



Pitfall Traps: A Novel Method to Study Approaching Time of Ant Species

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ABSTRACT

Ant fauna is probably the most dominant social organism in terrestrial ecosystems, which have more sense to approach the prey items. Normally, people scold the various ants for the sense of prediction of sugar or other food items in our domicile. Among the ant species, sensation may be varied. The present study revealed the abundance and diversity of ant species and their relation to the approaching time of the pitfall traps. Totally, eight species were recorded which is belonging to the sub-families of Formicidae (56%), Myrmicinae (33%), and Dolichoderinae (11%). In pitfall traps, *Camponotus chromaiodes* (69%) and *Camponotus floridanus* (39%) were high abundances in a two-hour duration. The *Oecophylla maragdina* was highly abundant in the four-hour duration. *Monomorium minimum* occupied 50 % of the total ant occupancy during a six-hour duration. *Camponotus consobrinus* and *Camponotus compressus* showed the highest abundance in the 24-hour duration of pitfall traps. The percentage of species assemblage was significantly varied among the various hours in all the species. Similarly, all the species varied significantly over time. The study concludes the abundance of ant fauna in pitfall traps was indirectly related to the attraction of pitfall traps by the ant. In diversity, indices showed not a greater variance among the different hours studied. This study brings to a close that the specific species study of Ant fauna needs to be apprehensive about the specific time of pitfall traps for sampling.

Keywords: Pitfalls, Ant, Abundance, Diversity indices, Duration.

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INTRODUCTION

Ants are vital components of the ecosystem not only because they constitute a great proportion of animal biomass but also because they are ecosystem engineers [1]. They are further significant in modifying the physical and chemical environment and can cause collision among plants, microorganisms, and other soil fauna [2]. Ants achieve a variety of roles, such as herbivores, predators, scavengers, seed dispersers, plant and arthropod mutualists, and soil engineers [3] and good indicators of the ecological condition [3, 4] for many reasons, such as they are diverse group, sensitive to environmental change, easily collected and assist in important ecological functions [5].

Ant fauna is social organisms which are having more sense to predict and approach prey items as well as pitfall traps. Usually, people scold the various ants for the sense of prediction of sugar or any other food items in our domicile. The sensation competence may be varied among the ant species. Pitfall trapping is the most common method for the collection of foraging arthropods, including ants, in areas of natural sciences [6]. It is less expensive and less laborious and is self-operating, sampling around the clock. It can better estimate the ant species richness and assemblage structure [7, 8], particularly in open habitats [9]. Pitfall traps are very efficient for the collection of ground-dwelling ants, particularly in low-leaf litter areas [10-12].

However, technical features of pitfalls should also be taken into account for maximizing capture competence, such as the diameter and depth of the collecting container, the liquid content [6, 13], the use of a cover (6) and bait [14], and trap design [6, 13]. Ant captures may be further biased depending on the ants' locomotion, activity, and avoidance of traps [15]. A bias in pitfall-trap catches due to their installation has also been reported [16], known as the digging-in effect [17].

Pitfall sampling is efficient for the estimation of the relative abundance of foraging ant species [18] as it captures both individuals and species in large numbers, hence making statistical analysis possible [19]. Few studies revealed various aspects of pitfall trap sampling for the collection of ant fauna. Pekar [20] has revealed the differential concentration of preservatives and detergents on the catching efficiency of active surface arthropods by pitfall traps. Cheli and Corley [13] tested four designs of traps, six types of preservatives, and different times of activation, as well as the number of traps for identifying the best pitfall, traps for surface or ground-dwelling arthropods. Lasmar *et al.* [21] have evaluated the effect of pitfall trap installation on ant sampling. Taken together, understanding the foraging behaviors and food preferences of ants is crucial in pest management because it helps to locate nest sites, provide cues for effective bait preparation, and determine an ideal time to manage the ants [22, 23].

Species vastly differ in their Cuticular Hydrocarbon composition, but also within species, C.H.C. profiles vary among individuals of different sex, caste, fertility, age, health state, etc. This variation has been intensely studied, especially in eusocial insects like ants, where differences are likely to have a signaling function [24]. Previously did not study the above aspects and sensations of ants, and this is the first study that revealed the pitfall approaching the time of various ant fauna. So, the present investigation carried out an aspect of pitfall traps approaching or attraction time by the various ant species. It may give a good podium of ideas about the approaching time of specific species of ant fauna for future researchers.

