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Diversity & Foraging Behaviour of Insect Pollinators on Some Forest Trees in K&i Area, Distt Gurdaspur, Punjab, India

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Abstract:
The present study deals with the pollination of insect on selected six trees i.e. Khair (Acacia catechu): Ber (Ziziphus maurtiana), Shisham (Dalbergia sissoo), Amla (Emblica officinalis), Kachnar (Bauhinia variegta) & Siris (Albizzia lebbek). These have been dealt tree-wise. Diversity of insect pollinators visiting the tree, Relative abundance of the pollinators, Foraging behavior in term of:-Foraging rate, Foraging duration & loose pollen grains adhered to the body. On the basis of the data, performance score & pollinating index (PI) of each species the pollinating efficiency ranking was done & it is observed that Apis mellifera is the most efficient pollinator of the Khair (Acacia catechu), Shisham (Dalbergia sissoo) & Amla (Emblica officinalis) trees. Polistes herbreaus is the most efficient pollinator of Ber (Ziziphus maurtiana) tree Apis cerana is the most efficient pollinator of the tree Kachnar (Bauhinia variegta) & Apis dorsata is the most efficient pollinator of the tree Siris (Albizzia lebbek).

Keywords : *Pollination, Apis sp., foraging rate, Foraging behviour*

1. Introduction

Worldwide, more than 3,000 plant species have been used as food, only 300 of which are now widely grown, & only 12 of which furnish nearly 90 percent of the world's food. These 12 include the grains: rice, wheat, maize (corn), sorghums, millets, rye, & barley, & potatoes, sweet potatoes, cassavas or maniocs, bananas, & coconuts (Thurston 1969). The grains are wind-pollinated or self-pollinated, coconuts are partially wind-pollinated & partially insect pollinated, & the others are propagated asexually or develop parthenocarpically. However, more than two-thirds of the world's population is in Southeast Asia where the staple diet is rice. Superficially, it appears that insect-pollination has less effect on the world's food supply - possibly no more than 1 percent. Within the United States, which accounts for only about 6 percent of the world's population, about 286 million acres were cultivated in 1969. About 180 million acres were devoted to the wind pollinated or self pollinated crops, primarily barley, corn, oats, rice, rye, sorghums & wheat, grass hay crops, sugar beets, sugar cane, potatoes, sweet potatoes, & tobacco. About 60 million acres were devoted to crops that may receive some benefit from insect pollination, but are largely self-pollinating (beans, cotton, flax, peanuts,
peas, & soybeans). About 40 million acres were devoted to hay crops produced from bee-pollinated seeds (alfalfa, clovers, lespedezas). About 6 million acres were devoted to producing fruits, vegetables, & nuts-most of which are dependent upon insect pollination. These plants provide about 15 percent of our diet. The animal products we consume contribute about an equal amount to our diet. These include beef, pork, poultry, lamb, & dairy products--derived one way or another from insect-pollinated legumes such as alfalfa, clover, Lespedeza, & trefoil. More than half of the world's diet of fats & oils comes from oilseeds--coconuts, cotton, oil palm, olives, peanuts, rape, soybeans, & sunflower (Guidry 1964). Many of these plants are dependent upon or benefited by insect pollination. When these sources, the animal & plant products, are considered, it appears that perhaps one-third of our total diet is dependent, directly or indirectly, upon insect-pollinated plants.

Another value of pollination lies in its effect on quality & efficiency of crop production. Inadequate pollination can result not only in reduced yields but also in delayed yield & a high percentage of culls or inferior fruits. In this connection, Gates (1917) warned the grower that, "he may fertilize, & cultivate the soil, prune, thin & spray the trees, in a word, he may do all of those things which modern practice advocates, yet without his pollinating agents, chief among which are the honey bees, to transfer the pollen from the stamens to the pistil of the blooms, his crop may fail."

