Foraging behaviour of bee species on Prosopis cineraria and Albizia lebbeck in Jaipur tehsil, Rajasthan.

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Abstract: **This study evaluates the foraging behaviour of bee species on *Prosopis cineraria* and *Albizia lebbeck* during of 2021-2023. The experiments and sample collections were carried out in the Jaipur tehsil (District Jaipur) of Rajasthan state and focused on assessing the duration, speed, and rate of foraging activities. Bee species demonstrated the longest foraging duration, beginning at 06:40 AM and ending at 18:00PM. *Apis dorsata* spent the most time in *P. cineraria* among the species examined, whereas *Apis cerana* spent the most time on the flowers of *A. lebbeck*. The study found that variations in foraging behaviour across species significantly affect the efficiency of *Prosopis cineraria* and *Albizia lebbeck* pollination. These insights are crucial for optimizing pollinator management strategies, thereby enhancing crop yields and supporting sustainable agricultural practices.**

Keyword: **foraging behaviour, *Prosopis cineraria, Albizia lebbeck,* pollination.**

INTRODUCTION

The Fabaceae (Leguminosae) family, commonly known as the legume, pea, or bean family, is one of the largest and most economically significant families of flowering plants. Leguminosae or Fabaceae family, with 277 species representing 81 genera, is the second-largest family in our state of Rajasthan. Leguminous plants play a crucial role in agriculture due to their ability to fix atmospheric nitrogen, enhancing soil fertility, and providing a rich source of protein for both human and animal consumption (Pilet-Nayel *et al.,* 2024; Fahde *et al.,* 2023).

The *Prosopis spp.* are amazingly found growing in unfavourable soil conditions and need just a modest amount of moisture to survive (NAS, 1979). Because every plant component of this adaptable tree is used, it is known as the "King of the Desert," the "Golden Tree of the Desert," the "Love Tree," and the "Pride of the Desert." In the months of December and April, the flower's yellow corolla attracts a great number of insects, including a big number of *Apis florea* and many other wild bees (Gorain *et al.,* 2012). There is a racemose spike of inflorescence. Small, regular, bisexual, bracteate, complete, zygomorphic, pentamerous hypogenous, creamy white or yellow, practically sessile flowers appear from March to May following the new flush of leaves, and they are organised in short peduncled axillary panicles.

Albizia lebbeck (L.) Benth. (Fabaceae: Mimosoideas), often known as Indian siris, is significant to humans due to its wide range of applications. *A. lebbeck* has spherical clusters of cream-colored, mimosa-like blooms with long stamens that bloom from April to May on lateral stems. In its native environment, flowering typically occurs between September and October, and ripe pods are accessible from May to July. The entire inflorescence is fluffy, yellow-green, 60 mm in diameter, and fragrant. Both self-pollination and cross-pollination have been identified in *Albizia lebbeck* flowers. The flowers in the area under investigation have been reported to be cross-pollinated by a number of insect species.

In comparison to other animal vectors, insects have significant benefits in pollination. Insects regulate one-third of global agricultural pollination, which yields seeds and fruits. Bees from a colony will visit a huge number of plants across a vast region to collect pollen and nectar (Bashir *et al.,* 2018). Through the four abovementioned ecological regions in the state of Rajasthan, a total of 878 insect species or subspecies that are members of 104 families and 14 orders were documented. Apoidean species, including honeybees, bumblebees, and solitary bees, are among the most effective pollinators due to their ability to navigate intricate flowers and their exclusive diet of nectar and pollen (Anjum *et al.,* 2018). The most common bee species worldwide for bee pollination is the Western honey bee (*Apis mellifera* L.), which serves 34% of request for pollination support throughout the United Kingdom (Stanley *et al.,* 2020). Bees and other pollinators get their energy, protein, and fats from nectar and pollen,

which is why bees are attracted to plants in the first place to feed their larvae (Shrestha *et al.,* 2020).

The number of bees has been declining recently all throughout the planet (Bashir *et al.,* 2020). Numerous factors have contributed, including a lack of high-quality food, human activities such as habitat destruction and fragmentation, climate change, and pesticide usage in agriculture (Potts *et al.,* 2010).

According to Singh *et al.* (2021), *Prosopis cineraria* was visited by honey bees (*Apis cerana indica* and *A. dorsata*), wasps (*Polister spp*.), and lady bird beetles (*Coccinella septempunctata*). In *P. cineraria*, the absence of fruit development during self-pollination showed self-incompatibility.

This study aims to investigate influence of insect pollination in the selected Legumes crops as *Prosopis cineraria* and *Albizia lebbeck* in Jaipur. The proposed experiment is the very beginning of determining the species of bees that actively cross-pollinate Leguminosae crops planted in Jaipur, Rajasthan.

