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***Research Article** (Open Access)*

DIVERSITY AND DISTRIBUTION OF HYMENOPTERA (INSECTA) IN THE SREE KRISHNA COLLEGE CAMPUS, THRISSUR, KERALA

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ABSTRACT
The present study was undertaken to survey the diversity of hymenopterans within the Sree Krishna College campus, Thrissur. This study recorded a collection of 265 numbers of specimens and total of 21 species from the 18 genera under six families (Apidae, Formicidae, Vespidae, Halictidae, Ampulicidae and Crabronidae). It was noted that with 11 species Formicidae emerged as the most dominant family followed by Apidae (5 species), Halictidae (2 species), and Vespidae, Ampulicidae and Crabronidae (1 species each). The highest percentage of 52.38 species was recorded from the family formicidae which was followed by 23.81 % in the family Apidae, Halictidae with 9.52 %, and the lowest percentage of 4.76 was recorded in the family Vespidae, Ampulicidae and Crabronidae. The Shannon-Wiener and Margalef diversity indices were H = 2.419 and R = 3.584. Pielou's Evenness was E = 0.7945. The high species diversity observed during the study indicates that the study area is a real bliss for Hymenopteran. This could be due to the undisturbed vegetation and well-maintained horticultural and agricultural ecosystems, which serve as hymenopteran breeding grounds in addition to providing a suitable nectar source throughout the seasons.

Keywords: *Abundance, Diversity, Hymenoptera, Insecta, Species*

INTRODUCTION
Hymenoptera, Ants, bees, wasps, and sawflies, is one of the most species-rich and numerous insect orders (Huber, 2017; Forbes *et al.,* 2018). After Lepidoptera and Coleoptera, Hymenoptera is the third biggest order of insects. Phytophagous insects, social insects, bees, solitary wasps, and parasitoids make up this order (Ovawanda *et al.,* 2016). Approximately 80% of the Hymenoptera genus are parasitoid species based on their natural function. Other species include pollinators, phytophages, and predators. There may be differences in the diversity of Hymenoptera species that live in various environments, particularly with regard to species richness and abundance. According to Goulet and Huber (1993), the order Hymenoptera is separated into two suborders: Symphyta and Apocrita. The suborder Symphyta contains a large number of plant pests. According to Viggiani (2000), the suborder Apocrita contains the greatest number of parasitoids and predatory species that are frequently employed in integrated pest management (IPM). More than 100,000 species have been identified in the order Hymenoptera, which includes some of the most sophisticated and highly specialised insects. It is important to the balancing and functioning of most ecosystems in the planet and most beneficial for the human economy. Bees generate wax and honey in addition to pollinating a variety of crops. Insect pests can be controlled without the use of chemical insecticides by releasing parasitic wasps in large quantities as a bio-control agent. In the Western Ghats' medium elevation wet evergreen forest, bees contributed to the pollination of 18% of 86 species of trees and 22% of the understory shrubs (Devy and Davidar, 2003). Numerous researchers have contributed significantly to our understanding of Hymenopteran groups (Sudheendrakumar, 1994; Narendran and Sheela, 1995; Hayat *et al.,* 2003).

Hymenoptera have a remarkable range of life histories and morphological adaptations, some of which set records among insects. For instance, the fairy wasp of the genus *Dicopomorph*a (Mymaridae) is the smallest insect on Earth (Huber & Noyes, 2013), whereas Darwin wasps of the genus *Megarhyssa* (Ichneumonidae) have the longest egg-laying organ (the ovipositor, measured in absolute size) (Nénon *et al.,* 1997). These two extreme instances share a key life history strategy: they are both parasitoids, which are carnivores who complete their entire life cycle feeding on just one individual prey item, the host (Godfray, 1994) But they have adapted to somewhat varied hosts: *Megarhyssa* is a parasitoid of wood-boring horntail larvae (Hymenoptera: Siricidae), whereas *Dicopomorpha* is an egg parasitoid of bark lice (Psocodea: Lepidopsocidae) (Mockford, 1997) (Nénon *et al.,* 1997). Hymenoptera are able to take advantage of a wide range of host niches through a variety of morphological, physiological, and genetic adaptations (Pennacchio & Strand, 2006). About 70% of all known hymenopterans are actually parasitoids, with the remaining 30% being either predators like many social wasps or phytophages like leaf-feeding and wood-boring sawflies, gall-inducing wasps, and pollen-collecting bees. (Eggleton and Belshaw, 1992; Heraty, 2017). Parasitoidism and its associated traits may be important factors in explaining diversification in Hymenoptera (Whitfield, 2003), as that the adaptation to various host species and consequent niche subdivision may have led to higher speciation rates in parasitoids.

