Ants of Bangalore with special reference to invasive ants

A Thesis

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by

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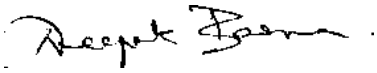
Certificate

This is to certify that this dissertation entitled "Ants of Bangalore with special reference to invasive ants" towards the partial fulfillment of the BS-MS dual degree programme at the Indian Institute of Science Education and Research, Pune represents study/work carried out by Kiran R at Indian Institute of Science, Bangalore under the supervision of Prof. Raghavendra Gadagkar, Centre for Ecological Sciences, during the academic year 2019 - 2020.



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This thesis is dedicated to

My family, friends and lab mates

Declaration

I hereby declare that the matter embodied in the report entitled “Ants of Bangalore with special reference to invasive ants” are the results of the work carried out by me at the Centre for Ecological Sciences, Indian Institute of Science , Bangalore, under the supervision of Prof. Raghavendra Gadagkar and the same has not been submitted elsewhere for any other degree.

Kiran R

Date: 8.4.2020

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Abstract

In this study the distribution of ants across different habitats in the Bangalore Urban area with special reference to invasive ants was observed. 24 sites which cover a wide variety of habitats were sampled. 61 species of ants belonging to 24 genera and 6 subfamilies were recorded from all localities and habitat types. Ant species diversity was the highest in places with more green cover. It was observed that the Invasive ant species ratio was higher in places with a lot of human activity compared to other sites There is a lack of literature dealing with distribution of invasive ants in Bangalore. We hope that this study will lead to a lot more studies in this field.

Acknowledgments

I thank Prof. Raghavendra Gadagkar for giving me a chance to work in his lab and for his continued guidance throughout the thesis. I thank Dr. Thresiamma Varghese for training me with various ant capturing techniques, identification of specimens, and also for valuable suggestions and feedback. I thank Dr. Rajbir Kaur for assisting me in some of the field trips. I thank Dr. Harini and Enakshi for their help with planning. I thank Dr. Deepak Barua for being a TAC member. I am grateful to all the members of Prof. Raghavendra Gadagkar's lab for their help and support. I was supported by a DST-Inspire scholarship during the tenure of the project.

Chapter 1 Introduction

Ants are eusocial insects of the Formicidae family under the order hymenoptera which also includes their related wasps and bees (Schultz, 2000). They are one of the most diverse and successful animal groups with more than 16,000 species known (www.antweb.org). The earliest fossil records of ants were found to belong to the Cretaceous period depicting an earlier origin (Grimaldi and Agosti, 2000; Wilson and Hölldobler, 2005). The only places which lack an indigenous ant species are Antartica,Iceland,Greenland, and some other remote islands. The ant population is so huge that it may constitute upto 15 - 20% of total biomass on land (Schultz, 2000). These tiny organisms achieve this feat in no small part due to their team effort. The parallels between human and ant social order has long since piqued the interests of scientists, which led to people working on them (Hou 2016).

The documentation of ants in south India was started by Jerdon (1851,1854) and was later supplemented by Forel (1900a,1900b,1901). Shortly after that Bingham (1903) made a complete list of Indian ants available at that point by including all the available data. Down the line, mention of Indian ants can be found in Asian ant checklist prepared by Chapman and Capco (1951). Later ant diversity of western ghats has been studied by Gadagkar et al., (1993)(140 species belonging to 6 subfamilies and 32 genera), and Narendra et al., (2010). A region wise genera list of ants in India was prepared by Guenard et al., (2010)(86 genera for India) for their studies in global generic richness and distribution in Asia. Bharti et al., (2016)(828 species belonging to 100 genera) provided the history of Indian ant documentation.

A preliminary list of ants in Bangalore was provided by Kumar et al., (1997)(75 ant species belonging to 33 genera and 6 subfamilies). Savita et al., (2008)(51 ant species from 7 subfamilies) studied the ant distribution and abundance across disturbance gradients in and around Bangalore city. For the ant species found in IISc, a preliminary study was conducted by Gadagkar et al.,(1997),(70 ant species belonging to 32 genera and 6 subfamiles) and later a checklist was made by Varghese (2003)(95 species,42 genera,8 subfamilies). An updated checklist is available at http://ces.iisc.ernet.in/thresi/AntsofIISc.htm. All of these studies gave a list of ants in various parts of Bangalore but none of them has been concerned about the distribution of invasive ants across habitats.The focal point of my study is to look at how distribution of ants, especially invasive ants vary with habitat.

Invasive species status is given to those species which are introduced from outside the geographical region under consideration and has established a reproductive population within the geographical region under consideration, and has negative impacts on biodiversity/ecosystem functions and services/economy, health, social, and cultural system.Invasive ants species are a subset of introduced ant species (Hollway et al., 2002). There are a number of characteristics shared by most invasive ant species which might give them an advantage over native ant species (Hollway et al., 2002). The aggressive behaviour and large scale forager employment helps the invasive ants in monopolizing resources (Hollway et al., 2002). Unicoloniality tends to be over-represented in invasive ant species. Holldobler and Wilson (1997) suggested that in the case of some invasive ants unicoliniality plays an important role in establishing their dominance

Invasive species is one of the major threats to biodiversity. Major threats to biodiversity can be represented by the acronym HIPPO (HIPPO – Habitat loss, Invasive species, pollution, Human population, overharvesting). The direct threats posed by invasive species include predation risks on native species, overexploitation of resources, disease risks, and limiting reproduction of native species. Invasive species may also cause denial of ecological services previously provided by the native species they have displaced.