The conservation status of the various insect pollinators is not well known mainly due to their small size & inconspicuous nature. The decline in insect species can go unnoticed until they approach local extinction. The pollinators that visit agricultural crops are often known, but there is a vast vacuum in our knowledge of insect pollinators, which visit or bring out pollination in our native plants. It is in this perspective that the present studies are proposed with the following objectives; To assess the species diversity of insect pollinators of selected forest plants, To study the foraging behaviour of the dominant & efficient pollinators on particular plants, to determine the influence of exotic pollinators on diversity & behaviour of native pollinators.

2. Study Area
The K&i tract of Gurdaspur forest division has come under the umbrella of the management plan under Section 4 of L& Preservation Act, 1900. The forest vegetation of the tract varies in composition, quality & density depending upon locality, geological formations, elevation & other aspects.

3. Material & Methods
St&ard technique with area/crop specific modifications where required will be employed to study insect pollinator diversity efficiency & behaviour. Six plants are selected Khair (*Acacia catechu*), Ber (*Zizyphus mauratiana*) Siris (*Albizzia lebbek*), Amla (*Emblica officinalis*), Kachnar (*Bauhinia verigata*), Shisham (*Dalbergia sissoo*), for The parameters to be used & the technique for its determination will be as follows:-

- **Pollinator diversity** – The variety of pollinators visiting the trees to be studied will be caught with the help of butterfly net & immediately killed by fumigation with ethyl acetate in a wide mouthed killing bottle. It will be stretched in the stretching box & pinned properly for preservation. The pollinators will be identified by following various taxonomic keys.
- **Abundance/visitation frequency** – Population abundance will be recorded by selecting five equal sized branches of forest trees. The number of insect visitors per five minutes in the selected areas will be recorded. Observations will be taken three times in a day & twice in a week during the full blooming period of the crop.

4. Foraging Rate
This is determined by recording the number of flowers visited per minute by each type of insect. Observations will be recorded five times during a day, repeated twice in a week during the full blooming period of crops.

5. Foraging Duration
The time spent by each insect on one flower (in seconds) will be measured with the help of stopwatch. Observations will be recorded on five inflorescences at one time & three times in a day. This process will be repeated twice a week during the full blooming period of crops & fruit trees.

6. Foraging Behaviour
Proportion of top worker & side worker bees was determined as follows; worker bees alighting upright on stamens to collect pollen or nectar were considered as top workers & those alighting on petals & collecting nectar were considered as side workers (Verma & Rana, 1994).

7. Pollen Counting
Three individuals of each species will be captured on the flowers & immediately killed individually in 70% alcohol. The pollen will be washed from their body & a constant volume of the rinsate will be prepared. For this procedure, the hind legs of the *Apis* visitors will be amputated before killing them & then the rinsate will be made.
The number of loose pollen grains adhered to the body of the pollinators will be counted with the help of Haemocytometer as suggested by Kumar *et al*. (1985). For different pollination attributes, viz. population abundance of flower visitors, their foraging rates, foraging duration, pollen counting i.e. loose pollen grains attached to their body & performance scores will be derived for each species. From various performance scores for different attributes of a species, the Pollination Index (PI) will be derived by multiplying all the PSs of that species. On the basis of the pollinating index (PI) of each species the pollinating efficiency of species will be determined with the formula given by Sihag & Rathi (1994) & conclusion will be drawn as to which of the insect species is better pollinator contributing highest degree to pollination.

8. Results & Discussion
The result obtained during the investigations carried out on insect pollinators & theirs pollinating attributes on are presented in this paper these have been dealt tree-wise under different parameters.