As pollinators, predators, bioindicators, and biocontrol agents of agricultural pests, wasps provide essential ecological services (de Souza et al. 2010; Ferreira et al. 2020). In addition to carrying pollen, bees visit flowers to gather nectar for honey production. By pollinating a wide range of plants, these eusocial, cosmopolitan insects are essential to maintaining biodiversity. Honey-producing bees are vital to humanity for both commercial and biological reasons. Plant-pollinator networks are crucial for the survival of several plant species and the general preservation of ecosystem biodiversity. Because of their remarkable connectivity and wide feeding range, social wasps and bees are unusual in these networks. Unlike many other pollinators that may specialise in certain plants, these insects visit a wide range of flowering species because they are generalist pollinators. Hymenopteran insect biodiversity exhibits a variety of patterns in area and time due to a variety of factors, including local history, topography, species interactions, and climate variations. Despite the ecological significance of hymenoptera, little is known about their diversity and distribution across many environments in this area. In this regard, the goal of the current study was to identify and record the diversity and distribution of hymenoptera on the campus of Sree Krishna College.

MATERIALS AND METHODS

The survey and documentation of Hymenoptera were conducted for a period of eight months, from July 2023 to February 2024. The selected study area is Sree Krishna College Campus which is situated in Thrissur district of Kerala. It is located between 10.6072º N and 76.0881º E with an elevation of 11.13 meters. Total area is 40 acres. For the study the entire campus has been surveyed which offers rural biological characteristics that are conducive to insect diversity because it is surrounded by gardens, grasslands, fruit orchards, and pond ecosystems.

Identification

Field observations were taken during morning hours (08:00–10:00) and evening hours (15:00–17:00), to comprehensively document the maximum finding of Hymenopteran fauna. Most of the hymenopteran species were collected by hand- picking method. Pitfall trap method was used for the collection of ground dwelling species and even sometimes ants. Aerial net was only used to collect flying hymenopterans such as Bees and Wasps. Soon after collecting, multiple photographs of the specimens were taken in the field itself and then they were released back. Later, the photographs were used for the identification based on the standard taxonomic keys available from the literature (Srivastava, 2004; Hook, 2008; Atwal and Dhaliwal, 2010).

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Statistical Analysis

The data analysis discussed in this study includes the abundance of the species (n), the richness of the species (s), the diversity of the species (H) and the evenness of the species (E). Shannon-Wiener was calculated for hymenopteran diversity. Species evenness was calculated by Pielou's evenness and species richness was calculated by Margalef's index. The abundance of the species is the number of individual species found in each site of sampling while the richness of the species is based on the number of species appear in each location of the study.

1. Shannon's diversity index, **$H' = -\sum (pi \ In \ Pi)$**
   where H'= Shannon Index, Pi = Proportion of individuals belonging to the i^{th} species,
   ln =Natural logarithm (natural number)
2. Simpson's value, **$D = \sum ni\ (ni-1)\ /N\ (N-1)$**
   Where ni = the number of individuals of a species N = Total number of all individuals
3. Margalef's index **(R) =S-1/In(N)**
   where R= Margalef's richness index, S= total of species, N= total no of individual sample
4. Berger-Parker's Index **(d)= Nmax / N** or Berger-Parker Compliment index (1-d)
   where N_{max} = the number of individuals in the most abundant species,
   N=total number of individuals in the sample.

The evenness of the species is determined by the Pielou's evenness (J) using the following formula: **J=H/ln(S)**
Where J = evenness; S = the number of species

RESULTS AND DISCUSSION

In this study, a total of 265 individuals were documented, representing 21 species, 18 genera, and six families. The species list and total number of Hymenoptera individuals are presented in **Table 1**.

