to their nest. Also, due attention was paid to observe and record the behaviour of the ants to ensure transportation of the food matter from the offered sites to the nest.

RESULTS

The ants *Pheidole roberti*, *Paratrechina longicornis*, *Anoplolepis gracilipes*, *Monomorium pharaonis* were seen to come in contact of the food materials offered on way of their foraging movement. Except *M. pharaonis* an ant individual was seen to examine the food matters and applied the following strategies to carry the food matters concerned. *M. pharaonis* preferred to cut the food matter into small pieces to apply individual carrying strategy though rarely, they exhibited the cooperative food carrying behaviour.

Pushing strategy: When one ant came across of a piece of food matter which was manageable by her individually then she applied the pushing strategy to carry the same (Fig.1a). Here, the ant lifted the food matter by holding the same with her mandibles and started moving forward keeping the food materials high at the level of head (Fig.1b).

Pulling strategy:

This strategy is applied when the food material is little bit heavier than the food material selected for procurement by an ant through the application of pushing strategy. In this case the ant is unable to lift the food matter from the ground individually but she is able to carry the same on way of dragging i.e. through the application of pulling strategy (Fig.1c).

Pushing-Pulling strategy

In many instances an individual ant was seen to carry a piece of food material by pushing-pulling strategy. The ant is unable to lift the food material up from the ground by the help of biting with the mandibles but was able to push forward the food material by biting-pushing act. But, she was seen to change her position. From behind the food material she moved to front side to pull the food through the biting by the mandibles. The said act was changed after few minutes to follow the pushing strategy (Fig. 1d). But, when the food matter was unmanageable for an ant individual she was seen to look for the assistance of other individuals of the said species to ensure transportation of the same. The behaviours exhibited by 2, 3, 4, 5 and 6 ant individuals involved in transporting a piece of food material were as follows.

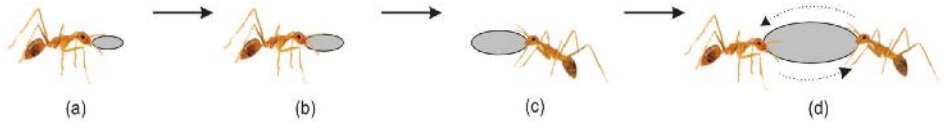

FIGURE 1: Strategies applied (a-d) by an ant individual to carry a food particle which was manageable herself, to the nest

By 2 ant individuals

Here, in some cases, one ant was seen to act as pusher (marked by 1) and the other (marked by 2) as puller (Fig.2a) while in some other cases both the ants were seen to act as either pusher (Fig. 2b) or puller (Fig. 2c) jointly. But, in case of one pusher and one puller food-carrying strategy, at certain intervals puller was seen to change the place to act as pusher while the puller was seen to move to the opposite end of the food element to take the position of a pusher (Fig. 2d).

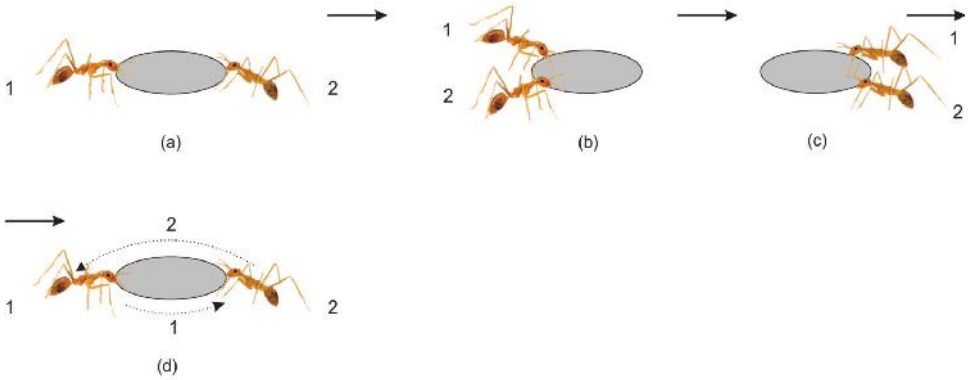

FIGURE 2: Strategies applied (a-d) by two ant individuals when a food particle was manageable by them, to carry the same to the destination.