According to the global invasive database (IUCN GISD) under IUCN, there are 8 invasive ant species in India. They are *Anoplolepis gracilipes, Trichomyrmex destructor, Monomorium floricola, Monomorium pharaonis, Paratrechina longicornis , Solenopsis geminata, Tapinoma melanocephalum* and *Technomyrmex albipes.* According to Bharti et al.,(2016) there are 24 non-native species in India. Some of the species listed above as invasive are not listed under non-native in Bharti et al.,(2016). Though there is an incongruity, we will use invasive species under IUCN for the purpose of the study. We would like to state that it is important for invasive ants databases to be up to date (Gruber et al., 2017)

Objectives

The objectives of the study are:

(i) How ant species composition varies across habitats?

(ii) How invasive ant species varies across habitats?

(iii) Are there any particular habitats favored by invasive ants?

(iv) Are there any habitat preferences for native ants ?

Chapter 2 Pilot study

A two month pilot study was undertaken in the IISc campus to familiarize myself with collection methods, identification procedures and to check the appropriateness of various methods in the future study. The first step was collecting ants from around the campus. Ant species identification was done using (Bolton, 1994) and taxonomic keys available for ant species in IISc campus. The identification process of ants was one of the most important steps since it was a novel subject for me. It made collection a lot easier and reduced the time taken for subsequent identifications. After the training two quadrats were selected in IISc campus and sampling was performed using five different methods which are commonly used for sampling ant fauna.

Quadrat Sampling: 100 m x100 m plot was divided into 10 m x 10 m quadrats and two quadrats were randomly selected for sampling (quadrat #42 and #57)

Sampling methods: The following 5 different methods (Hölldobler and Wilson, 1990) were used for sampling in each quadrant and their efficiency was compared later.

AOS: All out search. An intensive physical collection of as many species of ants as possible in a 10 m x 10 m plot . The search was done for 2 hours each in the morning from 8.00 to 11.00. The smaller ants are easy to miss while sampling.Since it is an active sampling method the yield is largely dependent on the sampling effort.

Net sweep: Net sweep was done to collect samples from grass and lower vegetation.The net was made out of thick cotton cloth and had a diameter of 30 cm at mouth and bag length of 60 cm. The ants collected were transferred into an eppendorf tube with 70% alcohol. Net sweep was done for a set amount of swings or time . Net sweep was always done between 13:00 and 16:00.

Bait trap : Honey spread in the center of a 5 sq.cm paper was used as a bait trap. Bait trap was checked every 15 min for 2 hr from 14:00 to 16:00. Total of 8 Bait traps were used per quadrat. Ants collected will dependent on the type of bait used.

Pitfall traps (Fig.2.1): 12cm x 6cm x 6cm box was used as pitfall traps. Pitfall traps contained alcohol solutions with detergent to trap the ants. 4 pitfall traps were used per quadrat. Pitfall boxes were dug in level with the ground level and leaves and soil were used to mask the edge of the box. Pitfall traps were laid in the afternoon and were collected the next day morning.

Winkler (Figs. 2.2-2.4): The soil with leaf litter from the quadrant is sifted using a soil sifter and the sifted soil is collected in a cotton bag. The sifted soil is transferred to inklet bags in the lab and is placed inside a winkler sac. A small plastic bottle with 70% alcohol is placed under the winkle sac to collect the ants which escapes to the bottom of the winkler sac. The plastic bottles with alcohol were collected after 48 hours. Mostly small ants are collected by this method.

Fig 2.1: Pitfall trap. The container used in the study was different

Fig 2.2: Inklet bags

Fig 2.3: Soil sifter

Fig 2.4: Winkler sac with inklet bags

Photo credits: Thresi

Since the Winkler method and pitfall trap methods are destructive, they are done after sampling by other methods were done.

Sample preservation: All samples collected from various methods were stored in a 5ml or 15ml glass vial with 70% alcohol. They were sorted later and except some genus, all other samples were identified upto species level.

Results

The ant fauna collected from IISc, Bangalore from various sampling methods and all out search consists of 5 subfamilies, 21 genera and 35 species (Table 2.1). This is quite different from the results of Varghese (2003) and Gadagkar et al. (1997). Since the collection from IISc is done as a training, the entire campus was not covered for sampling which may also be a reason for the decrease in species collected.

Table 2.1: Ants collected from IISc campus

Subfamilies	Genera	No of species
Ponerinae	*Diacamma*	1
	Leptogenys	2
	Pachycondyla	1
Myrmicinae	*Aphaenogaster*	1
	Carebara	1
	Crematogaster	1
	Lophomyrmex	1
	Myrmicaria	1
	Pheidole	4
	Solenopsis	1
	Tetramorium	1
Pseudomyrmecinae	*Tetraponera*	2
Dolichoderinae	*Tapinoma*	2
	Technomyrmex	1
Formicinae	*Acropyga*	1
	Anoplolepis	2
	Camponotus	5
	Lepisiota	3
	Oecophylla	1
	Paratrechina	2
	Plagiolepis	1
Total 5	**21**	**35**

Comparison of sampling methods: Of the 5 sampling methods used in quadrat sampling, including all out search(AOS), AOS was the most successful method followed by pitfall trap, Bait trap and net sweep (Fig 2.1). I couldn't conduct winkler in quadrant #42 because there were no leaf litter in that quadrant.The species found through AOS and bait traps were mostly the same. There was hardly one or two

unique species found through other methods when compared with all out search (Fig 2.2).

The proportion of invasive ants to native ants are as shown in figure 2.3. It is observed that except the bait and Winkler methods, other two methods sampled invasive ants also in lesser or more proportion. All out search along with pitfall trap were the preferred as the sampling method for the main sample collection as the most successful methods in trial study. But due to some technical reasons only all out search was used as the sampling method in the main study. Nevertheless AOS seems to be the best method to sample diverse and unique ant fauna as evident from the data shown in figure 2.1 and 2.2.

