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POLLINATOR DIVERSITY AND FORAGING BEHAVIOUR OF INSECT POLLINATORS IN AONLA

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ABSTRACT

This study is on the diversity, abundance of floral visitors, foraging rate and speed of major pollinators in aonla orchard. Aonla flowers were observed with 22 floral visitors belonging to the Hymenoptera, Diptera, Lepidoptera and Coleoptera. *Tetragonula iridipennis* was the most abundant floral visitor followed by *Apis cerana indica* and *A. dorsata*. Number of flowers visited by *A. cerana indica* (13.46 flowers/ min) and *T. iridipennis* (8.26) was maximum during 1100-1200 hr. The time spent by *A. cerana indica* (6.24 sec/ flower) and *T. iridipennis* (6.20) was also maximum during 1100-1200 hr.

Key words: *Phyllanthus emblica*, inflorescence, visitors, Hymenoptera, *Apis cerana indica*, *Tetragonula iridipennis*, rate, abundance, speed, Madurai

Aonla (*Emblica officinalis* Gaertn) is an important fruit crop in tropical and subtropical regions of India (Goyal et al., 2007). India ranks first in the area and production of aonla (National Horticulture Board, 2019). The limited pollination and imbalanced sex ratio contribute to low fruit set and retention (Allemullah and Ram, 2009). Insect pollination is an ecosystem service having significant economic, aesthetic, cultural values to human society (Kataria et al., 2023). An efficient pollinator continually visits flowers, carrying pollen and transferring it to the stigma in a single visit (Corbet et al., 1991). Many species of bees, wasps, ants, butterflies, flies and beetles engage in frequent visitation to flowers (Hathurusinghe et al., 2023; Kumar et al., 2023) and help in increasing fruit yield (Ollerton, 2017). Bees are the most studied and utilized pollinators throughout the world (Kasina et al., 2009; Marin, 2019; Tarakini et al., 2020; Ibarra and Rands, 2021) and provide the greatest contribution to pollination (Garibaldi et al., 2013; Ruiz et al., 2013; Dymond et al., 2021). The unisexual flowers of aonla requires pollination by pollen vectors (Vadde et al., 2018). The present study evaluates the diversity of insects visiting aonla flowers and foraging behaviour of major pollinators.

MATERIALS AND METHODS

The study was carried out in an aonla orchard (9°.97' N, 78°20' E), Agriculture College and Research Institute, Madurai, Tamil Nadu, India during February to April, 2023. Survey was conducted to record the pollinator diversity. Relative abundance, foraging rate and speed of foragers were calculated based on the method given by Bakshi et al. (2018). The floral visitors collected were identified by Dr. U Amala, Scientist, NBAIR, Bangalore. The experiment was laid out by randomized block design (RBD) and the data obtained were subjected to square root transformation and means were compared by least significant difference (p= 0.05) with AGRES statistical package.

RESULTS AND DISCUSSION

The insects attracted to flowers of aonla belonged to four orders, 12 families, 17 genera and 22 species (Table 1). The order Hymenoptera with 13 species contributed maximum share (59.09%) followed by Lepidoptera (18.18%), Diptera (18.18%) and Coleoptera (4.54%). These results were found to agree with the report of Vadde et al. (2018), that aonla blossoms attracted insects belonged to five orders, seven families, nine genera and twelve species, of which four were hymenopterans, two were coleopterans, four belonged to dipterans, and one each from Hemiptera and Lepidoptera. Similar study conducted in aonla ecosystem revealed that among the recorded floral visitors five were hymenopterans, six were dipterans and one was lepidopteran (Saini and Sihag, 2023). The majority of floral visitors belonged

Table 1. Foraging behaviour of floral visiters in aonla orchard (February – April, 2023)