By 3 ant individuals

Transportation of a food element while effected by the joint efforts of 3 ant individuals sometimes 1 was seen to act as pusher and 2 as puller (Fig.3a) or reverse i.e. 2 as pusher and 1 as puller (Fig.3b). But, depending upon the distance to be travelled and the hurdles to overcome to reach at the destination the ants were seen to change their position (Fig.3c-f) to act as pusher or puller as per need to ensure transportation of the food matter.

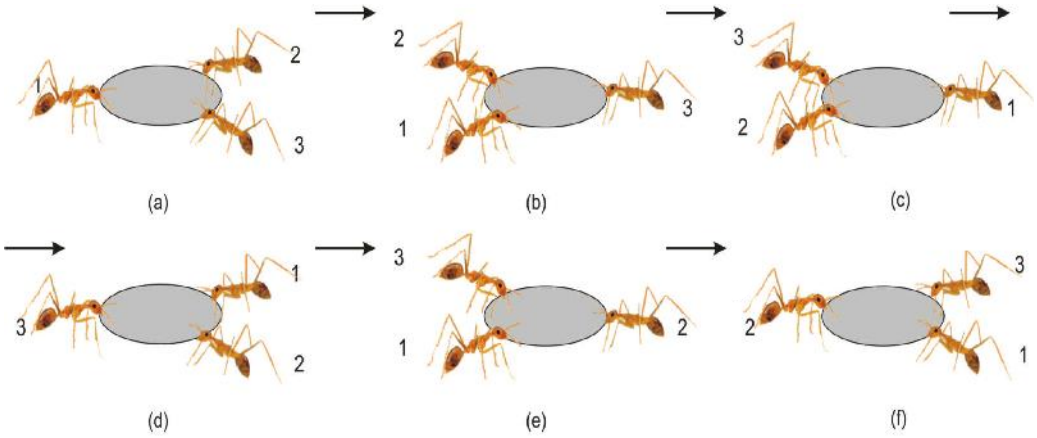

FIGURE 3: Strategies applied (a-f) by the three ant individuals when a food particle was manageable by them, to carry the same to the destination.

By 4 ant individuals

Usually, of the 4 ants 2 were seen to push the food material from the posterior end while other 2 were engaged in pulling the said material (Fig. 4a, b). But, in some cases 3 were seen either pushing or pulling the food element and the remaining one was either in pulling or pushing i.e. opposite act at the opposite end (Fig.4c-k). They were seen to change their position at frequent intervals. Moreover, in some cases one ant was seen pushing the food matter from posterior end of the same while the other one was engaged in pulling the food matter being positioned at the anterior end. Each of the remaining two ants was seen to push the food matter being positioned at the lateral side of the food element (Fig.4k). They were seen to change their position at frequent intervals.