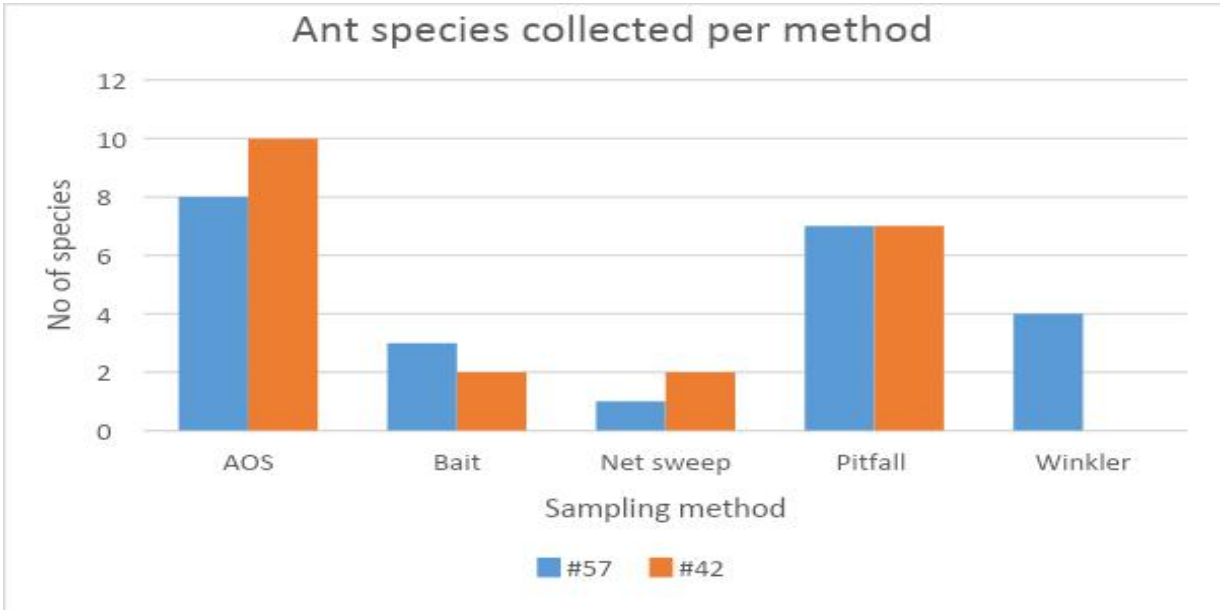


Fig 2.1: Ants collected through various sampling methods in Campus

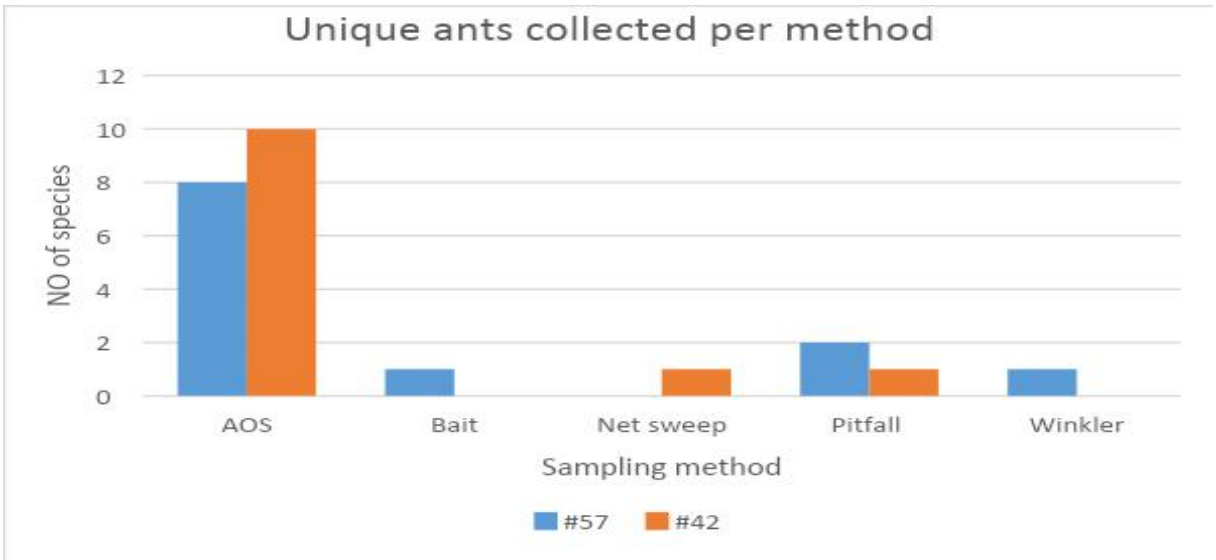


Fig 2.2: Unique ant species collected through different sampling methods

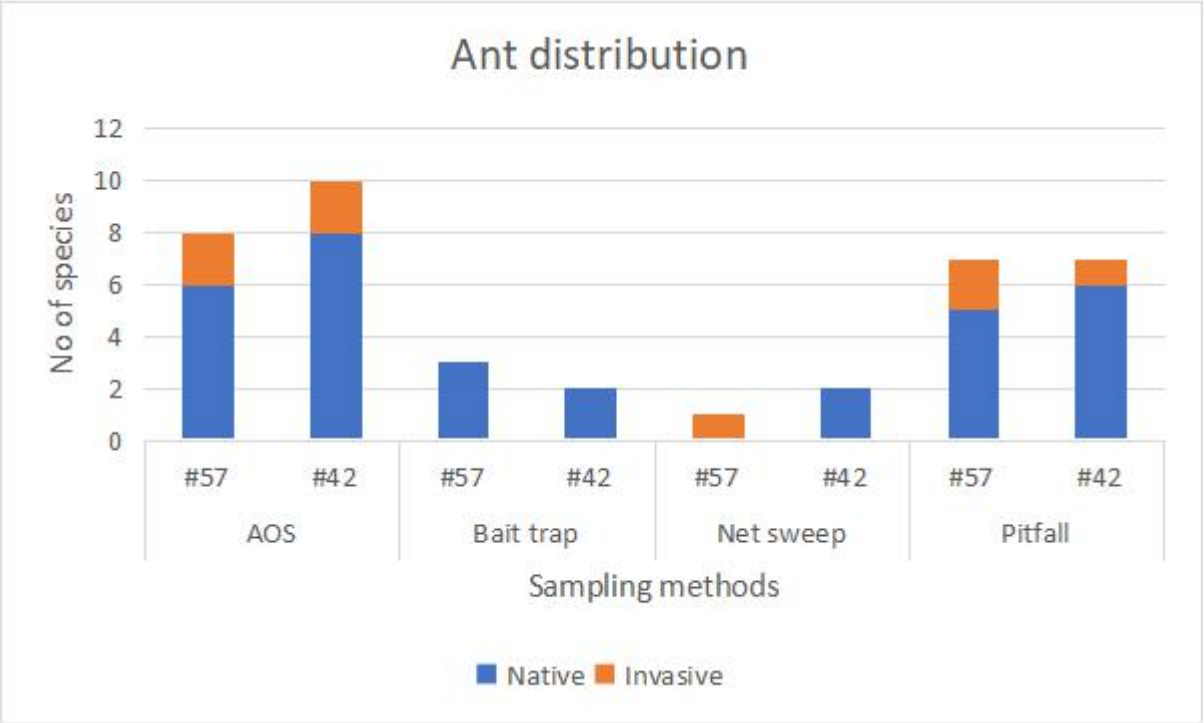


Fig 2.3: Ants sampled using different methods arranged according to their native or invasive nature

Chapter 3 Study sites

After the training in ant collection methods, preservation techniques and identification procedures I had expanded my study into a broader scale. With the knowledge gained from the pilot study and considering the suggestions and comments received from research guides I had made the following plan of sampling.

For this study 8 different habitat types were selected and 3 sites within each habitat type were sampled, for a total of 24 sites. The habitat types were selected such that it covers as many different habitat types as possible (Table 3.1). All sites were selected in the Bangalore urban area. All sites were sampled once for 4 hours.The sampling was done between 9:00 and 15:00. All-out search was selected as the sampling method for collection. The sampling was mainly done from September to February (Table 3.2). The following are the definitions of various habitats.

Table 3.1: Definitions of habitat types

Habitat type	Description
Parks	Public park owned by local councils
Footpath	Public walkways
Grounds	Sand/soil lands used for playing cricket or football by institutions
Plantations	A large piece of land with only one type of tree
Residential area	A Place which houses buildings for individuals or families for their private use.
Market	An area where purchase and sale of the provisions, livestock and other commodities are conducted
Institutional buildings	Buildings of an organization founded for an educational,religious, professional, or social purpose.
Unmanaged plots	A small area of land with a little or no vegetation

