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Viyolla Mendonce
Inspire fellow-DST, National Bureau of Agricultural Insect Resources, Bellary road, Bangalore 560 024, Karnataka, India

Abraham Verghese
GPS institute of Agricultural Management, Peenya, Bengaluru 560058, Karnataka, India

Reddy MS
Department of Zoology, Bangalore University, Bangalore 560 056, Karnataka, India

Correspondence
Viyolla Mendonce
Inspire fellow-DST, National Bureau of Agricultural Insect Resources, Bellary road, Bangalore 560 024, Karnataka, India

Co-existence among nectar feeding ant species: A case study on three flowering plants

Viyolla Mendonce, Abraham Verghese and Reddy MS

Abstract
The foraging activity of six ant species *viz. Camponotus sericeus, Camponotus parius, Tapinoma melanocephalum, Paratrechina longicornis, Solenopsis geminata* and *Myrmecaria brunnea* were recorded on three flowering plants namely *Tecoma capensis, Scaveola taccada* and *Woodfordia fruticosa*. On *S. taccada* there was significant positive relationship (at p=0.05) between *C. parius* and *C. sericeus* (0.223), between *T. melanocephalum* and *C. parius* (0.362) and also between *C. sericeus* and *S. geminata* (0.261). On *T. capensis* there was significant positive relationship only between *C. parius* and *P. longicornis* (0.226) while the foragers on *W. fruticosa* did not show similar trends. Temporal displacement among the ant species, and the abundant resources enhanced co-existence among ant species leading to absence of interspecific competition among the ants.

Keywords: Ants, Biodiversity, *Scaveola taccada, Tecoma capensis, Woodfordia fruticosa,* temporal portioning, co-existence

1. Introduction
Research on the taxonomy of ants, their biodiversity and social life are available, but information on co-existence among ants in a microniche and analogous conservation are limited. Interactions among species that are dependent on the same sources are very important in deciding the structure of a naturally occurring community. While resources are limited, closely related species share the existing resources by an intricate process of resource partitioning, resulting in co-existence where one species does not compete with the other. The limiting resource can be pictured as a pie and each species utilising one fraction of the pie by using different fractions or even using the same fraction but at different spans of time [1]. The two major hemispheres of a niche consisting of food and shelter are interrelated over yet another important aspect, time [2, 3]. Co-existence by means of sharing the limited resources promotes the long-term sustenance of both species, which otherwise would bring in competition, and local displacement of species. The affinity of ants to the sweet nectar secreted by numerous plants has been well studied. Ants are also known to tend homopterans on the plants where they feed on the honey dew excreted. In a faunistic study, four ant species on three plants were frequently encountered and collected. It was felt that, a long term study with regular sampling could elicit interesting ecological dimensions of invertebrates normally overlooked. In this study therefore, four ant species were studied to understand their co-occurrence in space and time and to understand their efficiency in resource utilisation.

2. Materials and methods
One of the prerequisites for the study was that the host plants or the area needed to be free of insecticides. Hence, a pesticide-free biodiversity park was selected. The study was carried out from October 2013 to September 2014 in a 10-acre peri-urban garden situated at 13°06′50″N 77°35′54″E, in outskirts of Bengaluru, Karnataka, India. The garden had more than 120 species of plants of various growth stages. Three perennial plants namely *Tecoma capensis, Scaveola taccada* and *Woodfordia fruticosa* were closely monitored for ant activity based on previous presumptions. All the three subject plants were at proximity of 10 mts of each other. There were five individual shrubs of *W. fruticosa* and *S. taccada* and seven of *T. capensis*. The plants were healthy, well watered and flowering lusciously. Samples of the ant species were collected curated and identified upto the species level before the start of the observations to avoid destructive sampling.

