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Relative Abundance and Foraging Behaviour of Pollinator Fauna on Niger (*Guizotia abyssinica* Cass.) and its Influence on Yield

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Niger (*Guizotia abyssinica* Cass.) is one of the important oilseed crop of Southern and Central India. Niger is a completely cross pollinated crop brought about by insects, referring to the importance of pollination, the study was undertaken to know the role of pollinators in Niger ecosystem and its influence on yield parameters. The present investigation was carried out during 2016-2017 at the Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bangalore, India. In this study, fourteen species of flower visitors were observed during the flowering period belonged to orders Hymenoptera (9 species), Lepidoptera (4 species) and Diptera (1 species). The overall diversity of pollinators was more during morning hours (8.00 AM to 11.00 AM) and gradually decreased after 12.00 PM to 5.00 PM. Among different pollinator species *Apis florea* was more abundant with 41.46% followed by *Apis dorsata* and *Apis cerana*. The peak activity of *A. florea* was observed at 11.00 AM followed by *A. cerana* at 10.00-11.00 AM *and A. dorsata* was at 11.00 AM. The highest number of probing was observed in *A. florea* (7.52) followed by *A cerena* and *A. dorsata*. The time (sec) taken for one probing was highest in *A. florea* followed by *A cerena* and *A. dorsata*. The number of filled seeds observed 37.66% less in caged condition when compare with open pollination and there was significant decrease in the yield in caged condition when compare with open pollination indicating importance of pollinators specifically honey bees for successful production of Niger.

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1. INTRODUCTION

India is one of the largest producers of oilseeds in the world and it occupies an important position in the Indian agricultural economy [1]. There are nine important oilseeds crops grown in India out of which seven are of edible oils (Soybean, Groundnut, Rapeseed Mustard, Sunflower, Sesame, Safflower and Niger) and two are of non-edible oils (Castor and Linseed). Among all edible oilseed crops, Niger (*Guizotia abyssinica* Cass.) is one of the important oilseed crops of Southern and Central India. It is being cultivated in an area of 3.824 lakh hectare and with an annual production of 1.064 lakh tonnes [1]. Niger is a completely cross pollinated crop with a self-incompatibility mechanism. Cross pollination of these flowers are brought about by insects, as flowers of Niger produce abundant quantity of nectar and pollen which attract large number of honey bees [2], which favours pollination [3]. Referring to the importance of pollination in Niger production, the study was conducted to know the role of pollinators on Niger eco-system.

2. MATERIALS AND METHODS

The present investigation was carried out during 2016-2017 at the Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bangalore [13°N & 77°35' E; 930 m above Mean Sea Level (MSL)] located in the South Eastern Dry Zone of Karnataka State.

Ad-libitum visual counting of insect-flower visitors was done starting from morning 07.00 AM till evening 5.00 PM with a recording time of five minutes at different hours of the day. Observations were made for the number of species of pollinators visited along with their frequency of visitation at different time hours in a day on Niger. Observations were repeated on different days during the flowering season. Most frequent species visiting Niger flowers were identified for further studies on foraging behaviour. Flower visitors of Niger were also collected at regular intervals and in different times of a day using an insect sweep net. Sweep net samples were collected on different days. Flower visitors were collected and transferred to a poison tube containing ethyl acetate, killed and were mounted using insect pins, properly dried and preserved for future identification. Identification of bee species was done using the available keys and the expertise in the Biosystematics lab, Department of Entomology. All voucher specimens have been deposited with the collections of the Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore. Pollinator count data was used to compute Shannon-Weaver index of diversity (H') using the following formula

$$H' = -\sum pi \times \ln pi$$

Where pi is the proportion of the i^{th} species of pollinator.

Relative abundance of dominating species of pollinator was worked out by using the following formula and expressed in percentage.

$$\text{Relative abundance of species A} = \frac{\text{Number of individuals of species A visiting flower}}{\text{Total number of individuals of pollinator visited}} \text{ X } 100$$

2.1 Foraging Behaviour of Pollinators

Studies on foraging behaviour was done between 07.00 AM to 05.00 PM for three honey bee species i.e *Apis dorsata, Apis cerana and Apis florea* and handling time was worked out [4].

$$\text{Handling time (Sec)} = \frac{\text{Time spent on flower head for probing}}{\text{Number of probing}}$$

2.2 Pollinator Exclusion Study

Controlled experiments were conducted to record the effect of pollinator visitation on seed set. A set of 100 plants were enclosed in field cages before flowering to prevent flower visitors.

2.3 Post-Harvest Observations on Niger

Observation on seed yield, percent seed filling, test weight, germination percent, root and shoot length were recorded under this experiment as follows.