Under each habitat type 3 sites were chosen for sampling and they are as shown in table 3.2.

1. **GKVK Campus:** A 1200 acre campus with moderate levels of vegetation and a lot of buildings which are far apart.
2. **Bangalore university:** A 840 acre campus with closely placed buildings, lawns and some large trees.
3. **Ramiah college:** 25 acre campus with a lot of roads and buildings and some small lawns. The vegetation is inferior to the 2 universities above in terms of number and age of trees.
4. **Jakkur unmanaged plot:** A small plot of land filled with bushes and some trees, a small walkway is formed through the middle of the plot
5. **Unmanaged plot near railway ground:** The plot is largely barren with a lot of dry leaf litter. It shares one of the boundaries with the road, there are a few trees on the boundaries of the plot.
6. **Unmanaged plot near Malleswaram ground:** Large portion of the plot is barren without any leaf litter and has a sole tree near one of it's boundaries.
7. **Gymkhana:** It has an area of standard football ground. Though the majority of the land is covered in sand there are lush grass patches growing from one of the sides.
8. **Playground near wood institute:** A regularly used ground which only has a mix of sand and soil.
9. **Malleswaram ground:** This is a stadium and the land consists solely of sand.
10. **Jubilee garden**: It is an acacia plantation. There is also some undergrowth and has a lot of leaf litter.
11. **GKVK mango garden:** Mango trees are growing closely and there are some thick growing plants in the understorey to the point it is difficult to see the ground.
12. **GKVK mango plantation:** Mango trees are planted quite far from each other. The ground is tilled.
13. **Hebbal market**: A short street with wayside stores selling groceries, electronic items and food items. No vegetation except the grass lawn quite far from the street.