Both flowering and non-flowering (vegetative) shoots were considered in sampling the plants.To keep the observations unbiased, the units/ side branch or shoot for sampling were picked from the whole plant based on random table number (for example, if the first random table number was 5, then multiples of two were taken and the 10th, 15th, 20th… shoots were selected for sampling) as explained by Southwood [4]. Ten such sampling units/plant/species formed the sampling plan. From the 10 sampling units (n) per species of plant sampled on every alternate day of the week, in a span of 12 months, and 116 days of sampling, 3480 units were sampled. Counts of all the species of ants seen on the flowering and non-flowering shoot both on were taken.

Tecoma capensis

Scaveola taccada

Woodfordia fruticosa

The data on the total number of ants were first tabulated and subjected to correlation analysis with 'r' as the test criterion at p=0.05. The ants that showed positive significant trend in occurrence were subjected to a 2x2 contingency table, based on the presence or absence of ant species on the plants as explained in Southwood [4] (significant associations at p=0.05). Species X was the more abundant and species Y was the less abundantly occurring ant species in the association. The χ^2 (chi-square) was calculated using the following equation to determine whether the null hypothesis of independence be accepted or rejected.

Table value for χ^2 at 5%, one degree of freedom is 3.84 and calculated value above this was significant according to Southwood [4].

3. Results

Table 1: Species richness on the subject plants

	Ant species					
Plant species	***C. sericeus***	***C. parius***	***T. melanocephalum***	***P. longicornis***	***S. geminata***	***M. brunnea***
T. capensis	✓	✓	✓	✓	-	✓
S. taccada	✓	✓	✓	✓	✓	✓
W. fruticosa	✓	✓	✓	✓	✓	✓

A total of six ant species *viz. Camponotus sericeus, Camponotus parius, Tapinoma melanocephalum, Paratrechina longicornis, Solenopsis geminata* and *Myrmecaria brunnea* were seen on the three plants. All the ant species had their nesting sites in close proximity to the plants (within 25 sq mts). On *S. taccada* and *Woodfordia fruticosa* the species richness were six, while *Tecoma capensis* had five species (except *S. geminata*) visiting it (Table 1).

Table 2: Correlation coefficients 'r' between ants on *S. taccada*

Ants	*C. sericeus*	*C. parius*	*T. melanocephalum*	*P. longicornis*	*S. geminata*
C. parius	0.223*				
T. melanocephalum	0.095	0.362*			
S. geminata	0.261*	-0.082	-0.077	-0.028	
M. brunnea	-0.048	-0.017	-0.020	-0.041	0.168

*Significant at p=0.05

Coefficients correlation 'r' matrix calculated among the ant species recorded on *S. taccada*. Showed that there was significant positive relationship (at p=0.05) between *C. parius* and *C. sericeus,* between *T. melanocephalum* and *C. parius* and also between *C. sericeus* and *S. geminata.* The other ant species did not show significant trends (table 2). Among these, associations between *C. parius* and *C. sericeus* and between *C. sericeus* and *S. geminata* were non significant though they showed the same temporal trends. Positive significant association between *C. parius* and *T. melanocephalum* was recorded on *S. taccada.*

Table 3: Interspecific association of ants on *S. taccada.*

Interspecific associationof ants on *S. taccada*		**Components of the contingency table**				**χ^2 value**	**Type of association***
Species X	Species Y	a	b	c	d		
T. melanocephalum	*C. parius*	12	14	17	73	**6.61***	ad>bc
C. sericeus	*C. parius*	14	12	32	58	2.108	--
C. sericeus	*S. geminata*	3	1	43	69	0.904	--

*χ^2 > 3.84 at p=0.05

Table 4: Correlation coefficients 'r' between ants on *T. capensis*

Ants	*C. sericeus*	*C. parius*	*T. melanocephalum*	*P. longicornis*
C. parius	0.132			
T. melanocephalum	0.046	-0.153		
P. longicornis	0.013	0.226*	0.019	
M. brunnea	-0.101	-0.098	-0.080	-0.036

*Significant at p=0.05

Similarly coefficients correlation 'r' matrix was calculated between the ant species recorded on the *T. capensis*. There was significant positive relationship (at p=0.05) only between *C. parius* and *P. longicornis* and they had a positive association.