S. No	Floral Visitors	No. of floral visitors/ 5 min/ inflorescence* during different hours of the day						Mean
		0600 - 0800 hr	0800 - 1000 hr	1000 - 1200 hr	1200 - 1400 hr	1400 –1600 hr	1600 - 1800 hr	
Hymenoptera Apidae								
1.	*A. cerana indica*	14.00± 0.07 (3.74)^{a}	13.50± 0.04 (3.67)^{b}	19.90± 0.55 (4.46)^{b}	11.40± 0.01 (3.37)^{c}	14.70± 0.12 (3.83)^{a}	13.05± 0.18 (3.61)^{b}	14.42
2.	*A. florea*	4.80± 0.19 (2.19)^{b}	4.70± 0.02 (2.16)^{c}	9.35± 0.29 (3.05)^{d}	8.70± 0.20 (2.94)^{d}	6.35± 0.09 (2.51)^{d}	4.20± 0.09 (2.04)^{c}	6.35
3.	*A. dorsata*	14.45± 0.20 (3.80)^{a}	13.30± 0.21 (3.64)^{b}	18.65± 0.04 (4.31)^{c}	16.95± 0.36 (4.11)^{b}	9.05± 0.22 (3.00)^{c}	4.66± 0.10 (2.14)^{c}	12.84
4.	*T. iridipennis*	14.90± 0.50 (3.86)^{a}	26.45± 0.43 (5.14)^{a}	32.1± 0.10 (5.66)^{a}	18.15± 0.33 (4.26)^{a}	11.9 ± 0.06 (3.44)^{b}	15.60± 0.04 (3.94)^{a}	19.85
5.	*A. mellifera*	1.20± 0.04 (1.09)^{gh}	3.00± 0.03 (1.73)^{d}	4.60± 0.01 (2.14)^{e}	0.60± 0.03 (0.77)^{hi}	0.75± 0.29 (0.86)^{ghi}	0.70± 0.03 (0.836)^{hij}	1.80
6.	*Amegilla* sp.	1.25± 0.05 (1.11)^{g}	0.00± 0.00 (0.70)^{g}	1.12± 0.04 (1.06)^{gh}	0.70± 0.04 (0.83)^{ghi}	0.00± 0.00 (0.70)^{i}	0.95± 0.03 (0.97)^{ghi}	0.67
Mean		8.43	10.15	14.28	9.41	7.12	6.52	9.32
Other than Apidae								
7.	*Xylocopa virginica*	0.00± 0.00 (0.70)^{i}	0.00± 0.00 (0.70)^{g}	0.80± 0.03 (0.89)^{ghi}	1.60± 0.06 (1.26)^{fg}	0.65± 0.03 (0.80)^{ghi}	0.00± 0.00 (0.70)^{j}	0.50
8.	*X. violacea*	0.35± 0.02 (0.59)^{hi}	0.00± 0.00 (0.70)^{g}	0.20± 0.02 (0.44)^{hi}	0.60± 0.02 (0.77)^{hi}	0.80 ± 0.03 (0.89)^{ghi}	0.50± 0.03 (0.70)^{ij}	0.70
9.	*Chlorion lobatum*	0.00± 0.00 (0.70)^{i}	0.00± 0.00 (0.70)^{g}	0.00± 0.00 (0.70)^{i}	1.60 ± 0.06 (1.26)^{fg}	0.00± 0.00 (0.70)^{i}	1.20± 0.05 (1.09)^{fghi}	0.46
10.	*Pollistes hebraeus*	1.30± 0.05 (1.14)^{g}	0.80± 0.05 (0.89)^{fg}	0.00± 0.00 (0.70)^{i}	0.00± 0.00 (0.70)^{i}	0.00± 0.00 (0.70)^{i}	1.30± 0.07 (1.14)^{fghi}	0.56
11.	*Delta conoidium*	2.95± 0.07 (1.71)^{cd}	0.80± 0.03 (0.89)^{fg}	0.90± 0.85 (0.94)^{gh}	1.85 ± 0.07 (1.36)^{f}	1.20± 0.05 (1.09)^{fg}	1.50± 0.05 (1.22)^{fghi}	1.53