9. Relative Abundance
During Present investigation the average number of insects per species visiting per m^2 on tree per five minutes were observed : *Apis dorsata* X 2.00±0.40; *A.mellifera* 2.26±3.58 & *A. cerana* 0.40±0.20 on *Acacia catechu*, *Polistes hebraeus* 0.6±0.89 & *Rhynchium* 0.6±1.34 on *Ziziphus maurtiana*, *Apis dorsata* 1.40±0.89 ; *A.mellifera* 9.6±7.86 & *A. cerana* 0.4±0.89 on *Dalbergia sissoo*, *Apis dorsata* 0.66±0.46,: *A. mellifera* 0.40±0.20 & *A. cerana* 1.0±0.40 on *Emblica officinalis*, *Apis dorsata* 0.60±0.20; *A.mellifera* 0.73±0.23; *A. cerana* 1.2±0.46 & *Vanessa cardus* 0.40±0.20 on *Bauhinia variegta.* & *Apis dorsata* X 21.53±1.47, *A.mellifera* 18.67±0.92 & *A. cerana* 2.60±1.51 on *Albizzia lebbek* (Table. 1.6).
Relative abundance was greater during 1200h-1400 h followed by 1500 h – 1700 h on *Acacia catechu*, 0900-11h followed by 1200-1400h on *Ziziphus maurtiana*, 0900-11h followed by 1500-1700h on *Dalbergia sissoo*, 1200h- 1400 h *Emblica officinalis*, 1500 h – 1700 h on *Bauhinia variegta*, 0900-11h followed by 1500-1700h on *Albizzia lebbek* (Reddi & Reddi,1983, Bhalla *et al.* 1983).

10. Foraging behaviour

- **Foraging rate:** Data pertaining to the number of flower visited per insect per min. for the various insect visitors were: *Apis dorsata* X1.66±0.50; *A.mellifera* 2.13±0.50 & *A. cerana* 1.53±0.12 on *Acacia catechu*, *Polistes hebraeus* 5.6±1.06 & *Rhynchium* 3.93±0.46 on *Ziziphus maurtiana*, *Apis dorsata* 16.6±3.66; *A.mellifera* 13.8±2.00 & *A. cerana* 16.2±3.21on *Dalbergia sissoo*, *Apis dorsata* 5.66±1.03 ; *A. mellifera* 9.33±0.83 & *A. cerana* 16.0±3.08 on *Emblica officinalis*, *Apis dorsata* 1.60±0.23; *A.mellifera* 6.46±1.31; *A. cerana* 9.26±1.14 & *Vanessa cardus* 1.93±0.12 on *Bauhinia variegta*, *Apis dorsata* 7.80±0.53, *A.mellifera* 8.20±1.00 & *A. cerana* 7.60±1.56 on *Albizzia lebbek* (Table. 1.6)..

  Forging behaviuor was greater during 1200 h – 1400 h followed by 0900-1100 h on *Acacia catechu*, 1200-1400 h followed by 0900-11h on *Ziziphus maurtiana*, 0900-11h followed by 1500-1700h on *Dalbergia sissoo*, 1700h- 1400 h followed by 1200 h – 1400 *Emblica officinalis*, 1500 h–1700 h followed by 0900h -1100 h on *Bauhinia variegta*, 0900h - 1100 h followed by 1200 h–1400 h on on *Albizzia lebbek* . Bhalla *et al.* 1983 reported that honey bees started foraging after 0900 h & were most active from 1100 h to 1600 h. Abrol & Bhat (1987) observed that foraging activity of *A. cerana* was positively & significantly correlated with temperature & non-significant with relative humidity.
- **Foraging duration:** The data on average time (in seconds) spent for foraging duration per insect per flower by different insect visitors on different trees were: *Apis dorsata* 84.0±21.52,; *A.mellifera* 28.06±18.19 & *A. cerana* 140.60±107.25 on *Acacia catechu*, *Polistes hebraeus* 7.40±1.39 & *Rhynchium* 7.06±4.81 on *Ziziphus maurtiana*, *Apis dorsata* 2.86±2.26 ; *A.mellifera* 1.8±0.77 & *A. cerana* 8.13±7.03 *Dalbergia sissoo*, *Apis dorsata* 11.00±3.47; *A. mellifera* 12.66±3.25, *A. cerana* 11.40±4.04 on *Emblica officinalis*, *Apis dorsata* 36.66±11.10; *A.mellifera* 19.26±5.46; *A. cerana* 5.53±1.62 & *Vanessa cardus* 62.46±60.13 on *Bauhinia variegta*, *Apis dorsata* X 6.87±2.72, *A.mellifera* 7.73±3.03 & *A. cerana* 6.67±2.53on *Albizzia lebbek* (Table. 1.6).

