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Apis florea, A Dwarf Honey Bee [Insecta, Hymenoptera, Apoidea, Apidae] as major forager in the North Eastern region of Rajasthan, India

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ABSTRACT

Bees are the important fauna of ecosystem which provide pollination service to the sexually reproducing plants. Amongst the all pollinators of the world, Honey bees are precious which provide not only pollination service but also economically important products like wax and honey. *Apis florea* is commonly called as dwarf honey bee which forages on variety of plant species. Abundance of this bee was estimated as the number of bees /m^2/ 5 minutes. Highest abundance of dwarf honey bee was estimated on *Tagetes erecta* and lowest abundance was estimated on *Pisum sativum* because *Tagetes erecta* is a large sized flower plant while *Pisum sativum* is a cleistogamous flower which need not cross pollination. Foraging activity of this bee has been estimated in the different time of the day and found that foraging activity was highest estimated in the noon as compared to morning and noon when temperature was high and low relative humidity of environment. Temperature showed positive correlation with foraging activity while relative humidity showed negative correlation.

Figures : 05 References : 18 Tables : 03
KEY WORDS : *Apis florea,* Cleistogamous, Foraging activity, Pollination.

Introduction

Bees are considered to be the primary pollinators of many cultivated and wild plants all over the world[12]**.** It has been reported that about one-third of our total diet is dependent on bee-pollinated plants, making this creature critical to human survival[13]**.** Present study of foraging activity is confined only to the foraging behaviour of *Apis florea* because it was found as the principal pollinator in the study area. This is an important honey bee in the study area, and it is also known as the Dwarf honey bee due to its smallest body size among all honey bees in the world (Fig. 1). It was first time indentified[3]. The defensive behaviour, and foraging activity are very unique in the honey bee family. Apidae order Hymenoptera of class Insecta. Length of worker is approximately 7-10 mm with Proboscis length around 3.11 to 3.37mm[14]**.**

Bees graze from one flower to another in order to collect their food resources, which include pollen as a protein source and nectar as a carbohydrate and water source. Foraging activity of insects is an important biological phenomenon. Bees that collect pollen and nectar from a wide range of plant species are referred to as generalists, whereas bees that rely on a limited range of plants are referred to as specialists[8]**.** Temperature, relative humidity, and wind velocity all have an impact on the foraging behaviour of all bees. Extremely high and low air temperatures have been reported to reduce foraging activity[9]**.**

Previous findings conclude that bee pollination efficiency is directly proportional to temperature but inversely proportional to wind velocity[15]**.** It was also revealed that bees' foraging activity is affected by the size, colour and odour of the flowers on which they forage[9]**.** An investigation discovered that foraging activity of insect visitors is influenced by a combination of extrinsic factors such as wind velocity, ambient temperature, solar radiation, and competitive interactions with other insects, as well as intrinsic factors [2,7,10]**.** Bee

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TABLE-1: Forage resources of *Apis florea*

S.N.	Plant species	Family	Flower colour	Flower size	Abundance Bees/m^2/5 minutes
1	*Brassica campestris*	Brassicaceae	Yellow	Small	6.84
2	*Eruca sativa*	Brassicaceae	Yellow	Small	5.72
3	*Pisum sativum*	Fabaceae	White	Medium	3.16
4	*Tagetes patula*	Asteraceae	Red	Large	13.63
5	*Tagetes erecta*	Asteraceae	Orange	Large	15.30
6	*Caesalpinia lutea*	Fabaceae	Yellow	Large	9.63
7	*Rosa chinensis*	Asteraceae	Pink	Large	11.45
8	*Verbesina encelioides*	Asteraceae	Yellow	Large	12.56
9	*Jacquemontia pentathos*	Convolvulaceae	Violet	Medium	5.70
10	*Cleome viscosa*	Cleomaceae	Yellow	Small	5.63
11	*Vigna radiata*	Fabaceae	Yellow	Medium	4.12
12	*Pyrostegia venusta*	Bignoniaceae	Orange	Large	6.71
13	*Gaillardia spp.*	Asteraceae	Yellow-orange	Large	10.45

species are also influenced by the appearance of flowers, such as their size, shape, morphology, display area, and odour[4,18]**.** The current study provides a scientific approach to *Apis florea* and its foraging behaviour on 13 different crops in the North Eastern region of Rajasthan. Estimating foraging rate can be used to compare pollination efficiency of bee pollinators. The foraging rate of insect pollinators is defined as the number of flowers visited by bee pollinators per minute. Pollination efficiency increased with the higher foraging frequency[16]**.**