METHODOLOGY

The experiments and sample collections were carried out in the Jaipur tehsil (District Jaipur) of Rajasthan state. Field studies were conducted to determine the diversity of insect pollinators and their foraging behaviour on various legume crops.

Studies in the field

Inspection of pollinators

With the assist of an Olympus binocular with Model Number BINO-1295 made by the Olympus Corporation, 192-85072957 Ishikawa, Tokyo, Japan, the composition of bee species and their diurnal and seasonal manifestation on the diverse cultivated and wild plants were investigated.

Collection of specimens

The collection of bee species feeding on dispersed wild flowering and cultivated plants were conducted using standard 38 cm sweep nets employing the stratified random sample approach. Recently trapped small specimens were preserved with p-Dichlorobenzene and wrapped in tissue paper to preserve them dry.

Abundance of insect pollinators

The total number of insects per metre^2 every five minutes (number of bees/m^2/5 minutes) was used to determine the abundance of insect pollinators. From 6 am to 6 pm, seven days in a row, the field was regularly inspected and the information were gathered at regular intervals of two hours, such as 6 am-8 am, 8 am-10 am, 10 am-12 pm, 12 pm-02 pm, 02 pm-04 pm and 04 pm-06 pm.

Studies in the laboratory

Spreading of specimens

In the laboratory, the collected specimens were categorised according to several taxonomic categories. The specimens' mouthparts were gently stretched to reveal their internal components.

Specimen identification

A stereo zoom microscope was employed for examining specimens that had been preserved. Specimens were identified with the help of taxonomic literature, including Michener's 2007 book Bees of the World and different widespread taxonomic research publications.

Biodiversity assessment

According to Daly *et al.* (2018), the Shannon Index (H) and Simpson Index (D) were used to quantify the biodiversity, a quantitative indicator of species/family variety within a specific community. Piclou's evenness index (E) demonstrates how closely related the abundance values are to one another.

RESULTS AND DISCUSSIONS

In contrast to noon and evening, it has been observed that insects spend the most time in the early hours of the day.

On *P. cineraria*, a total of 20 insect pollinators have been recognised, including 9 species belonging to the family Apidae (Table). The Hymenoptera family Apidae has been displayed to be the largest family. The sequences below exhibit numerous families of insects that were noticed. Apidae (9 species) > Megachilidae (3 species) = Halictidae > Scoliidae (2 species) > Syrphidae (1 species) = Vespidae = Muscidae. On *Prosopis cineraria*, *Apis cerana* was identified to be the most prevalent bee pollinator (7.15 bees/m^2/5 minutes), whereas *Xylocopa latipe* was the least abundant (1.11 bees/m^2/5 minutes).

Three different species of honey bees, including *Apis cerana*, Apis *florea* (2.16 bees/m^2/5 minutes) and *Apis dorsata* (5.52 bees/m^2/5 minutes), have been reported on this particular crop.

On *A. lebbeck*, a total of 17 insect pollinators have been noticed, with 7 species belonging to the family Apidae. The Hymenoptera family with the greatest abundance has been reported to be the Apidae family. Following sequences exhibit insects belonging to various families. Apidae (7 species) > Megachilidae (3 species) > Halictidae (2 species) > Scoliidae (1 species) =Vespidae = Syrphidae = Pieridae = Andreninae. On *A. lebbeck* plant, *Apis dorsata* was observed to be the most abundant bee pollinator (6.14 bees/m^2/5 minutes), even with *Coelioxys capitatus* was the least abundant (1.14 bees/m^2/5 minutes).

For plant *Prosopis cineraria*				For plant *Albizia lebbeck*		
Sr. No.	Name of pollinators	Family	Average abundance minutes	Name of pollinators	Family	Average abundance minutes
1	*Amegilla zonata*	Apidae	4.17	*Amegilla zonata*	Apidae	4.23
2	*Apis cerana*	Apidae	7.15	*Andrena sp.*	Andreninae	4.26
3	*Apis dorsata*	Apidae	5.52	*Apis cerana*	Apidae	3.21
4	*Apis florae*	Apidae	2.16	*Apis dorsata*	Apidae	6.14
5	*Campsomeriella annulata*	Scoliidae	2.49	*Campsomeriella annulata*	Scoliidae	2.16
6	*Ceratina smaragdula*	Apidae	5.14	*Ceratina smaragdula*	Apidae	2.98
7	*Coelioxys capitatus*	Megachilidae	1.21	*Coelioxys capitatus*	Megachilidae	1.14
8	*Halictus spp.*	Halictidae	4.55	*Halictus spp.*	Halictidae	3.46
9	*Megachile disjuncta*	Megachilidae	2.45	*Megachile disjuncta*	Megachilidae	2.66
10	*Megachile flavipes*	Megachilidae	2.86	*Megachile flavipes*	Megachilidae	1.26
11	*Musca domestica*	Muscidae	4.47	*Nomia iridipennis*	Halictidae	1.24
12	*Nomia iridipennis*	Halictidae	2.22	*Pieris brassicae*	Pieridae	2.06
13	*Nomia latreille*	Halictidae	5.48	*Syrphus spp.*	Syrphidae	3.04
14	*Scolid binotata*	Scoliidae	2.15	*Trigona laeviceps*	Apidae	2.44
15	*Syrphus spp.*	Syrphidae	4.11	*Vespa orientalis*	Vespidae	2.78
16	*Trigona iridipennis*	Apidae	1.58	*Xylocopa fenestrata*	Apidae	3.16
17	*Trigona laeviceps*	Apidae	6.15	*Xylocopa latipes*	Apidae	4.14
18	*Vespa orientalis*	Vespidae	4.89			
19	*Xylocopa fenestrata*	Apidae	2.47			
20	*Xylocopa latipes*	Apidae	1.11			