Table 5: Interspecific association of ants on *T. capensis.*

Interspecific associationof ants on		Components of the contingency table				χ^2 value	Type of association*
Species X	Species Y	a	b	c	d		
C. parius	*P. longicornis*	4	0	30	82	**6.77***	ad>bc

*$\chi^2 > 3.84$ at p=0.05

The coefficients correlation 'r' matrix was calculated between the ant species recorded *W. fruticosa*. No ant species showed significant trends in occurrence on the plant.

Table 6: Correlation coefficients 'r' between ants on *W. fruticosa*

Ants	*C. sericeus*	*C. parius*	*T. melanocephalum*	*P. longicornis*	*S. geminata*
C. parius	-0.123				
T. melanocephalum	-0.153	-0.174			
P. longicornis	0.035	-0.108	0.145		
S. geminata	-0.030	-0.074	-0.055	-0.036	
M. brunnea	-0.061	0.060	-0.118	-0.052	-0.035

All 'r' values were non-significant and hence the association study was not done.

4. Discussion

The shrub *S. taccada* showed high activity of *C. sericeus, C. parius* and *T. melanocephalum*. The shrub, also called the half flower is a hand-fan shaped flower with open nectaries. The nectaries of this plant are rich and support many pollinators [6]. The easily accessible nectarines offered adequate nectar to the ants. Here three ant species showed positive significant correlation among them indicating spatial co-occurrence (table 2). Among these, *T. melanocephalum* and *C. parius* had significant positive association (table 3) indicating co-existence and resource sharing [5]. Here, positive trends of *T. melanocephalum* and *C. parius* was seen as both ant species were foraging on floral nectarines. They were found together on a flower, hence the positive association was recorded (Table 3) indicating interspecific tolerance without competition as the resources were abundant. They were recorded on the same day and showed dynamics and trends traced on a same time scale. The presence of both these ants during the same span could possibly bring in competition between them but in actuality, they co-existed and foraged on the same plant hence potential aggression or temporary displacement was not evident.

Tapinoma melanocephalum is an opportunist ant in feeding. It is known to utilize available resources (both feeding and nesting) to the best of its advantages even when resources are scanty [7]. Its small body size (1.3mm - 2 mm) may have served positively by going unnoticed during foraging. Ants were seen patrolling all over the plant not only exploiting nectaries of flowers, but also feeding on plant exudates and the exudates oozing from dead insects preyed by *S. geminata*. Therefore, this foraging diversification has also contributed to avoidance of competition between the two species, hence the positive association.

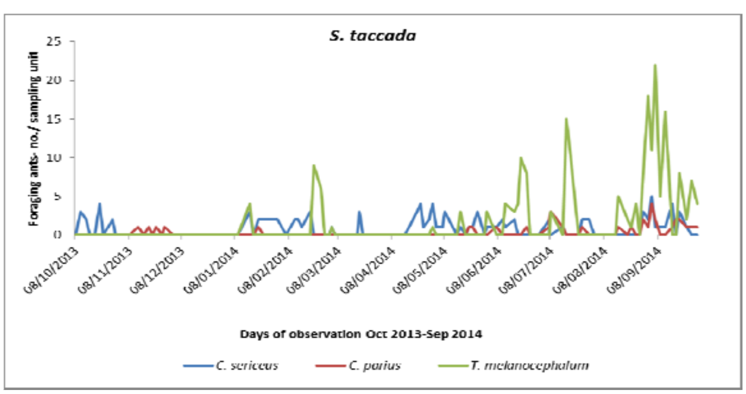

Fig 1: Foraging activity of ants *C. sericeus, T. melanocephalum* and *C. parius* on *S. taccada*

There were significant positive trends between *C. parius* and *C. sericeus* and between *C. sericeus* and *S. geminata*. Co-occurrence of these two ant species might have occurred by chance as their associations with each other were not positive.