14. **Malleswaram market:** A bustling market with a lot of stores on either side of a large road for more than 500m. The stores range from grocery to fashion products.
15. **Yeshwantpur market:** This market which mainly focuses on grocery and local products. This place is quite busy with a continuous influx of people.
16. **Footpath near tollgate**: Paved footpath with little to no vegetation.
17. **Footpath near KVPY gate:** Footpath with paved and unpaved regions. No vegetation.
18. **Footpath near Sankey tank:** Paved footpath on either side of a bridge.
19. **Cubbon park:** 120 ha park with a lot of lawns and trees.
20. **Lal Bagh:** With an area of 97 ha it contains various types of flowering plants, trees and some lawns.
21. **Sankey tank park:** It is a small park compared to Lalbagh and Cubbon park. It has jogging tracks, exercise equipment, and some plants along the road. It is part of a man-made lake. It also has a region with a lot of trees.
22. **Houses Near Tatva:** These are housing complexes built for families and the surrounding area is filled with leaf litter.
23. **Houses Near Gymkhana:** Dormitories made for students and the surrounding region has a lot of dry leaf litter.
24. **Houses Near Tollgate:** Houses built by private owners. The region has a few trees but no other vegetation.

Table 3.2: Study sites, plots and sampling dates

Habitat type	Plot	Date of collection	Coordinates	Distance covered approx. (in m)
Institutional campus	GKVK Campus	18.11.2019	13.072595,77.592418	4,000
	Bangalore university	26.11.2019	12.974438,77.583238	2.000
	Ramaiah college	7.1.2020	13.030426,77.564877	500
Footpath	Footpath near Tollgate	4.1.2020	13.017790,77.560937	100
	Footpath near KVPY gate	10.1.2020	13.012792,77.568005	200
	Footpath near Sankey tank	13.1.2020	13.007934,77.572541	200
Grounds	Gymkhana			
	Playground near wood institute	30.10.2019	13.015164,77.561539	100
		28.10.2019	13.011090,77.569368	100
	Malleshwaram ground	14.2.2020	12.997254,77.568940	100
Market	Hebbal market			
	Malleswaram market	12.2.2020	12.997072,77.570022	100
	Yeshwantpur market	18.2.2020	13.002983,77.571268	200
		7.2.2020	13.020818,77.554024	250
Parks	Cubbon park			
	Lal Bagh	30.8.2019	12.976355,77.592876	1000
	Sankey tank park	28.11.2019	12.950845,77.584630	2000
		2.3.2020	13.009079,77.572610	500
Plantations	Jubilee garden			
	GKVK mango garden	7.11.2019	13.022890,77.566777	300
	Gkvk mango plantation	5.9.2019	13.081920,77.564784	300
		17.1.2020	13.076195,77.586532	220
Residential area	Houses Near Tatva			
	Houses Near Gymkhana	22.2.2020	13.025055,77.565912	100
	Houses Near Tollgate	24.2.2020	13.018370,77.563931	100
		25.2.2020	13.019093,77.561678	100
Unmanaged plots	Jakkur unmanaged plot			
	Near railway ground	14.11.2019	13.085301,77.606534	50
	Near Malleshwaram ground	8.2.2020	13.026522,77.551843	50
		16.1.2020	12.997162,77.570044	50

Though the collection spanned on almost 5-6 months, the climate conditions were comparable on the days of collection. During rainy season, collection was done on 2-3 days after rainfall and only once was collection done on the day of slight rainfall.

Plate 1. Study sites

Fig 3.1: Gkvk Campus

Fig 3.2: Bangalore University

Fig 3.3: Ramaiah College

Fig 3.4: Footpath near KVPY gate

Fig 3.5: Footpath near Sankey tank

Fig 3.6: Gymkhana Ground

Photo credits: Kiran

Plate 2. Study sites

Fig 3.7: Playground near Wood institute

Fig 3.8: Malleshwaram ground

Fig 3.9: Hebbal market

Fig 3.10: Yeshwantpur Market

Fig 3.11: Cubbon park

Fig 3.12: Lal Bagh

Photo credits: Kiran

Plate 3. Study sites

Fig 3.13: Sankey tank park

Fig 3.14: Jubilee garden

Fig 3.15: Gkvk Mango garden

Fig 3.16: GKVK mango plantation

Fig 3.17: House near Tatva

Fig 3.18: Housing near Gymkhana

Fig 3.19: Plot near Jakkur

Fig 3.20: Plot near Railway ground

Photo credits: Kiran

Chapter 4 Results and discussions

Ant fauna in Bangalore urban: Ants collected from different habitats across Bangalore by all out search consists of 6 subfamilies, 24 genera and 61 species (Table 4.1). It is comparable to the results from Kumar et al.,1997 (75 ant species belonging to 33 genera and 6 subfamilies) which sampled ants from similar habitats in Bangalore by similar methodology.

The results show that the Institutes and parks were the most species rich habitats among the eight habitat types in this study (Fig 4.1). They were also the places with the most diverse vegetation among the study sites . Kumar et al.,(1997) shared a similar conclusion that ant species richness increases with increase in vegetation. A statistically significant but weak correlation between ant species diversity and plant species diversity was also observed by Gadagkar et al.,(1993) . Myrmicinae and Formicinae are the most species rich subfamilies (Table 4.1). This is in agreement with Savitha et al.,(2008) and Rastogi et al., (1997). It is understandable as they are the largest and second largest subfamilies in worldwide distribution. They also have the highest representation in all of the habitats (Fig 4.2). Dolichoderinae is found in all habitat types, which is different from the findings of Savitha et al.(2008).