MATERIALS AND METHODS

Study area

The study was Mannampandal Panchayat, Mayiladuthurai District, Tamil Nadu, India, and is located between 11° N latitude and 79° E longitude. The place is 28 km away from the Bengal Sea (Tranqubar) at an elevation of 19 m S.L. and 278km away from Chennai, the Capital of Tamil Nadu. It is also a part of the Cauvery delta region in the South-Eastern in alluvial plains. The entire belt is dominated by farming activity, and the site selected has vegetable crops and few common trees. The study was carried out from December 2018 to March 2019 on the basis of twice in a week.

Pitfall trap

The pitfall trap technique [13] suggested measuring the ant fauna over a study period in the study area by simple trap design (i.e., without funnel and roof). A pitfall trap can be any small container placed in the ground with the top level with the surrounding surface and filled with a preservative and sugar solution. The pitfall traps liquid was prepared by using a mixture of 16 ml of 10% formaldehyde and 4 ml of 10% glucose solution.

A total of 20 pitfall traps were installed in an intervals of 5 meters and 10cm depth for each trap. Randomly selected traps were removed (5 numbers) for quantifying and qualifying the ant fauna from the field for intervals of 2, 4, and 6 hours. The remaining undisturbed traps were kept for 24 hours duration for the fulfillment of the study. The captured specimens in each trap were counted and then identified by an updated checklist of ants in India [25] and by the expert.

Statistical analysis

The collected data on every observation of each target species were entered and summarized in each observation-wise into an excel file. Hour-based (2hrs, 4hrs, 6hrs, and 24hrs) diversity indices and abundance were calculated by the statistical software of *PAST 3.0*. Species relative abundance, species assemblage were compared by Analysis of Variance (ANOVA) among the duration, as well as species by SPSS.

RESULTS AND DISCUSSION

A total of 16,334 individuals were identified, which is belonging to eight species and three sub-families, namely *Formicidae*, *Myrmicinae*

and *Dolichoderinae* (Table 1) during the present study. Over time, there have been progressively a greater number of individuals. Moreover, species richness, dominance index, diversity index, Shannon H' index, and evenness do not show variation among the hours of pitfall trap sampling (Table 2). Species relative abundance of various time intervals, *Camponotus chromaiodes* (69%) were high abundance in two-hour duration followed by *Camponotus floridanus* (39%) and other species in two-hour duration. In a four-hour duration, the arboreal

ant species of *Oecophylla smaragdina* were highly abundant species, and the rest of the species were observed to be less than 25 % of their total population during the study period. *Monomorium minimum* species occupied 50 % of the total ant occupancy during the six-hour interval. Likewise, *Camponotus consobrinus* and *Camponotus compressus* showed the highest abundance in the 24-hour duration of pitfall traps (Figure 1).

Table 1. Checklist of Ant fauna recorded during the study period (n=6)

| Sl. No. | Scientific name | Common name | Subfamily |
|---------|--|-------------------|----------------|
| 1 | <i>Camponotus chromaiodes</i> (Bolton, 1995) | Red carpenter ant | Formicidae |
| 2 | <i>Camponotus consobrinus</i> (Erichson, 1842) | Banded sugar ant | Formicidae |
| 3 | <i>Camponotus compressus</i> (Fabricius, 1787) | | Formicidae |
| 4 | <i>Camponotus floridanus</i> (Buckley, 1866) | Carpenter ant | Formicidae |
| 5 | <i>Monomorium minimum</i> (Buckley, 1867) | Little black ant | Myrmicinae |
| 6 | <i>Oecophylla smaragdina</i> (Fabricius, 1775) | Weaver ant | Formicinae |
| 7 | <i>Solenopsis geminate</i> (Fabricius, 1804) | Fire ant | Myrmicinae |
| 8 | <i>Tapinoma</i> sp. (Foerster, 1850) | | Dolichoderinae |

Table 2. Diversity indices of Ant fauna against different hours of pitfall trap samplings (n=6)

| Diversity indices | 2 hrs. | 4 hrs. | 6 hrs. | 24 hrs. |
|-------------------------|--------|--------|--------|---------|
| Species richness | 8 | 8 | 8 | 8 |
| Individuals | 4627 | 8893 | 11516 | 16334 |
| Dominance index | 0.14 | 0.17 | 0.14 | 0.14 |
| Simpson Diversity Index | 0.85 | 0.82 | 0.85 | 0.85 |
| Shannon H' Index | 1.98 | 1.92 | 2.00 | 1.98 |
| Evenness | 0.9 | 0.85 | 0.92 | 0.9 |