Table 1: Checklist of Hymenopteran fauna observed in the Sree Krishna College Campus, Ariyannur, Thrissur

Sl No.	Scientific Name	Common Name	Family	Order	Importance	Abundance (Nos.)
1	*Xylocopa aestuans*	Carpenter bee	Apidae	Hymenoptera	pollinators	4
2	*Ceratina sps.*	small carpenter bees	Apidae	Hymenoptera	pollinators	7
3	*Thyreus nitidulus*	Neon Cuckoo bee	Apidae	Hymenoptera	pollinators	4
4	*Apis dorsata*	Giant honey bee.	Apidae	Hymenoptera	pollinator	17
5	*Apis florea*	Dwarf honey be	Apidae	Hymenoptera	pollinator	46
6	*Monomorium pharaonis*	Pharaoh ant	Formicidae	Hymenoptera	Pest	12
7	*Camponotus japonicus*	Japanese carpenter ant	Formicidae	Hymenoptera	Pest	8
8	*Polyrachis rastellata*	Black weaver ant	Formicidae	Hymenoptera	predator	14
9	*Oecophylla smaragdina*	Asian weaver ant	Formicidae	Hymenoptera	Predator	85
10	*Pheidole indica*	Indian Big-headed Ant	Formicidae	Hymenoptera	predator	6
11	*Diacamma intricatum*	Indian queen less ant	Formicidae	Hymenoptera	predator	7
12	*Camponotus sericeus*	carpenter ant	Formicidae	Hymenoptera	predator	12
13	*Anoplolepis gracilipes*	long-legged ant/ yellow crazy ant	Formicidae	Hymenoptera	Pest	9

14	*Plagiolepis sps.*	Restless ant	Formicidae	Hymenoptera	Pest	5
15	*Myrmicaria brunnea*	Hunchback Ant/ Brown Ant	Formicidae	Hymenoptera	predator	4
16	*Polyrachis dives*	Asian Spiny Weaver Ant	Formicidae	Hymenoptera	predator	10
17	*Lasioglossum sps1.*	Sweat bees	Halictidae	Hymenoptera	pollinators	4
18	*Lasioglossum sps2.*	Sweat bees	Halictidae	Hymenoptera	pollinators	3
19	*Rapalidia marginata*	Paper wasp	Vespidae	Hymenoptera	predator	3
20	*Ampulex compressa*	Emerald Cockroach Wasp	Ampulicidae	Hymenoptera	parasitoid	2
21	*Trypoxylon attenuatum*	Slender Wood Borer Wasp	Crabronidae	Hymenoptera	predator	3
						265

Formicidae family recorded the highest number of individuals with relative abundance of 64.91% (172 individuals) followed by Apidae (29.43 %, 78 individuals), Halictidae (2.64%, 7 individuals), Vespidae and Crabronidae (1.13 %, 3 individuals each) and Ampulicidae (0.75 %, 2 individuals) **(Figure 1).**

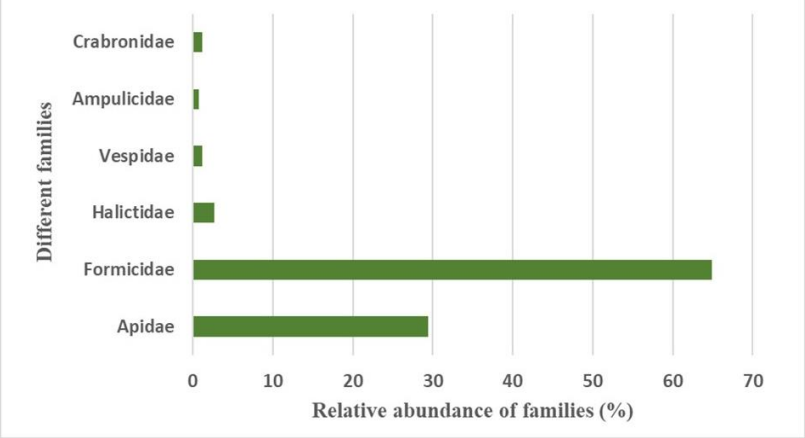

Figure 1: Relative abundance of different families (%)

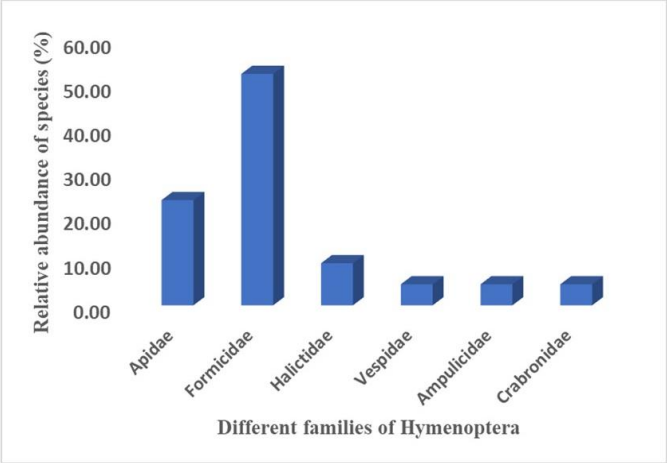

Figure 2: Relative abundance of Species (%)