Apparently, the *C. sericeus* and *C. parius* were seen foraging on the flowers and the *S. geminata* was found patrolling over leaves and on the shoots. This niche diversification led to no association in spite of positive correlation. *Myrmecaria brunnea* and *C. sericeus, C. parius* and *S. geminata,* and *C. parius* and *M. brunnea* showed negative significant correlation as they were displaced temporally (being present in the absence of the other ant species) on the plant. There was no competition for resources by any ant species.

Tecoma capensis hosted five species of ants on it, among which, *M. brunnea, C. sericeus, C. parius* and *T. melanocephalum* were recorded regularly. The plant is known for its rich floral nectaries and hence the common name honey-suckle [8]. Colonies of aphids (*Aphis gossypii*) infesting the plant also served as source of honeydew for the ants, nevertheless, the nectarines of the plant served as a better and higher source of food for the ants. The ants were seen to occupy or forage at alternate sources during the regular observations. Only *C. parius* and P. *longicornis* showed positive correlation with each other. The occurrence of *P. longicornis* was not as much as the other four ant species. In the vagrant visitations that occurred, it showed positive association with *C. parius* as they shared floral nectarines without ant signs of competition.

This was possible as *T. capensis* produced surfeit amounts of nectar in the bright floral clusters. When densities vary, though correlated, competition is ruled out when one species is lower in number. Thus *P. longicornis* is less likely to be a competition for resources with other ants. Further, each plant supports numerous nectarines and shoots which is an unlimited source of nectar.

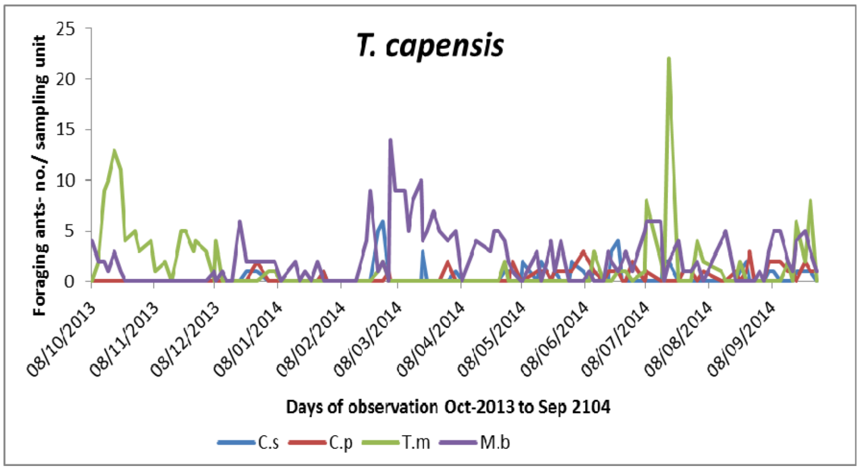

Fig 2: Foraging activity of ants *C. sericeus, T. melanocephalum*, *C. parius* and *M. brunnea* on *T. capensis*

The graph above shows temporal partitioning of the ant species *C. parius, T. melanocephalum C. sericeus* and *M. brunnea* on *T. capensis.* However, the few coincidences in occurrence could be due to harvesting of different resources as discussed earlier. Although extra floral nectar has been found to attract different species of insects and arthropods (e.g., parasitoids, predatory mites, spiders), in most cases it seems to be specially designed to attract ants, whose feeding ecology and behaviour fit very well with the plants defensive needs [9-11]. While the *T. melanocephalum* and *M. brunnea* were often found at the flowers, the other two ant species of genera *Camponotus* foraged on other shoots or patrolled on the plant (figure 2). These might have occurred on different sampling units or on the same, mutually sharing the plentiful nesting resources at different vertical strata on the shrub [12]. Perhaps the study of nectaries and characterisation of nectar in *T. capensis* will clearly reveal the affinity of ants to the plant and the services they render in return for the sweet treats they obtain. The present observation was in disagrees to the findings of Gordon and Sanz [13], that colonies spaced at close proximity indicate competition.