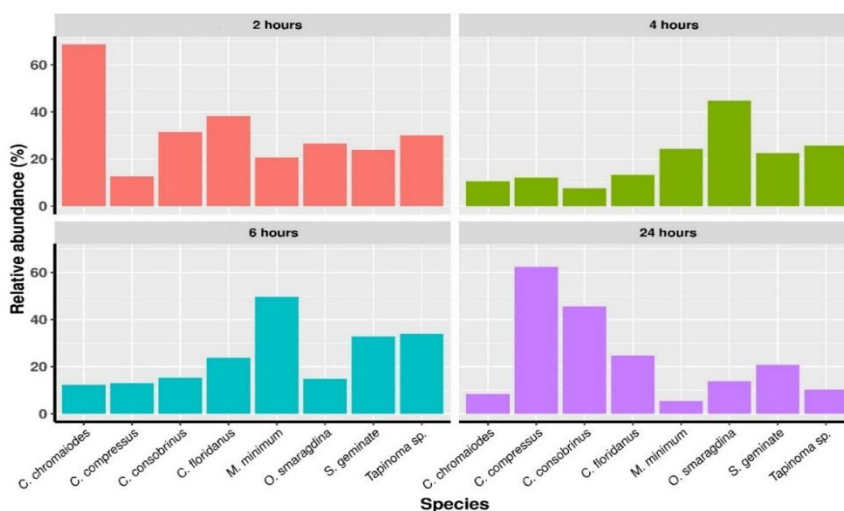


Figure 1. Percentage of relative abundance of Ant species in different hours during the study period (n=6)

The percentage of species assemblage significantly varied among the species at every

time interval. In the two-hour interval, species assemblage was significantly varied among the species, in which *Camponotus chromaiodes* (27%) showed the highest percentage, followed by *C. floridanus* (15%), *C. consobrinus* (13%), *Tapinoma* sp. (12%), *O. smaragdina* (10.52%), *S. geminate* (9.48%), *M. minimum* (8.19%) and *C. compressus* (4.96%) (F=181; p<0.01). *O. smaragdina* (28%) was the highest percentage in four-hour pitfall traps, followed by *Tapinoma* sp. (16%), *M. minimum* (15%), *S. geminate* (14%), *C. floridanus* (8%), *C. compressus* (8%), *C. chromaiodes* (7%) and *C. consobrinus* (5%)

(F=158.8; p<0.01). In six hours, the duration of pitfall traps showed the highest percentage in *M. minimum* (25%), trailed by *Tapinoma* sp. (17%), *S. geminate* (17%), *C. floridanus* (12%), *C. consobrinus* (8%), *O. smaragdina* (8%), *C. compressus* (7%) and *C. chromaiodes* (6%) (F=153.6; p<0.01). In 24 hours, pitfall traps showed the highest proportion in *C. compressus* (33%), followed by *C. consobrinus* (24%), *C. floridanus* (13%), *S. geminate* (11%), *O. smaragdina* (7%), *Tapinoma* sp. (5%), *C. chromaiodes* (4%) and *M. minimum* (3%) (F=213.9; p<0.01) (Table 3).

Table 3. Percentage of species assemblage in different hours of pitfall traps (n=6).

| Species name | 2 hours | 4 hours | 6 hours | 24 hours |
|-------------------------------|----------------------|---------------------|---------------------|---------------------|
| <i>Camponotus chromaiodes</i> | 27.3 ± 0.53 | 6.6 ± 0.61 | 6.2 ± 0.55 | 4.4 ± 0.51 |
| <i>Camponotus consobrinus</i> | 12.5 ± 0.33 | 4.7 ± 0.70 | 7.8 ± 0.38 | 23.9 ± 1.26 |
| <i>Camponotus compressus</i> | 5.0 ± 0.61 | 7.5 ± 0.64 | 6.7 ± 0.75 | 32.6 ± 0.53 |
| <i>Camponotus floridanus</i> | 15.2 ± 0.60 | 8.3 ± 0.38 | 12.1 ± 0.28 | 12.9 ± 0.69 |
| <i>Monomorium minimum</i> | 8.2 ± 0.44 | 15.1 ± 0.28 | 25.4 ± 0.45 | 2.9 ± 0.28 |
| <i>Oecophylla smaragdina</i> | 10.5 ± 0.39 | 27.8 ± 0.55 | 7.6 ± 0.69 | 7.2 ± 0.55 |
| <i>Solenopsis geminate</i> | 9.5 ± 0.39 | 14.0 ± 0.67 | 16.8 ± 0.45 | 10.9 ± 0.55 |
| <i>Tapinoma</i> sp. | 11.9 ± 0.47 | 16.0 ± 0.53 | 17.4 ± 0.28 | 5.3 ± 0.38 |
| F & (p) Value | 181.0 (0.000) | 158.8(0.000) | 153.6(0.000) | 213.9(0.000) |