12.	*Vespa tropica*	0.90 ± 0.03 (0.94)^{gh}	1.50± 0.06 (1.22)^{ef}	0.35± 0.02 (0.59)^{ghi}	1.75± 0.05 (1.32)^{fgh}	1.10± 0.04 (1.04)^{ghi}	1.80± 0.06 (1.34)^{fgh}	1.23
13.	*Polistes bellicosus*	1.50± 0.06 (1.22)^{g}	0.80± 0.04 (0.89)^{fg}	0.35± 0.02 (0.59)^{ghi}	0.40± 0.02 (0.63)^{ghi}	1.60± 0.05 (1.26)^{fg}	0.65± 0.02 (0.80)^{hij}	0.88
Mean		1.00	0.55	0.62	1.11	0.76	0.99	0.84
Diptera								
14.	*Musca* sp.	0.00± 0.00 (0.70)^{i}	0.00± 0.00 (0.70)^{g}	0.00± 0.00 (0.70)^{i}	1.15± 0.04 (1.07)^{fgh}	0.80± 0.04 (0.89)^{ghi}	1.35± 0.07 (1.16)^{fghi}	0.55
15.	*Episyrphus* sp.	5.25± 0.11 (2.29)^{b}	0.00± 0.00 (0.70)^{g}	0.00± 0.00 (0.70)^{i}	1.50± 0.06 (1.22)^{fgh}	2.45± 0.09 (1.56)^{ef}	1.60± 0.05 (1.26)^{efg}	1.80
16.	*Sphaerophoria* sp.	3.45± 0.09 (1.85)^{c}	2.80± 0.09 (1.67)^{d}	2.20± 0.07 (1.48)^{f}	0.00± 0.00 (0.70)^{i}	1.35± 0.40 (1.16)^{fgh}	0.00± 0.00 (0.70)^{j}	1.63
17.	*Sarcophaga* sp.	2.40± 0.07 (1.54)^{ef}	2.85± 0.07 (1.68)^{d}	0.35± 0.02 (0.59)^{ghi}	0.55± 0.03 (0.74)^{hi}	3.20± 0.05 (1.78)^{e}	2.85± 0.06 (1.68)^{d}	2.03
Mean		2.77	1.41	0.63	0.80	1.95	1.45	1.50
Coleoptera								
18.	*C. sexmaculata*	1.60± 0.06 (1.26)^{fg}	1.55± 0.04 (1.24)^{ef}	1.15± 0.04 (1.07)^{gh}	3.30± 0.07 (1.81)^{e}	1.45± 0.07 (1.20)^{fgh}	2.00± 0.05 (1.41)^{def}	1.84
Mean		1.60	1.55	1.15	3.30	1.45	2.00	1.84
Lepidoptera								
19.	*Colotis aurora*	0.85± 0.03 (0.92)^{gh}	0.75± 0.03 (0.86)^{fg}	1.05± 0.04 (1.02)^{ghi}	1.60± 0.06 (1.26)^{ghi}	1.95± 0.04 (1.39)^{ef}	1.25± 0.04 (1.11)^{fghi}	1.24
20.	*Junonia lemonias*	2.15± 0.08 (1.46)^{fg}	2.20± 0.07 (1.48)^{ef}	1.05± 0.03 (1.02)^{ghi}	1.00± 0.04 (1.00)^{fgh}	2.75± 0.09 (1.65)^{ef}	1.85± 0.05 (1.36)^{ghi}	1.83
21.	*Danaus chrysipphus*	3.05± 0.10 (1.74)^{c}	2.75± 0.08 (1.65)^{d}	1.20± 0.04 (1.09)^{fg}	3.45± 0.11 (1.85)^{e}	0.40± 0.02 (0.63)^{hi}	2.25± 0.07 (1.50)^{de}	2.18
22.	*Melanitis leda*	0.90± 0.03 (0.94)^{ghi}	1.65± 0.07 (1.28)^{def}	1.45± 0.03 (1.20)^{gh}	0.55± 0.02 (0.74)^{hi}	0.85± 0.04 (0.92)^{ghi}	0.75± 0.03 (0.86)^{ghij}	1.02
Mean		1.71	1.47	1.18	1.98	1.48	1.62	1.57
CD (0.05)		0.233	0.241	0.174	0.220	0.282	0.262	