11. Pollen counting

Average no. of pollen grain per insect has been observed on the basis of performance score & pollinating index (PI) of each species the pollinating efficiency ranking was done. The average pollen grain per insect per flower by different insect visitors on different trees has been *Apis dorsata* 28333.33; *A.mellifera* 34166.66 & *A. cerana* 97500.00 on *Acacia catechu*, *Polistes hebraeus* 6666.66 & *Rhynchium* 3333.33 on *Ziziphus maurtiana*, *Apis dorsata* 783333.33; *A.mellifera* 18333.33 & *A. cerana* 21666.66 *Dalbergia sissoo*, *Apis dorsata* 14166.66 ; *A. mellifera* 74166.66 & *A. cerana* 9166.66 on *Emblica officinalis*, *Apis dorsata* 115833.33; *A.mellifera* 80833.33; *A. cerana* 56666.66 & *Vanessa cardus* 4166.66 on *Bauhinia variegta*, *Apis dorsata* 13333.33; *A.mellifera* 7500.00 & *A. cerana* 9166.66 on *Albizzia lebbek* (Table. 1.6).

12. Pollinating Index

On the basis of different parameters like relative abundance, foraging behaviour, foraging duration & pollen counting pollinating index were calculated : *Apis dorsata* 31.422, *A.mellifera* 164-439 & *A. cerana* 140.60±107.25 on *Acacia catechu*, *Polistes hebraeus* 79.021, *Rhynchium* 11.932 on *Ziziphus maurtiana*, *Apis dorsata* 2178.274 *A.mellifera* 2395.48 *A.cerana* 190.139 *Dalbergia sissoo*, *Apis dorsata* 51.651, *A. mellifera* 234.971, *A. cerana* 138.248 on *Emblica officinalis*, *Apis dorsata* 121.962, *A.mellifera* 802.515, *A. cerana* 4584.923, *Vanessa cardus* 2.059 on *Bauhinia variegta* & *Apis dorsata* X 147.72, *A.mellifera* 67.19 & *A. cerana* 12.30 on *Albizzia lebbek* (Slauson, 2000). (Table. 1.6).

13. Conclusion

On the basis of present Investigation, performance score & pollinating index (PI) of each species the pollinating efficiency ranking was done & it is observed that *Apis mellifera* is the most efficient pollinator of the Khair (*Acacia catechu*), Amla (*Emblica officinalis*) & Shisham (*Dalbergia sissoo*), Partab & Partab,1997. *Polistes herbreaus* is the most efficient pollinator of Ber (*Ziziphus maurtiana*), *Apis cerana* is the most efficient pollinator of the tree Kachnar (*Bauhinia variegta*) & *Apis dorsata* is the most efficient pollinator of the tree Siris (*Albizzia lebbek*).

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S.No.	Name of insect	Abundance	Foraging Rate	Foraging Duration	Pollen Counting	Pollinating Index (PI)	Pollinating efficiency ranking
1.	*Apis dorsata*	2.00 (1.260)	1.66 (0.914)	84.0 (36.575)	28333.33 (0.746)	31.422	3
2	*A.mellifera*	2.26 (1.423)	2.13 (1.174)	28.06 (109.49)	34166.66 (0.899)	164-439	1
3.	*A.cerana*	4.73 (2.980)	1.53 (0.843)	140.60 (21.851)	97500.00 (2.567)	140.909	2