The percentage of species assemblage was calculated on an hourly basis for the contribution of ants in pitfall traps. Every species considerably fluctuated throughout time, showing both positive and negative population trends. Six of the eight species show significantly differed over the different time

periods. *Camponotus compressus* and *Camponotus consobrinus* have an increasing trend over time. On the other hand, *Camponotus chromaiodes*, *Monomorium minimum*, *Oecophylla smaragdina*, and *Tapinoma* sp. showed a declining pattern in relation to the time duration of the study period (Figure 2).

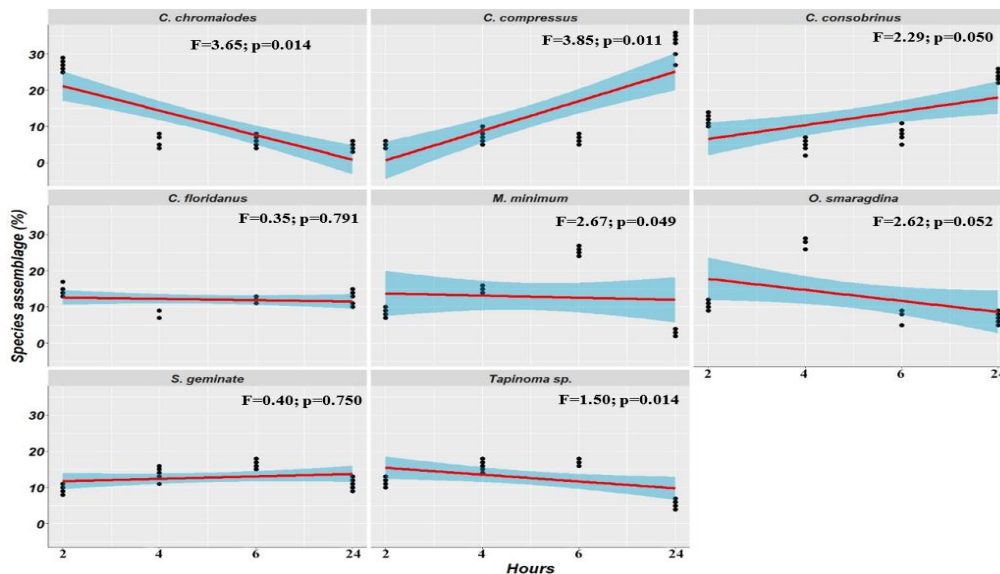


Figure 2. Relationship between species assemblage and time duration of pitfall during the study period.

The present investigation revealed the species-specific pitfall trap attraction by the ant fauna by using abundance and diversity in different hours of pitfall trap sampling. Ant fauna is eusocial organisms which are having more sense to predict and approach food items as well as pitfall traps. People frequently chastise ants for sensing the presence of sugar or other foods in our homes and foretelling their arrival. The reason is the study was initiated and successfully carried out. The sensation competence may be varied among the ant species. The pitfall traps sampling method was used and is a cost-effective and easier method to do research in the field of Entomology as well as Arthropods. Previously there was no study in relation to pitfall traps approaching time, and it was firsthand information. It is directly discussed with the pitfall traps approaching time by the various species of ant fauna. Even though the foraging patterns and food preferences of ants also influence the course of time to approach the pitfall traps [26]. This study revealed that there is no change in diversity indices and a great variation among the individuals and species assemblage during the different hours of pitfall traps. Similarly, Dornelas *et al.* [27] did not detect a systematic loss of α diversity. However, community composition changed systematically through time, in excess of predictions from null models. The *Camponotus chromiodes* and *Camponotus floridanus* were recorded maximum abundance in two hours, followed by 6, 4, and 24 and 24, 6 and 4 hours duration of pitfalls traps sampling, respectively. It also indicated that *C. chromiodes* and *C. floridanus* have more sense in predicting food items other than the species. Nest mate recognition is helped to identify the food items of the colony in a short duration of time. It is also due to the nest mate behavior of ants, and the particular species of ants have more nestmate recognition. In social behavior, nestmate (N.M.) recognition is especially important for establishing and maintaining discrete societal boundaries for *C. floridanus* and many other species of ant [28]. *Camponotus consobrinus* and *Camponotus compressus* recorded high abundance in 24 hours, trailed by 2, 6, and 4 hrs and 6, 2, and 4 hrs duration of pitfall traps, respectively. It also indicates that, less sense to approach pitfall trap sampling due