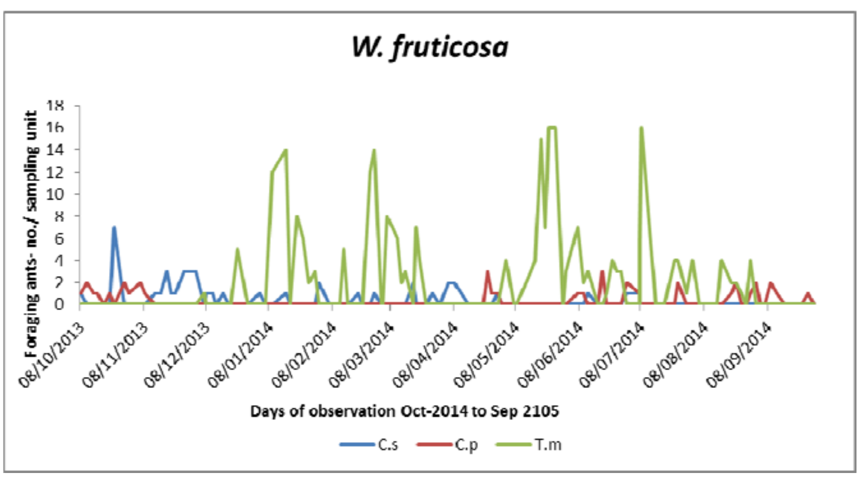

Fig 3: Foraging activity of ants *C. sericeus, T. melanocephalum* and *C. parius* on *W. fruticosa*

Woodfordia fruticosa showed high occurrence indices for *C. sericeus, T. melanocephalum* and *C. parius* on them. The bright fiery red flowers bear nectaries which are excellent sources of rich sugars for the ants. This plant is endemic in India [14]. The flowering on *W. fruticosa* is so intense on the plant that the plentiful resource does not need to be competed for as habitat and dietary overlap of lifeforms are the primary mechanisms due to which competition occurs [15]. There are records in literature of the flowers secreting high amounts of water and nectar (12.5 mg/flower) consisting of fructose and glucose. *Apis dorsata, A. cerana*, wasps, and many ants and flies visited the flowers for nectar as per records of [16]. These studies were in agreement with observations of Bettiga [17], where ant biodiversity in a grape horticultural ecosystem was sustained as there was sharing of resources, niche partitioning and avoidance of competition among the *Formica* spp, *Cardioconyla* sp, *Tetramorium* sp, *Paratrechina* sp, *Prenolepis* sp, *Pheidole* sp and *Solenopsis* sp.

Nectar feeding ants hence exploit flowering plants at different time spans utilizing available resources as per their colony requirement and avoid competition among them (figure 3). Similar reports on resource sharing and niche partitioning were explained in higher vertebrates in studies by Davies and Houston [18]. This strategy is hence explains of ant colony survival in both densely and sparsely vegetated area, for example the *T. melanocephalum* being less selective in food choices can find or exploit a resource more efficiently, These develop or reproduce more rapidly, increasing the use of resources efficiently [19, 20] and hence are favoured under many circumstances. The plentiful flowers bearing nectaries, seeds and extra floral nectaries might have served as enough resource to avoid competition as explained in studies conducted in grape ecosystems where abundant resources sustained diverse ant species without competition for resources [21, 17]. These factors can be further utilized in understanding the complex intricacies that aid in ant colony survival.

The above study indicates that in a floricultural ecosystem free from pesticides, several ant species can co-exist utilising plant resources for feeding and nesting. Ants are a numerically less dominant biota compared to the more numerous and voluminous flora that support a large number of flowers and nectarines. Spatially, for an ant species varying from an few millimetres to about a centimetre in length, the floral resources are unlimited considering the plant sizing up to eight or ten feet with approximately 100-200 flowers. Hence the ants forage freely without dicplacing or competing with each other for a common niche and that the ant species co-exist. The study further indicated that biodiversity of ants can be increased by planting suitable flora and avoiding pesticidal use that kill ants.

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