Material and Methods

Investigation was carried out in the North Eastern region of Rajasthan which comprises four district namely Jhunjhunu, Sikar, Alwar and Jaipur (Fig. 2). This is an important region of Rajasthan because it covers some area of Aravalli range of Rajasthan which makes this region geographically distinct from the other regions of Rajasthan. This region has been usually found calm with average temperature about 24°C, relative humidity 63%, and mean wind velocity 1 km/h. The experiment was conducted in the winter season from November to first week of March month of 2021 and 2022. Foraging activity was estimated by calculating foraging rate and foraging speed. Foraging rate was estimated in terms of number of flowers visited per minute and foraging speed was measured in terms of time spent by the *Apis florea* on each flower. Foraging activity was noted with the help of Olympus binocular BINO-1295 build in dioptric correction adjusts to individual eyesight with UV coating, made in China and by repeated watching of video of bee foraging in the investigated crop field. Photography and video shooting were performed with CANON EOS 1200D camera. Photos of *Apis florea* were captured with the help of stereo zoom microscope, Model No. 15A1236 manufactured by Olympus Opto Systems Pvt. Ltd., Noida.

TABLE-2 : Foraging rate of *Apis florea*

S.N.	Plant species	Foraging rate of *Apis florea* on different plant species (Number of flower visited/ minute)			
		6 am- 9am	9 am- 12 pm	12 pm – 3 pm	3 pm – 6 pm
1	*Brassica campestris*	4	12	10	6
2	*Eruca sativa*	3	10	9	5
3	*Pisum sativum*	1	5	3	2
4	*Tagetes patula*	3	9	8	5
5	*Tagetes erecta*	2	8	7	4
6	*Caesalpinia lutea*	1	5	4	2
7	*Rosa chinensis*	3	7	5	3
8	*Verbesina encelioides*	2	6	5	3
9	*Jacquemontia pentathos*	2	8	6	4
10	*Cleome viscosa*	1	6	4	1
11	*Vigna radiata*	0	4	3	2
12	*Pyrostegia venusta*	2	5	3	3
13	*Gaillardia spp.*	3	6	5	4

Significance of the time of the day on the foraging rate and foraging speed was statistically ANOVA analyzed by using MS Excel-2019 and SPSS version-25.

Result

Apis florea was observed on 13 different species of flowering plants belonging to Brassicaceae, Fabaceae, Asteraceae and Convolvulaceae families (Table-1). Abundance of *Apis florea* on the flowers was measured in terms of Bees/m^2/ 5 minutes. Highest abundance (15.30 Bees/m^2/ 5 minutes) of *Apis florea* was noted on *Tagetes erecta* followed by *Tagetes patula* (13.63 Bees/m^2/ 5 minutes), *Verbesina encelioides* (12.56 Bees/m^2/ 5 minutes), *Rosa chinensis* (11.45 Bees/m^2/ 5 minutes), *Gaillardia spp* (10.45 Bees/m^2/ 5 minutes) while lowest abundance of Apis florea was observed on *Pisum sativum* (3.16 Bees/m^2/ 5 minutes). Abundance of *Apis florea* on the flowers depends on the colour, scent and size of flower top. *Tagetes erecta* is a large sized flower, colourful with pleasant smell so attracted large number of *Apis florea* as compared to another while *Pisum sativum* is a self pollinated and closed (cleistogamous) flower, so lowest abundance of *Apis florea* was observed on it. Abundance of *Apis florea* showed great variation as per time of the day on the basis of climatic parameters like relative humidity, temperature and wind velocity. It was found that the farms which were very near to roads and human colonies showed less abundance of *Apis florea* due to anthropogenic disturbance. Artificial lights of road sides also affected abundance of this bee because of disturbance of nesting site by the artificial light source.

Artificial light along the road sides or domestic light

TABLE-3 : ANOVA for the foraging rate of *Apis florea* on different crops in the North Eastern region of Rajasthan, India

Groups	Count	Sum	Average	Variance		
Column 1	13	27	2.076923	1.24359		
Column 2	13	91	7	5.333333		
Column 3	13	72	5.538462	5.435897		
Column 4	13	44	3.384615	2.089744		
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	187.7692	3	62.58974	17.75273	6.87E-08	2.798061
Within Groups	169.2308	48	3.525641			

of human residence affected the behaviour pattern of *Apis florea* as well as foraging behaviour of this bee.

Foraging rate of *Apis florea* was measured in terms of number of flowers visited per minute and foraging speed was observed as the time spent by the bee on the flower. Foraging rate was observed from 6 am to 6 pm on the day of observation after a regular interval of 3 hours (Table-2). Foraging rate was highest observed between 9 am to 12 pm in case of all studied crops and least foraging rate was observed in the early morning between 6am to 9am when there were high humidity, less temperature as compared to noon and evening (Fig. 3). Foraging rate was observed highest on *Brassica campestris* because the flowers were very small in size. Foraging rate was observed highly dependent on the climatic parameters like wind velocity, relative humidity and temperature. At the high temperature of the day, *Apis florea* actively forage different flowers and frequently went one flower to another which increased foraging rate but decreased foraging speed (time spent by the bees on the flowers). In the early morning when relative humidity was high, bees rested for long duration on the flowers and spent more time on the flower top which increased foraging speed. In the condition of high wind velocity, bees returned to its nesting site and stopped foraging or decreased foraging.