Table: 1 Pollination efficiency ranking of insect pollinators of Khair (Acacia catechu) on the basis of different pollinating attributes (all mean values)

S.No.	Name of insect	Abundance	Foraging Rate	Foraging Duration	Pollen Counting	Pollinating Index (PI)	Pollinating efficiency ranking
1.	*Polistes herbreaus*	1.46 (2.073)	5.60 (0.659)	7.40 (116.621)	56666.66 (0.746)	79.021	1
2	*Rhynchium flavolineatum*	0.60 (0.852)	3.93 (0.462)	7.06 (122.237)	3333.33 (0.248)	11.932	2

Table: 2 Pollination efficiency ranking of insect pollinators of on Ber (Ziziphus maurtiana) tree are the basis of different pollinating attributes (all mean values)

S.No.	Name of insect	Abundance	Foraging Rate	Foraging Duration	Pollen Counting	Pollinating Index (PI)	Pollinating efficiency ranking
1.	*Apis dorsata*	1.80 (1.168)	16.6 (1.679)	2.86 (251.132)	78333.33 (4.423)	2178.274	2
2	*A.mellifera*	6.40 (4.155)	13.8 (1.396)	1.8 (399.022)	18333.33 (1.035)	2395.48	1
3.	A.cerana	1.66 (1.077)	16.2 (1.634)	8.13 (88.344)	21666.66 (1.223)	190.139	3

Table: 3 Pollination efficiency ranking of insect pollinators of on the Shisham (Dalbergia sissoo) basis of different pollinating attributes (all mean values)

S.No.	Name of insect	Abundance	Foraging Rate	Foraging Duration	Pollen Counting	Pollinating Index (PI)	Pollinating efficiency ranking
1.	*Apis dorsata*	0.66 (0.937)	5.66 (0.666)	11.00 (78.454)	14166.66 (1.055)	51.651	3
2	*A.mellifera*	0.40 (0.568)	9.33 (1.098)	12.66 (68.167)	74166.66 (5.527)	234.971	1
3.	*A.cerana*	1.00 (1.420)	16.00 (1.883)	11.40 (75.701)	9166.66 (0.683)	138.248	2

Table: 4 Pollination efficiency ranking of insect pollinators of Amla (Emblica officinalis) on the basis of different pollinating attributes (all mean values) on the basis of different pollinating attributes (all mean values)

S.No.	Name of insect	Abundance	Foraging Rate	Foraging Duration	Pollen Counting	Pollinating Index (PI)	Pollinating efficiency ranking
1.	*Apis dorsata*	0.60 (1.050)	1.60 (0.524)	36.66 (70.821)	115833.33 (3.130)	121.962	3
2	*A.mellifera*	0.73 (1.278)	6.46 (2.118)	19.26 (134.802)	80833.33 (2.184)	802.515	2
3.	*A.cerana*	1.20 (2.101)	9.26 (3.036)	5.53 (469.493)	56666.66 (1.531)	4584.923	1
4	*Vanessa cardus*	0.40 (0.700)	1.93 (0.632)	62.46 (41.567)	4166.66 (0.112)	2.059	4

Table: 5 Pollination efficiency ranking of insect pollinators of Kachnar (Bauhinia variegta)

S.No.	Name of insect	Abundance	Foraging Rate	Foraging Duration	Pollen Counting	Pollinating Index (PI)	Pollinating efficiency ranking
1.	*Apis dorsata*	21.53 (1.773)	7.80 (1.175)	6.87 (42.182)	13333.33 (1.681)	147.72	1
2	*A.mellifera*	18.67 (1.537)	8.20 (1.235)	7.73 (37.455)	7500.00 (0.945)	67.19	2
3.	*A.cerana*	2.60 (0.214)	7.60 (1.145)	6.67 (43.448)	9166.66 (1.155)	12.30	3

Table: 6 Pollination efficiency ranking of insect pollinators of Siris (Albizzia lebbek) on the basis of different pollinating attributes (all mean values)