Seed yield: The seeds harvested from ten plants were cleaned and weighed in electronic balance and expressed in percentage. The yield from caged flowers obtained by excluding pollination was compared with open pollination.

Percent seed filling: In each head total number of filled and unfilled seeds were counted. The ratio of number of filled seeds to the total number of seeds per head was expressed in percent. The difference between open pollinated and caged flower was recorded.

Test weight: Thousand filled seeds were counted from five plants its mean weight was expressed in grams. Test weight was compared between open pollinated and caged flowers.

Germination percent: Fifty seeds were placed on moist blotting paper and kept for observation. The germination counts were taken seven days later and seeds germinated were expressed in percent. Seeds germinated from caged flowers compared with open pollination.

Root and shoot length: Root and shoot length of five seedlings were recorded after seven days of germination.

3. RESULTS AND DISCUSSION

The finding of the present study revealed that, fourteen species of flower visitors which belonged to orders Hymenoptera (9 species), Lepidoptera (4 species) and Diptera (1 species) were observed during the flowering period (Table 1). Kumar et al. [5] had recorded 13 insect species belonging to nine families under three orders viz., Hymenoptera, Lepidoptera and Diptera on Niger. Painkra et al. [6], observed 15 species belonged to order Hymenoptera, Lepidoptera, Diptera and Hemiptera on Niger.

3.1 Diversity of Pollinators at Different Times of the Day on Niger

The peak diversity of pollinators was recorded during 10.00 AM to11.00 AM (0.27) and least at 2.00PM (0.16). The overall diversity of pollinators was more during morning hours (8.00 AM to 11.00 AM) and gradually decreased after 12.00 PM to 5.00 PM (Fig.1). Similarly, Kumar et al. [5] observed the maximum activity of pollinators in morning and minimum in the evening hours.

3.2 Abundance of Pollinators on Niger

The percent composition of Apidae was found more abundant with 90.84% among total Hymenoptan (92.85%) pollinators. Among different pollinator species *A. florea* was more abundant with 41.46% followed by *A. dorsata* (27.23%), *A. cerana* (22.15%), Diptera (5.48%), Lepidoptera (1.62%), Halictids (1.21%), Xylocopa (0.60%) and leaf cutter bee (0.20%). Supporting this study, [7,8] recorded *A. florea* as dominant species on Niger. In contrast to this study [9] reported *A. dorsata* was dominant species on Niger. Painkra et al. [6] reported *A. ceerena indica* as dominant species. This variation may be due to presence of bee population in that locality. The peak activity of *A. florea* was observed at 11.00 AM (9.33 bees) followed by *A. cerana* at 10.00-11.00 AM (5.33 bees) and *A. dorsata* was more at 11.00 AM (6.67 bees). Similarly, [10] reported peak activity of all the bees at 11.00 AM and least at evening hours. The activity of *Xylocopa* was noticed at 9.00 AM (1.00 No./flower), leaf cutter bee at 1.00 PM (0.33 No./flower). Halictids were recorded morning at 8.00 AM (1.00 No./ flower), 11.00 AM (0.67 No./flower) and evening at 4.00 PM (0.33 No./flower). Lepidopterans activity was observed during 8.00 AM (0.33 No./flower) to 10.00 AM (1.00 No./flower) and 4.00 PM (0.33 No./flower). The activity of Dipterans was noticed only during morning hours from 7.00 AM (5.00 No./flower) to 9.00 AM (0.67 No./flower). The overall composition of pollinators was peak at 11.00 AM and slightly decreased towards afternoon-evening hours (Table 2).

3.3 Foraging Behaviour of Honeybees on Niger in Bangalore India

On Niger the number of probing into the flower by *A. dorsata* ranged from 1.20 (1.00 and 2.00 PM) to 6.00 (8.00 AM), with 3.44 mean number of probing. The maximum number of probing was performed at 8.00 AM (6.00). The time spent by *A. dorsata* ranged from 1.40 Sec. (3.00 PM) to 6.00 Sec. (10.00 AM) with 3.75 Sec. mean time spent. The time taken for one probing was highest at 10.00 AM (1.76 Sec.) and lowest at 3.00 PM (0.64 Sec.). The mean time required for one probing was 1.09 Sec. The number of probing on the Niger flower by *A. cerana* ranged from 1.37 (2.00 PM) to 10.40 (12.00 PM), with 4.65 mean number of probing. The maximum number of probing was performed at 12.00 PM (10.40). The time spent by *A. cerana* ranged from 1.25 Sec. (2.00 PM) to 12.20 Sec. (12.00 PM) with 5.60 Sec. mean time spent. The time taken for one probing was highest at 10.00 AM (1.90 Sec.) and lowest at 7.00 AM (0.69 Sec.). The mean time required for one probing was 1.13 Sec. The number of probing on the Niger flower by *A. florea* ranged from 1.13 (2.00 PM) to 11.80 (11.00 AM), with 7.52 mean number of probing. The maximum number of probing was

performed at 11.00 AM (11.80). The time spent by *A. florea* ranged from 4.00 Sec. (2.00 PM) to 12.60 Sec. (11.00 AM) with 7.51 Sec. as mean time spent. The time taken for one probing was highest at 10.00 AM (1.98 Sec.) and lowest at 4.00 PM (0.78 Sec.). The mean time required for one probing was 1.19 Sec (Table 3).