On the flowers of *P. cineraria*, *Apis dorsata* spent the maximum amount of time (8.41 seconds/flower), whereas *Xylocopa latipes* spent the least time (2.41 seconds/flower). On the flowers of *A. lebbeck*, *Apis cerana* spent the most time (12.06 seconds/flower), however *Coelioxys capitatus* spent the least time (5.56 seconds/flower).

For plant *Prosopis cineraria*			For plant *Albizia lebbeck*	
Sr. No.	Insect species	Mean time	Insect species	Mean time
1	*Amegilla zonata*	6.15	*Amegilla zonata*	8.61
2	*Apis cerana*	7.73	*Andrena sp.*	10.42
3	*Apis dorsata*	8.41	*Apis cerana*	12.06
4	*Apis florae*	6.84	*Apis dorsata*	9.94
5	*Campsomeriella annulata*	5.38	*Campsomeriella annulata*	9.84
6	*Ceratina smaragdula*	5.92	*Ceratina smaragdula*	6.65
7	*Coelioxys capitatus*	8.2	*Coelioxys capitatus*	5.56
8	*Halictus spp.*	6.38	*Halictus spp.*	7.08
9	*Megachile disjuncta*	5.69	*Megachile disjuncta*	9.76
10	*Megachile flavipes*	4.79	*Megachile flavipes*	6.94
11	*Musca domestica*	5.07	*Nomia iridipennis*	9.41
12	*Nomia iridipennis*	3.94	*Pieris brassicae*	6.75
13	*Nomia latreille*	2.58	*Syrphus spp.*	7.31
14	*Scolid binotata*	2.91	*Trigona laeviceps*	7.45
15	*Syrphus spp.*	4.33	*Vespa orientalis*	8.57
16	*Trigona iridipennis*	3.26	*Xylocopa fenestrata*	7.27
17	*Trigona laeviceps*	2.57	*Xylocopa latipes*	9.29
18	*Vespa orientalis*	5.38		
19	*Xylocopa fenestrata*	4.97		
20	*Xylocopa latipes*	2.41		

When insects were randomly collected from *P. cineraria* in the natural environment, the Simpson index value (0.0914) suggested that there was a 5% probability that they would be of the same species. Pielou's evenness index value and Shannon index were calculated to be, respectively, 1.065 and 3.190.

Whenever insects were randomly collected from *A. lebbeck* in the natural environment, the Simpson index value (0.0589) demonstrated that there was a 5% probability that they would be of identical species. The calculated values of Pielou's evenness index and Shannon index were 0.872 and 2.471, respectively.

	Prosopis cineraria	*Albizia lebbeck*
Total species no.(S)	20	17
Simpson similerity (D)=ΣPi2	0.091441618	0.058949307
Simpson diversity(1-D)	0.908558382	0.941050693
Reciprocal of Simpson index(1/D)	10.93593953	16.9637279
Shannon s Index(H)= -ΣPi ln pi	3.190526062	2.471943437

Evenness index by Pielou (E) =H/ ln (S)	1.065023764	0.872487574

CONCLUSION

The investigation of the foraging behaviours of several *Apis* species in *P. cineraria* and *A. lebbeck* crops delivers important fresh perspectives on how these bees interact with the crop, affecting pollination effectiveness and, in consequently, seed productivity. Particularly successful as a pollinator, *Apis dorsata* spent the most time in *P. cineraria* among the species examined, whereas *Apis cerana* spent the most time on the flowers of *A. lebbeck*. Twenty insect pollinators have been identified on *P. cineraria*, but only seventeen have been observed on *A. lebbeck*.

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