Effect of the time of the day on the foraging rate of *Apis florea* was statistically analyzed by estimating ANOVA (Table-3). P-value was computed 6.87E-08 which

Fig 1: *Apis florea* in the North Eastern region of Rajasthan, India

Fig. 2: North Eastern region of Rajasthan, India

was found very low than the level of significance (á 0.05) and calculated value of F-crit (2.798061) was less than F-value (17.75273). F-distribution curve showed that foraging rate was highly affected by the time of the day on the basis of climatic parameters (Fig. 4). Result was significant and Null hypothesis cannot be accepted. Time of the day significantly affected the foraging rate. Foraging activity of *Apis florea* (Fabricius) observed on different flowering plants in different time of the day (Fig. 5).

Discussion

Apis florea is a major forager in the study area and it is the most abundant honey bee as compared to another species of honey bees in the studied region. This bee showed great economic importance by helping in the pollination of sexually reproducing plants and enhanced crop production. Population of this bee decreased in the past decades due to lacking knowledge amongst cultivators about rearing of *Apis florea*. Cultivators were using different chemicals as insecticides or pesticides greatly affected the population density of this bee and habitat loss was another problem due to anthropogenic activity.

Pollination service depends on the abundance and foraging activity of pollinators. Flowering plants greatly attracted the bee pollinators so should be planted near the cultivated crop filed to increase crop production.

Foraging activity was reported highly dependent on the temperature. Foraging activity decreased on extreme high or low temperature. Highest foraging activity of honey bees was reported at ambient temperature of 20° C [17]. In a past report, negative correlation was estimated between temperature and foraging activity [1]. Ambient temperature for foraging activity not only depends on the climatic season but also on the species of a forager. Honey bee forage on flowers for the collection of nectar as water resource and pollen as protein resource. Foraging preference of honey bee also depends on the water content of water resources. It was reported that flower reward affected the foraging activity of bees [5]. Foraging activity increased in the noon because of high temperature and low relatively humidity. Relative humidity showed negative correlation with foraging activity. In a past investigation, it was reported that altitude of region also affected the foraging activity [11]. Foraging activity and abundance of *Apis florea* was observed less in the road side farms because of pollution by heavy vehicles. It was reported that Diesel exhaust by heavy vehicles decreased the