3.4 Variation in Yield Parameters of Niger in Open and Caged Conditions of Pollination

This study focuses on the difference in qualitative and quantitative parameters in open pollination and caged condition. It was observed that number of filled seeds were 37.66% less in caged condition when compare with open pollination and there was significant decrease in the yield in caged condition when compare with open pollination. [7], observed similar positive result with 73% seed set in open-pollinated condition and only 3% in caged condition. Seed yield was found four times higher in open pollinated condition when compare with caged condition. The overall mentioned parameters indicating positive in open pollinated condition when compare with caged condition (Table. 4).

Table 1. Taxonomical position of pollinators recorded on Niger in Bangalore India

Order	Family	Subfamily	Tribe	Genus	Species
Hymenoptera	Apidae	Apinae	Apini	*Apis* Linnaeus	*Apis dorsata* Fabricius *Apis cerena* Fabricius *Apis florea* Fabricius
		Xylocopinae	Ceratinini	*Ceratina* Latreille	*Ceratina binghami Cockerell*
			Xylocopini	*Xylocopa* Latreille	*Xylocopa* sp.
	Meghachilidae	Meghachilinae	Lithurgini	*Lithurgus* Newman	*Lithurgus atratus* Smith
	Halictidae	Halictinae	Halictini	*Seladonia* Robertson	*Selodonia* sp.
		Nomiinae	Nomiini	*Nomia* Latreille	*Nomia crassipes* Fabricius
	Scoliidae	Scoliinae	Scoliini	*Scolia* Fabricus	*Scolia* sp.
Lepidoptera	Nymphalidae	Danainae	Danaini	*Danaus* Kluk	*Danaus chrysippus* Linnaeus
	Papilionidae	Papilioninae	Papilionini	*Papilio* Linnaeus	*Papilio polytes* Linnaeus
	Erebidae	Arctiinae	Syntomini	*Amata* Fabricius	*Ammata passalis* Fabricius
	Hespiridae	Hesperiinae	Gegenini	*Pelopidas* Walker	*Pelopidas* sp.
Diptera	Syrphidae	Eristalinae	Eristalini	*Eristalinus* Rondani	*Eristalinus arvorum* Fabricius