Table 4.1: Ants collected from 24 localities in Bangalore by AOS

Subfamilies	Genera	No of species
Ponerinae	*Diacamma*	2
	Leptogenys	3
	Pachycondyla	3
Dorylinae	*Aenictus*	1
Myrmicinae	*Carebara*	1
	Cardiocondyla	1
	Cataulacus	1
	Crematogaster	5
	Monomorium	4
	Myrmicaria	1
	Pheidole	6

	Solenopsis	2
	Tetramorium	3
	Trichomyrmex	1
Pseudomyrmecinae	*Tetraponera*	3
Dolichoderinae	*Tapinoma*	3
	Technomyrmex	2
Formicinae	*Anoplolepis*	1
	Camponotus	6
	Lepisiota	4
	Oecophylla	1
	Paratrechina	3
	Plagiolepis	2
	Polyrhachis	2
Total: 6	24	61

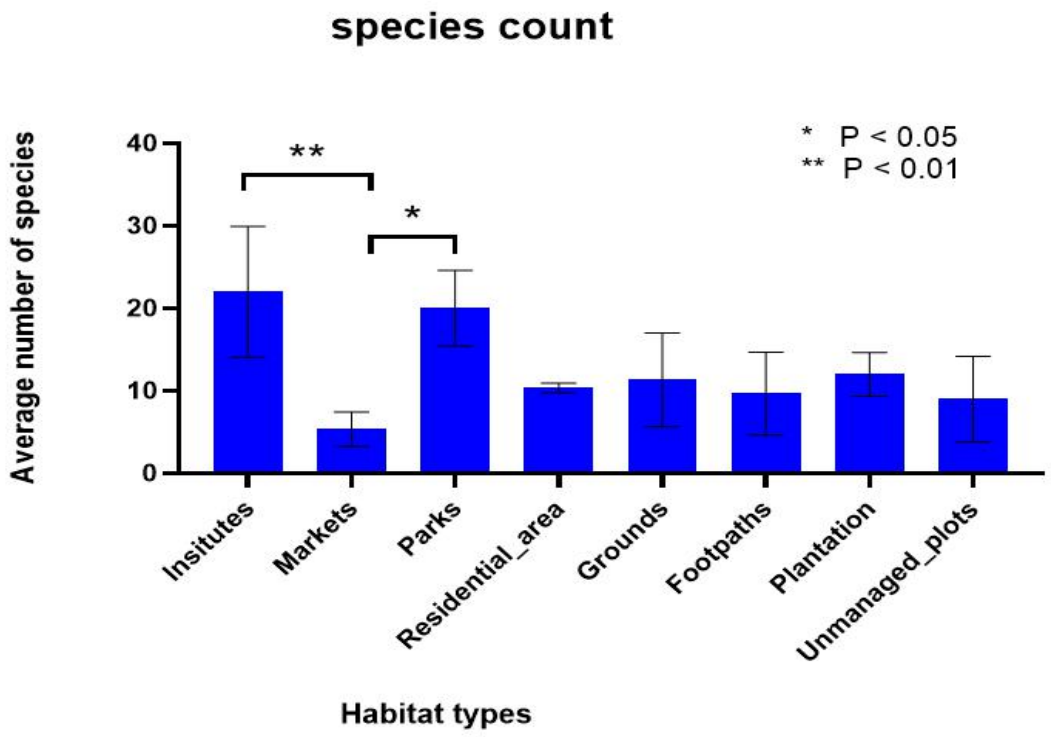


Fig 4.1: Species collected per habitat (Error bars indicate SD)

Tukey's HSD test is used here

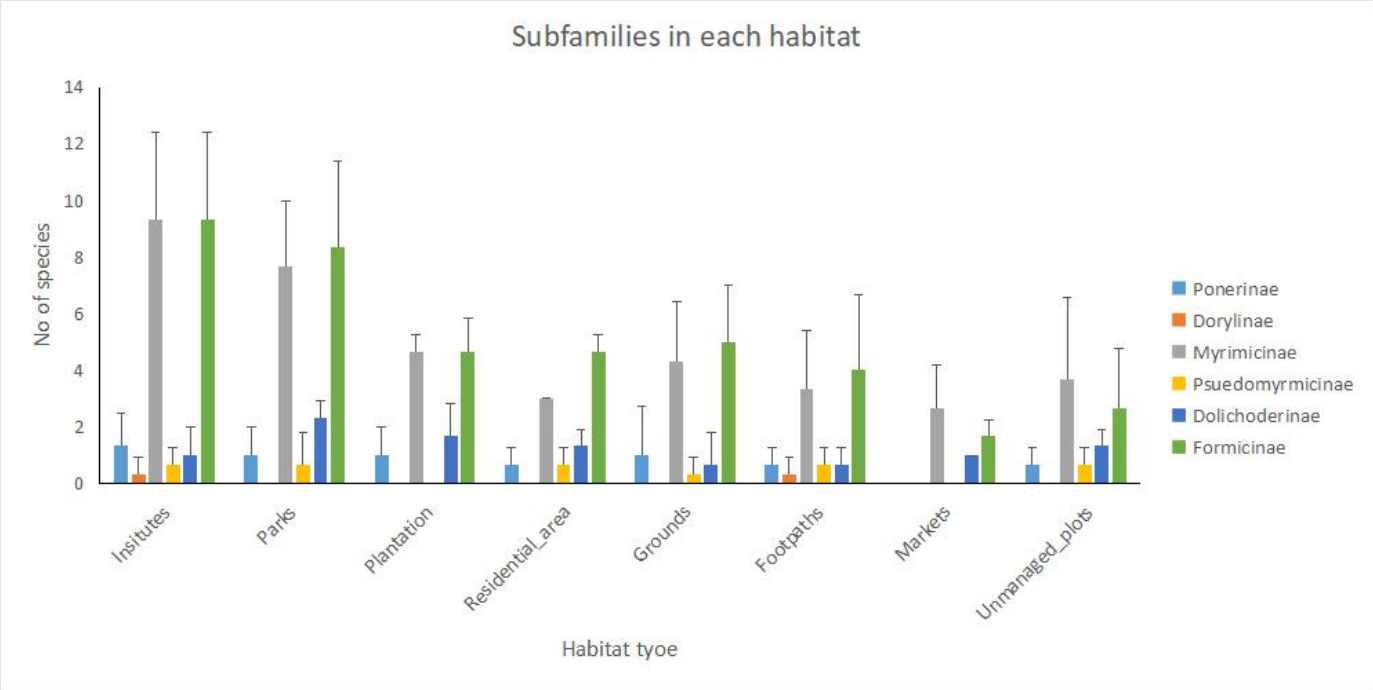


Fig 4.2: Distribution of subfamilies in each habitat (Error bars indicate SD)