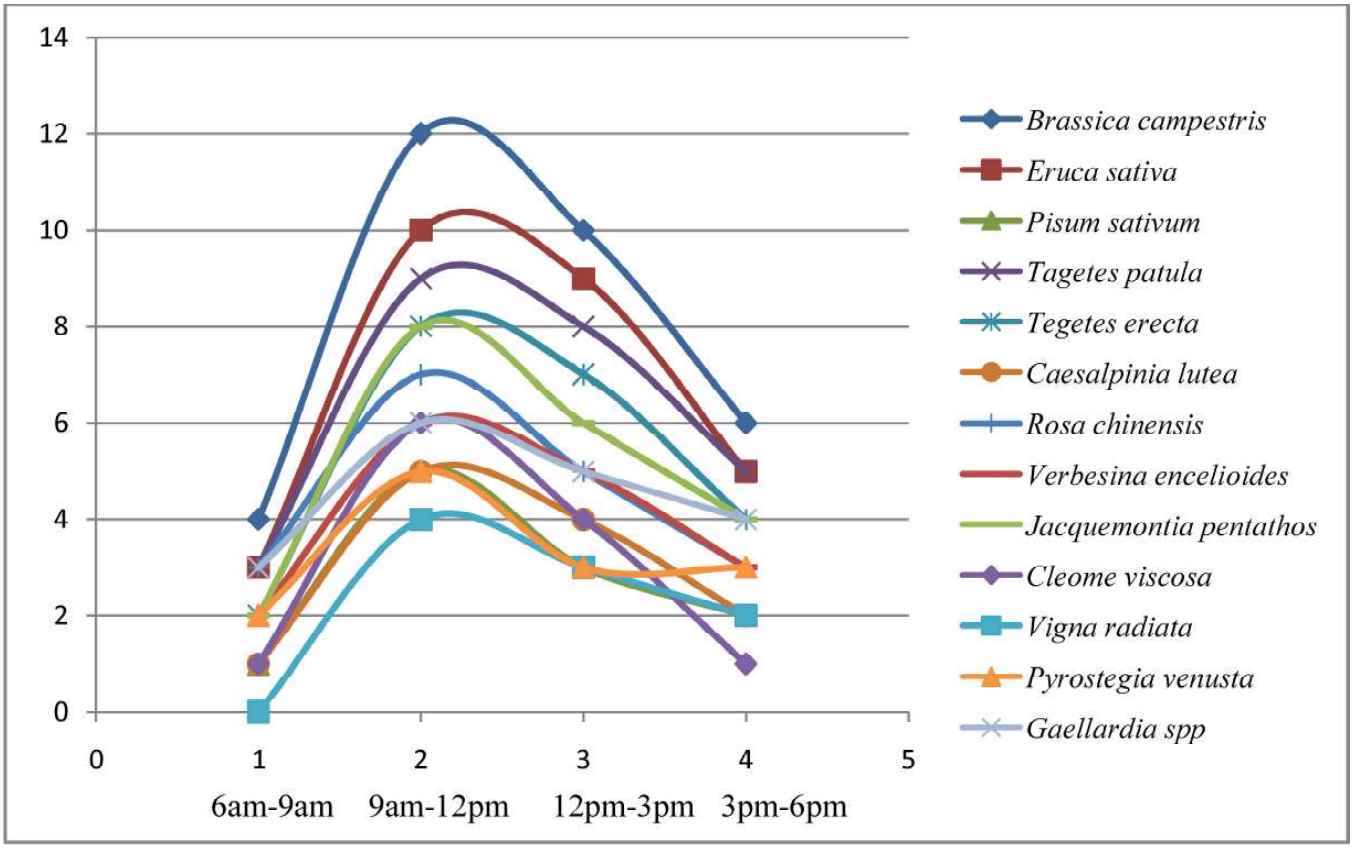

Fig 3: Foraging rate of *Apis florea* in different time intervals on studied crop

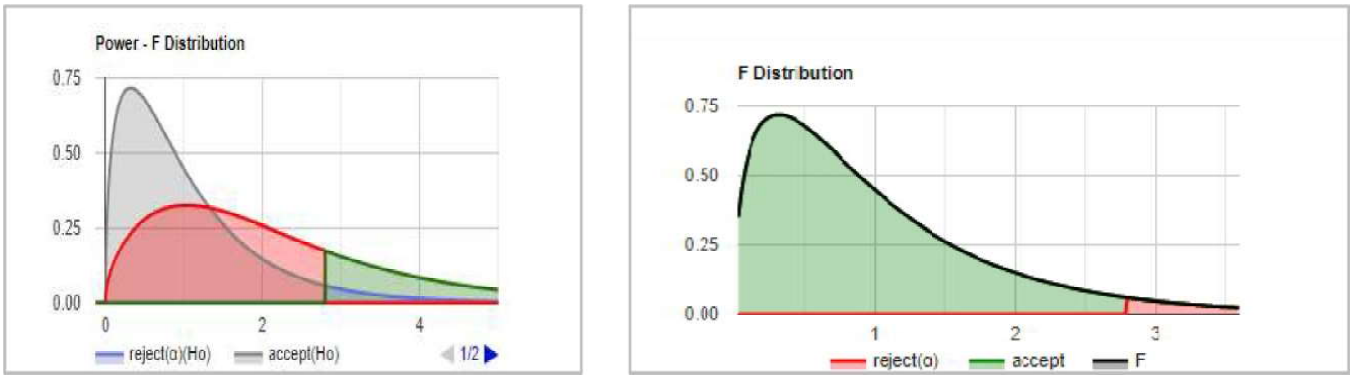

Fig. 4: F-distribution curve for the foraging rate of *Apis florea* on studied crops in the North Eastern region of Rajasthan, India

attraction efficiency of worker bees towards the flowers by diminishing flower odour [6].

Conclusion

Apis florea (Fabricius) is a dominant pollinator in the north eastern region of Rajasthan, India. It plays a major role in the pollination service. Its foraging activity was highly dependent on the time of the day due to the impact of various climatic parameters *i.e.* temperature, relative humidity and wind velocity. For the better crop production of cultivated crops and other wild crops, this bee has to be conserved by protecting its habitat by various anthropogenic activities and use of agro-chemicals should be diminished to conserve this bee.

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A. *Brassica campestris*

B. *Eruca sativa*

C. *Pisum sativum*

D. *Tagetes patula*

E. *Tagetes erecta*

F. *Caesalpinia lutea*

G. *Rosa chinensis*

H. *Verbesina encelioides*

I. *Jacquemontia pentathos*

J. *Cleome viscosa*

K. *Pyrostegia venusta*

L. *Gaillardia spp.*

Fig. 5: Foraging activity of *Apis florea* on different plant species in the North Eastern region of Rajasthan, India (A-L)

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