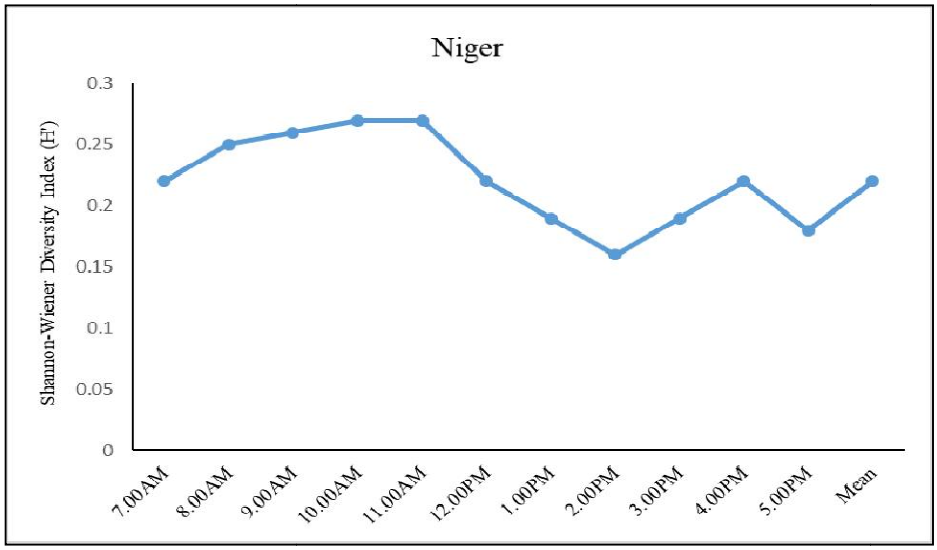

Fig. 1. Shannon-Wiener Diversity (H') at different times of the day on Niger

Table 2. Abundance of pollinators on Niger in Bangalore India

Time	*A. dorsata*	*A. cerena*	*A. florea*	*Xylocopa*	Leaf cutter bee	Halictids	Lepidoptera	Diptera	Total	% composition
7.00 AM	4.00	1.67	2.00	0.00	0.00	0.00	0.00	5.00	12.67	7.72
8.00 AM	6.33	3.33	3.67	0.00	0.00	1.00	0.33	3.33	18.00	10.97
9.00 AM	5.33	4.00	4.33	1.00	0.00	0.00	1.00	0.67	16.33	9.95
10.00 AM	6.33	5.33	6.00	0.00	0.00	0.00	1.00	0.00	18.67	11.38
11.00 AM	6.67	5.33	9.33	0.00	0.00	0.67	0.00	0.00	22.00	13.41
12.00 PM	3.00	3.67	9.00	0.00	0.00	0.00	0.00	0.00	15.67	9.55
1.00 PM	1.67	2.67	6.67	0.00	0.33	0.00	0.00	0.00	11.33	6.91
2.00 PM	2.00	1.67	5.67	0.00	0.00	0.00	0.00	0.00	9.33	5.69
3.00 PM	3.00	2.33	9.67	0.00	0.00	0.00	0.00	0.00	15.00	9.14
4.00 PM	4.33	3.33	7.00	0.00	0.00	0.33	0.33	0.00	15.33	9.34
5.00 PM	2.00	3.00	4.67	0.00	0.00	0.00	0.00	0.00	9.67	5.89
Total	44.67	36.33	68.00	1.00	0.33	2.00	2.67	9.00	164.0	100
Mean	4.06	3.30	6.18	0.09	0.03	0.18	0.24	0.82	14.91	
SD	1.87	1.25	2.46	0.30	0.10	0.34	0.39	1.70	3.91	
% species composition	27.23	22.15	41.46	0.60	0.20	1.21	1.62	5.48	100	
Total Apidae %	90.84%									
Total Hymenoptera %	92.85%									

Table 3. Foraging behaviour of *Apis* bees in Niger in Bangalore India

Time of observation	*A. dorsata*			*A. cerana*			*A. florea*		
	Mean number of probing (No.)	Mean time spent (Sec.)	Mean time taken for one probing* (Sec.)	Mean number of probing (No.)	Mean time spent (Sec.)	Mean Time taken for one probing*(Sec.)	Mean number of probing (No.)	Mean time spent (Sec.)	Mean time taken for one probing* (Sec.)
7.00 AM	2.80	2.60	0.83	3.20	2.20	0.69	4.40	4.40	1.00
8.00 AM	6.00	4.60	0.77	3.40	4.80	1.11	7.80	8.00	1.03
9.00 AM	3.60	4.60	1.28	5.80	7.40	1.28	11.20	9.00	1.80
10.00 AM	3.40	6.00	1.76	4.00	7.60	1.90	9.20	9.00	1.98
11.00 AM	4.00	5.00	1.25	6.40	7.00	1.09	11.80	12.60	1.07
12.00 PM	3.00	3.00	1.00	10.40	12.20	1.07	7.00	7.40	1.06
1.00 PM	1.20	1.60	1.23	3.00	4.00	1.03	4.00	4.40	1.10
2.00 PM	1.20	1.60	1.13	1.37	1.25	1.00	1.13	4.00	1.30
3.00 PM	2.20	1.40	0.64	3.80	2.80	0.74	6.20	6.80	1.10
4.00 PM	5.00	4.80	0.96	5.40	6.40	1.19	11	8.60	0.78
5.00 PM	5.40	6.00	1.11	4.40	6.00	1.36	9.00	8.40	0.93
Mean ± SD	3.44±1.59	3.75±1.75	1.09±0.30	4.65±2.37	5.60±3.08	1.13±0.32	7.52±3.37	7.51±2.54	1.19±0.36

Table 4. Seed yield parameters in open and caged condition of Niger in Bangalore India

Yield parameters	Open	Caged	% variation in caged over open pollination
Number of filled seed (No.)	15.93	9.93	-37.66
Number of unfilled seeds (No.)	5.13	9.73	23.66
Total number of seeds (No.)	20.8	19.67	-5.43
Percent seed filling	77.54	50.87	-34.39
Test weight (g)	3.48	3.09	-11.20
Volume weight (g)	28.97	17.87	-38.31
Seed yield (Kg/ha)	310	43.12	-86.09
Germination (%)	75.00	61.67	-17.77
Root length (cm)	13.65	7.63	-44.10
Shoot length (cm)	10.11	7.15	-29.27

4. CONCLUSION

Pollinators majorly honeybees are importance in the successful production and increasing the productivity of Niger. The number of filled seeds (37.66%), were less in caged condition when compared with open pollination and there was significant decrease in yield under caged condition when compared with open pollination, indicating importance of pollinators specifically honey bees for successful production of Niger.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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