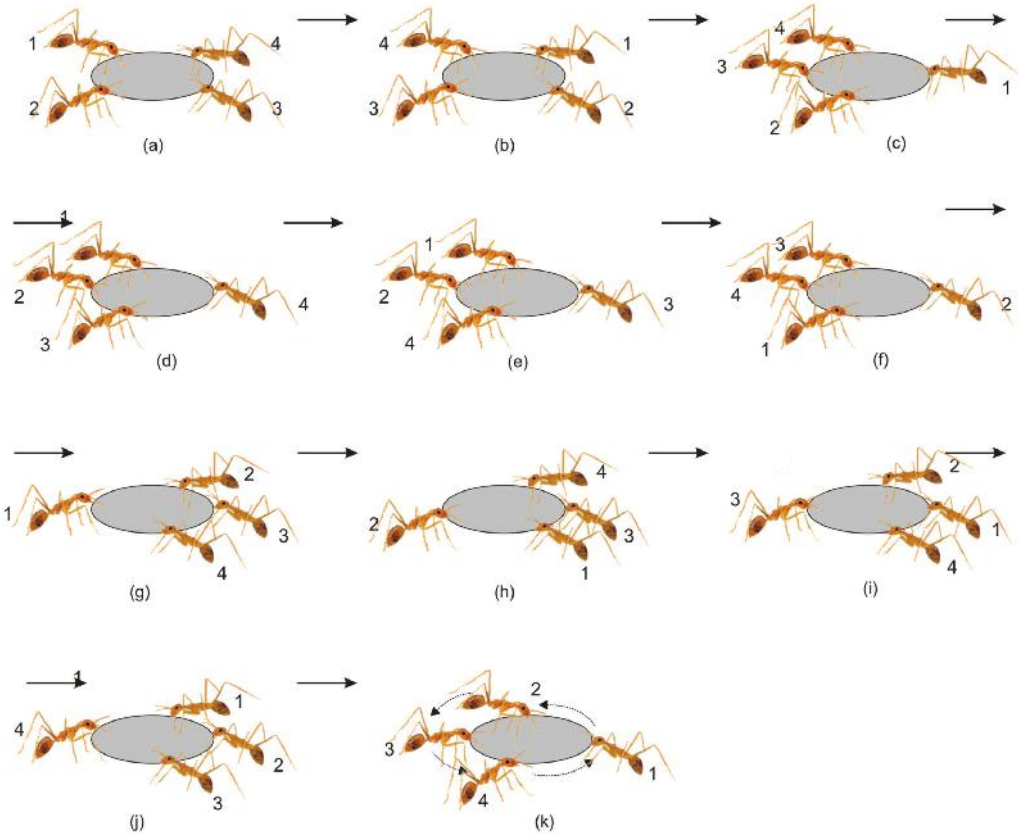

FIGURE 4: Strategies applied (a-k) by the four ant individuals when a food particle was manageable by them, to carry the same to the destination.

By 5 ant individuals

Of the 5 ants sometimes 2 or 3 were seen either in pushing or in pulling act at the posterior or anterior side respectively (Fig.5a, b). Also, in some other instances one ant was seen in pushing act at the posterior end of the food while another one was pulling the food being positioned at the anterior end. The remaining 3 ants were also seen in pushing act, sometimes 2 of them positioned themselves at the lateral side either at the right side or at the left side of the food element and the other one at the other lateral side (Fig.5c). They were seen to change their position at frequent intervals.

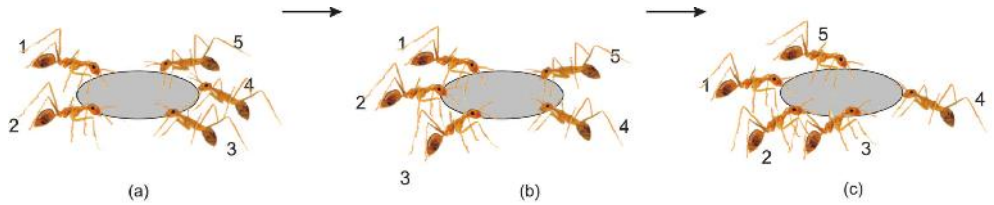

FIGURE 5. Strategies applied (a-c) by the five ant individuals when a food particle was manageable by them, to carry the same to the destination.

By 6 ant individuals

The ants were seen to take their position at different sides of the food element: sometimes one was seen in pushing act at the posterior end and the other one in pulling act at the anterior end; of the remaining 4 ants 2 were seen in pushing act at the right marginal side while the other 2 were seen at the left marginal side in the pushing act (Fig.6a). Also, in some instances 2 ants were seen in

pushing and the other 2 ants were in pulling act while the remaining 2 ants were also seen in pushing act positioning one at the right lateral margin and the other one at the left lateral margin of the food material involved in carrying act (Fig. 6b). However, involvement of 3 ants as pusher at the posterior end and the other 3 individual's involvement as puller at the anterior end of the food element was not uncommon (Fig.6c). They were seen to change their position at frequent intervals (indicated by arrows).