to the less sensation.

Oecophylla smaragdina was recorded maximum in 4 hours followed by 2, 6, and 24 hrs. This may be due to the nest mate recognition being medium to approach the other entire individual to the pitfall traps in a short time. Previously a study indicated that C.H.C. of the particular species acts as a chemical messenger. The major cuticular hydrocarbons such as Hexadecane, Octacosane, Octadecane, 9-ethyl-9-heptyl, Heptacosane, Eicosane, 9-octyl, and Pentatriacontane. These cuticular hydrocarbons might be acted as a chemical messenger between the ant colony, nest, and nest-mate recognition of the weaver ant *O. smaragdina* [29].

Monomorium minimum, *Solenopsis geminata*, and *Tapinoma* sp were the highest abundance in six hours duration, followed by 4, 2, and 24 hrs and 2, 4 and 24 hrs duration of pitfall traps, respectively. The four and six hours pitfall trap sampling indicates that a moderate approach might be having these types of ants species. Generally, the ant species approach the pitfall traps varying among the species. It might be due to the concentration of the preservatives mixed in the pitfall traps. Subsequently, the concentration of the preservatives was evaporated in the course of time extended for sampling. Pekar [20] studied the differential effects of formaldehyde concentration and detergent on the catching efficiency of surface-active arthropods by pitfall traps. In contrast, studying the pitfall traps approaching the time of the ants need to be known about the foraging activities of ants. In this aspect, a few studies revealed that the daily foraging activities of *Tapinoma indicum* and *Linepithema humile* were negatively correlated with temperature and positively correlated with relative humidity. Therefore, more ants foraged during nighttime because of lower temperatures and higher relative humidity [30, 31].

Brindis *et al.* [32] have revealed that the medium workers of *S. geminata* exhibited a high trail-following behavior as well as a high antennal response to Dufour gland secretion. This and their relative abundance in field foraging areas suggest that medium-sized workers specialized in foraging activities. In this present investigation, the initial high capture could be a result of various reasons. Pitfall

installed near the nest, already the particular species have territory near the pitfall, and pitfall solution concentration may be attracted by the species. Later hours have high capture could be a result of some reasons like pitfall preservatives concentration and environmental gases that may be influenced the solution and turn over an attractive aroma of the particular ant species. Moreover, the later hour of pitfall traps has lower capture might be indicated various reasons like depletion of population and untraced odor for the particular species of ant. According to Greenslade [33], the initial high captures could be a result of pitfall penetration in nest galleries, environment exploration by ants learning different parts of the territory, and/or traps installed on the ants' trail; and the subsequent decrease during the pitfall operating time could result from depletion of populations. In addition, the output of CO₂ from dug soil may attract foraging invertebrates in the early stages of pitfall operation [34, 35]. Sure to explain the present study will give an idea to the researcher to do the research without wasting time on the specific species of ant and invest considerable time in exploring the fine point of the technique in order to become proficient.

CONCLUSION

The study concluded that the specific pitfall installation found various ant species. That is, *Camponotus chromiodes* and *Camponotus floridanus* were highly sensitized at 2 hours duration. *Camponotus consobrinus* and *Camponotus compressus* recorded high abundance in 24 hours duration of pitfall installation. *Oecophylla maragdina* was recorded maximum in 4 hours duration. *Monomorium minimum*, *Solenopsis geminata*, and *Tapinoma* sp were the highest abundance in six hours duration of pitfalls. From this, the specific species need to be the specific duration of pitfall traps. This study also recommends that the research community is to be implemented for further studies on ants, and it should give more accurate and ultimate results.

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