The data revealed that there is a variation in the number of species among different families, as Formicidae family recorded the highest number with 11 species (52.38 %) and dominated over the other families such as Apidae with 05 species (23.81 %), Halictidae with 02 species, 9.52 %, and Vespidae,

Plate I: Diverse hymenopterans observed in the Sree Krishna College campus

Ampulicidae and Crabronidae with only one species each (4.76 %) (Plate I; Figure. 2). This could be because trees are crucial habitats for the Hymenoptera community in the forest area. According to a study conducted by Budiaman *et al.* (2020), the Hymenoptera diversity found in pine plantation forest, West Java is considerably high even after the thinning of timber, which tends to lower the species composition but not the species abundance and number of individuals. As members of canopy arthropods, wasps, particularly parasitoids, are crucial to the equilibrium of insect populations (Godfray, 1994). Parasitoids are crucial to terrestrial ecosystems because they have a significant impact on herbivore populations (Azhar *et al.,* 2022). Dyer *et al.* (1993) found that lower levels of herbivory are associated with higher levels of plant development, which in turn boosts wildlife diversity. Parasitoid insects are extremely diverse, making up approximately 10% of all known insect species today in part because of their high degree of host specialisation (Santos and Quicke, 2011).

The results of Bharati (2008), who examined the altitudinal diversity of ants in Himalayan regions and identified 199 species, are similar to those of the current study. In the Wayanad region of the Western Ghats, Sabu et al. (2008) investigated the variety of forest litter-inhabiting ants along elevations and

identified 29 ant species from 18 genera and six subfamilies. According to Veena et al. (2018), 35 species from 9 hymenopteran families were found, with the Formicidae family being the most prevalent.

In the present study we also observed the presence of 05 species of Apidae and 01 species of Vespidae families which act as both pollinators and predators, indicating the likelihood of good pollination in the nearby agricultural areas. The abundance of Apidae members recorded in the present study correlates with the presence of a large number of flowering plants in the campus which indicate higher foraging and nesting activity. The campus's massive trees, buildings, and serene surroundings make it the perfect place for bees to create enormous colonies.

A few parasitoids from the Ampulicidae family, which are excellent bio-control agents of lepidopteran eggs and larvae were found in the current study. As a result, the number of dangerous pests of agricultural crops was kept under control. As a result, they are significant natural enemies and crucial elements of Integrated Pest Management (IPM) techniques. Regular surveys of these insects are therefore necessary to preserve their population, which comprises both beneficial and detrimental insects as well as the habitats made up of their host plants. We can plan and adjust our agricultural cultural practices and IPM in accordance with such reports in order to increase crop output.

Based on the diversity profile among sampling site, the Shannon's diversity index (H=2.419), Simpson's Index of Diversity (D=0.8521) and Marg alef's Index, (R=3.584) shows the rich diversity of hymenoptera in the study site **(Table 2)**. The evenness index (J=0.7945) of Hymenoptera community indicating no species dominance in the community (Table 2). This could be the result of favourable weather patterns and the accessibility of natural resources required for their survival. Therefore, comprehensive biodiversity data is essential for assessment and influence on the environment as well as conservation. The high species diversity observed during the study indicates that the study area is a real bliss for Hymenoptera.

Table 2: Various diversity indices of Hymenoptera

Alpha Diversity indices of Hymenoptera	
Number of Taxa	21
Simpson's index, D = ∑n(n-1)/N(N-1)	0.1479
Simpson's Index of Diversity as 1 – D	0.8521
Shannon Diversity Index H = -Σpi * ln(pi)	2.419
Pielou's evenness index J=H/ln(S)	0.7945
Marg alef's Index, R = (S – 1) / In N	3.584
The Berger-Parker Index, d= N_{max}/N	0.3208
The Berger-Parker Index,1/d	3.117

CONCLUSION

This is the first report on the diversity and distribution of Hymenoptera in the Sree Krishna college campus revealed 21 species, belonging to 6 family. The overall study depicts Formicidae is the most dominant family, followed by Apidae, Halictidae, Vespidae, Ampulicidae, and Crabronidae. The study area is full of trees, flowering plants and buildings that offer a tranquil and ideal habitat for a wide variety of insects. This study offers useful baseline data that may be used to implement the appropriate safeguards and actions to preserve the campus's insect diversity.

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