The species richness is highest in parks and institutions and lowest in the market. Rest of the habitats have intermediate levels of species richness.(Fig 4.1). All the habitats are dominated by Myrmicinae and Formicinae subfamilies (Fig 4.2), which also contain most invasive species (Table 4.2). The most common genera is *Camponotus* followed by *Paratrechina* and *Pheidole*. *Myrmicaria brunnea* is the most common native ant species found in most number of sites.

For subfamilies present in all habitats, more or less similar subfamily composition is observed. No subfamily which prefers one single habitat over the others was not observed, though Pseudomyrmecinae is not found in all habitats (Fig 4.2).

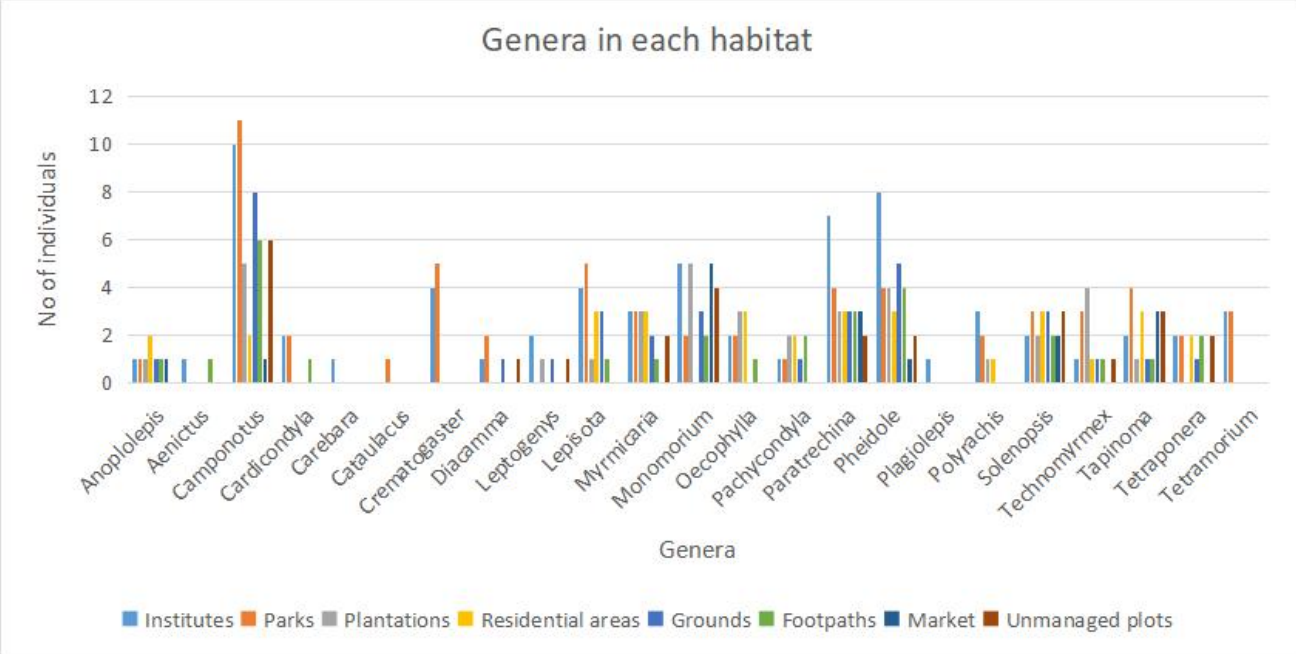


Fig 4.3: Genera variation across habitats

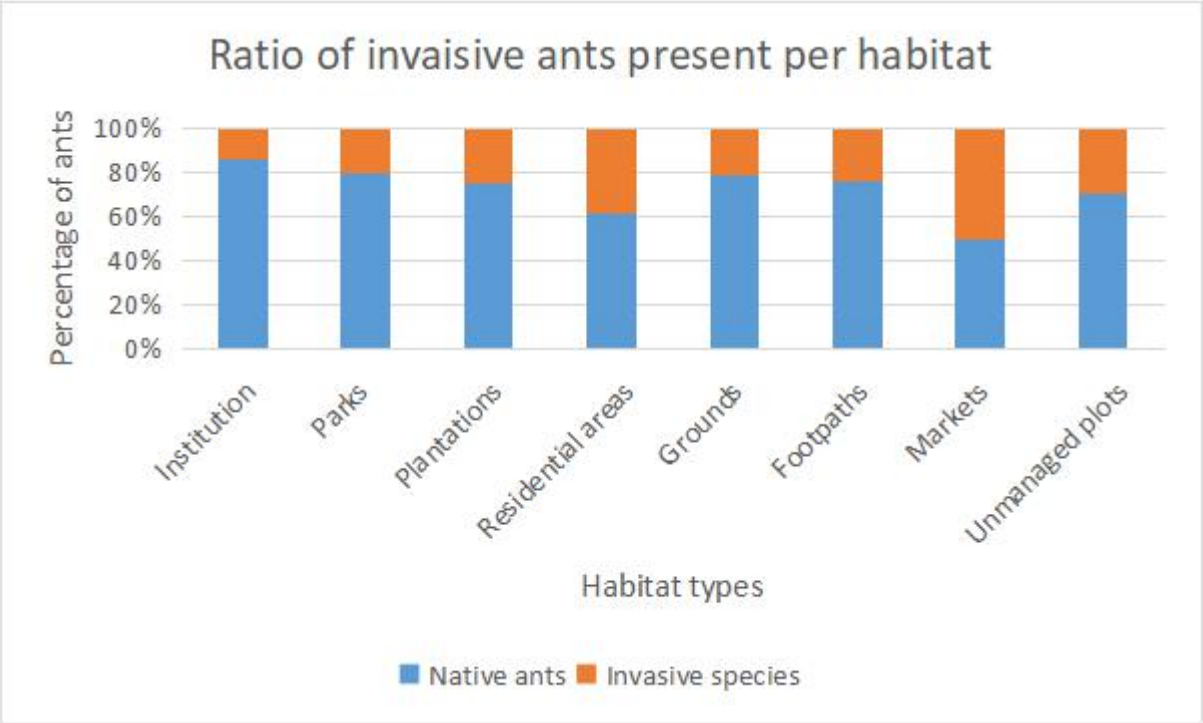


Fig 4.4: Proportion of invasive ants present in each habitat

Seven of the 8 invasive species are found in the study sites. The invasive ant species *P. longicornis* is present in almost all sites, whereas other invasive species such as *S.geminata* and *T.melanocephalum* are present in 2/3rd of the study sites. Markets and the residential areas have the highest ratio of invasive ants in them (Fig 4.4). Rest of the habitats have similar proportions of invasive ants present in them. The higher proportion of invasive ants in the market may be due to higher chances for introduction of species. The markets and residential areas are among the habitats with high human activity. Further study with a lot more sites and sampling methods are necessary to make sure whether invasive ants are more favored in places of high human activity.

In other words, invasive species might be more resistant to disturbances in habitats by humans whereas most of the native species may be less resistant and prefer to inhabit habitats with lesser disturbances. General decrease in ant species richness in regions of increased disturbance is observed by Savita et al.,(2008) and Kumar et al.,(1997).

Table 4.2: Table listing Invasive species sampled and their subfamilies

Subfamily	Genera	Species
Myrimicinae	*Monomorium*	*Monomorium pharaonis*
	Solenopsis	*Solenopsis geminata*
	Trichomyrmex	*Trichomyrmex destructor*
Dolichoderinae	*Tapinoma*	*Tapinoma melanocephalum*
	Technomyrmex	*Technomyrmex albipes*
Formicinae	*Anoplolepis*	*Anoplolepis gracilipes*
	Paratrechina	*Paratrechina longicornis*

The following are some of the common ants encountered in my survey from different habitats.