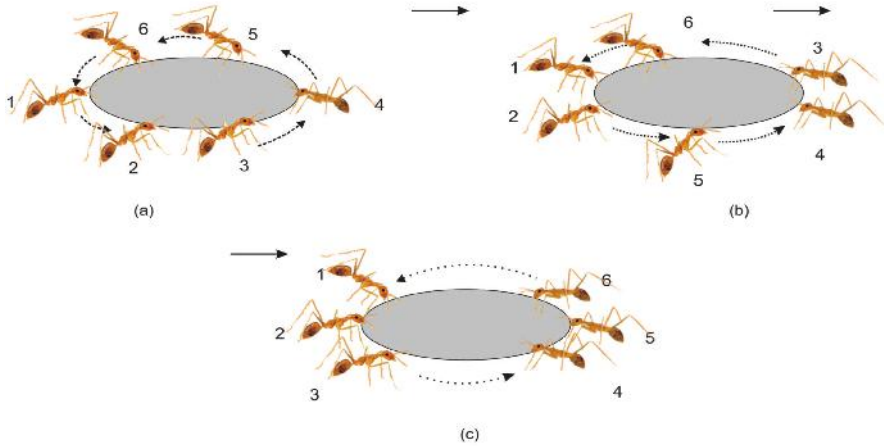

FIGURE 6. Strategies applied (a-c) by the six ant individuals when a food particle was manageable by them, to carry the same to the destination.

By more than 6 ant individuals

The food materials which were not manageable by 6 ant individuals were transported by active participation of many ant individuals where ants were seen to change their position at frequent intervals from pulling to pushing or vice versa activities. In cases of transport of a heavier food element where space for the required number of ants was not available a few ants were seen to move from the front side to the back or lateral sides to act as pusher. As there were no room for their position it was seen that each one of such workers tried effectively to find the space to bite the food matter with a view to push the same forward. Besides, it was also seen that the ants never failed to accommodate themselves at the definite location or site of the food element so as to ensure the movement of the said element which was snagged for the time being.

DISCUSSION

It appears that, ants left no option to transport the food material to the destination site. Depending upon the size/weight of the food to be procured the strategy applied varied to a great extent. As regards to a manageable food particle to be transported by a single ant the lifting option is unique. There exists no dispute regarding safe transportation of the said food particle. The immediate second option i.e. the pulling strategy emerged for transportation of a food particle slightly heavier than that one considered to be transported through lifting strategy. This stimulated us to think over the problem that the ant being a tiny creature at the bottom of the ladder of evolution is able to exercise its intelligence not only to estimate the weight of the food particle but also to select a second device i.e. pulling to enable her to carry the same. The climax of ant's intelligence in transporting food material perhaps, attained in developing the art of application of both the strategies i.e. pushing and pulling alternatively by the same ant individual. This indicates that the ant have developed the art of applying pulling and pushing strategy alternately perhaps to overcome the impact of hurdle to carry the same alone. Therefore, she applied both the strategies to dislodge the snagged item. It is really cumbersome and stressful for an ant to carry a food item in such a way. But, even such being the case no consideration was taken into account for the help from other ant individual. That is, perhaps, up to such weight (or size) it is the task of an individual ant to manage the food item to carry the same to the nest as the energy to be spent by another ant in transporting the said item is not permissible so far cost benefit effect is concerned.

However, such behavioural adaptation is equally befitting in case of cooperative transport. Because, in cases of transporting a food item by two ant individuals the puller and pusher are also habituated to change their position to act as puller and pusher from time to time in course of carrying act. It is most likely that the ants have developed a communication system in respect to behavioural change from pusher to puller among themselves. Though frequent deadlock with no forward movement are the characteristic features of uncoordinated transport (Sudd 1965; Moffett 1986, 1992, Pratt 1989) random changes in the composition, orientation or behaviour of the group members are proved effective to resolve the deadlocks (Sudd 1965). But, in the present study it is noted that the change of place by the members of the cooperative transport group is not random at all, rather judicious. Because, involvement of 4, 5 or 6 ants in transporting a food item revealed the placement of individuals at various points to dislodge the snagged matter. This indicates that the ants are able to realize the hurdle induced problem in respect to barrier inhibiting the movement of the food item. This could be well judged from the fact of attempts of the ants to accommodate themselves almost forcibly because of lack of space, at particular sites of the food material which is being transported to the nest.

Thus, it appears that cooperative transport is a reflection of self learning behaviour of individual ant, of course, in a

coordinated way to ensure supply of food to the colony members both qualitatively and quantitatively. Though it is possible to meet the food demand of the colony members qualitatively on way of food collection by the ants individually there exists no possibility to provide food to the colony members from qualitative view, for certain ant species. To ensure the same cooperative transport is inevitable and thus was evolved.

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