Plate 4: Common ants of Bangalore

Anoplolepis gracilipes

Aenictus pachycereus

Anochetus graeffei

Aphaenogaster beccarii

Camponotus irritans

Cardiocondyla wroughtoni

Carebara affinis

Cataulacus taprobanae

Plate 5: Common ants of Bangalore

Crematogaster rothneyi

Diacamma indicum

Harpegnathos saltator

Monomorium pharaonis

Myrmicaria brunnea

Oecophylla smaragdina

Pachycondyla crassa

Paratrechina longicornis

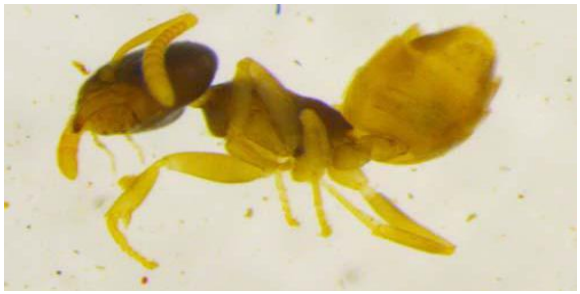
Plate 6: Common ants of Bangalore

Pheidole malinsii

Plagiolepis

Polyrhachis

Solenopsis geminata



Tapinoma melanocephalum

Technomyrmex albipes

Tetraponera rufonigra

Tetramorium walshi

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Conclusions:

As part of the study 61 species from 24 sites were sampled.In my study, I found seven of the eight invasive ant species identified by the global invasive database (IUCN GISD) under IUCN. One thing I noticed is that Invasive ant species are observed in all of the sites, especially *P.longicornis* (observed in 22 out of 24 sites). There were no sites devoid of at least 2 different invasive ant species. Markets in particular seem to have the highest proportion of invasive ants in them. Ants belonging to *Myrmicinae* and *Formicinae* subfamilies were found in all 24 sites sampled.*Dolichoderinae* subfamily which contains only 5 species including 2 invasive species were found in 20 out of 24 sites sampled. Parks and institutes had the highest species richness among habitats sampled, while markets had the lowest. They were also the habitats sporting highest and lowest levels of vegetations respectively. An interesting observation I made is the following, subfamilies can be ranked from high to low on the basis of presence of the subfamily in the habitats, or according to number of species belonging to subfamily in the habitat as Myrmicinae, Formicinae, Dolichoderinae, Ponerinae, Pseudomyrmicinae and Dorylinae, and it holds true for almost all habitats in the study. It is observed that different subfamilies have different realized niches.

As this study only used AOS as the collection method the collection might have missed on smaller ants, also the collection which we use for the analysis represents only a part of the entire ant fauna of the study sites. Using multiple sampling methods and spending more time for collection in future sampling efforts will lead to a more comprehensive documentation of the ant fauna of the study sites.

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