*Each value mean of 20 observations; Figures in parentheses square root transformed values; Mean± S.E; In a column, means followed by same letter on par (DMRT, p=0.05)

to the Hymenoptera of which *T. iridipennis* (19.85 insects/ inflorescence/ 5 min) had a maximum mean population followed by *A. cerana indica* (14.42), *A. dorsata* (12.84) and *A. florea* (6.35). This study was correlated with the results reported by Saini (2011) who found that hymenopterans were the most abundant pollinators followed by dipterans in aonla. Diez and Juan (2023) found that honey bees accounted for 48.6% of total flower visitations.

Foraging rate and speed of major pollinators in aonla ecosystem is depicted in (Fig. 1). Maximum number of flowers visited by *A. cerana indica* (13.46 flowers/ min), *T. iridipennis* (8.26) was recorded at 1100-1200 hr and minimum (6.08, 4.00) numbers were recorded at 1700-1800 hr. Similar results were obtained by Karuppaiah et al. (2018) who reported that foraging rate of *A. cerana indica* was maximum (12.87) during 1000-1200 hr and the rate started decreasing thereafter. Similar study conducted by Deuri et al. (2018) on mango inflorescence revealed that foraging rate of *A. cerana indica* was maximum (11.64) at 0900-1000 hr and minimum (3.49) at 1300-1400 hr. Singh et al. (2018) also reported that maximum foraging rate (10.86) was recorded at 1200-1300 hr and minimum (6.37) at 0900-1000 hr. The time spent by *A. cerana indica* (6.24 sec/ flower) and *T. iridipennis* (6.20) on aonla flowers were recorded maximum at 1100-1200 hr and lower values (2.42 and 3.04) were observed at 1700-1800 hr. Bakshi et al. (2018) reported that foraging speed of *A. cerana indica* on cherry was maximum (15.23) at 1000 hr. These results were also in line with the results of Phadatare et al. (2019) who recorded *A. cerana indica* foraging speed (16.00) at 0800-1000 hr as the highest and 1400-1600 hr as the lowest (9.60). This was also in accordance with the results of Divija et al. (2022) who recorded *T. iridipennis* spent a maximum time (44.20) in radish flowers.

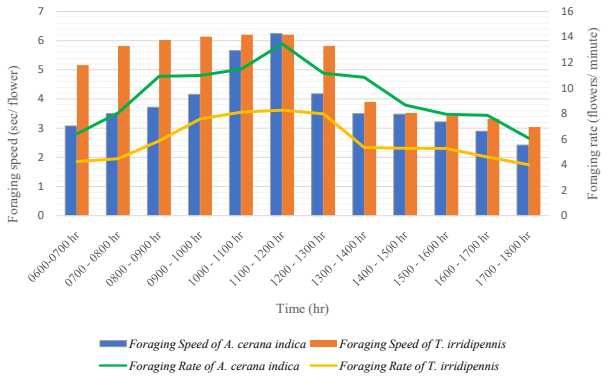

Fig. 1. Foraging rate and speed of major pollinators in aonla ecosystem

Thus, hymenopterans were found as the most abundant insect visitor on aonla flowers. Irrespective of different day hours, significantly maximum number of *T. iridipennis* was recorded from aonla flowers followed by *A. cerana indica* and *A. dorsata*. Pushpalatha et al. (2023) reported that the flower visitor numbers and the time of their visitation determine the pollination efficiency. The foraging activity was recorded high in the noon hours in aonla orchard. The results from our survey were in good agreement with the reports of Mohanty et al. (2023) that maximum temperature had a positive correlation with the foraging activity of Indian honey bees leading to an increased fruit set ratio.

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CONFLICT OF INTEREST

No conflict of interest.

AUTHOR CONTRIBUTION STATEMENT

V. Devadharshini, K. Suresh, B. Usharani conceived and designed the research. V. Devadharshini conducted the experiments and drafted the manuscript. R. Nalini and M. Ananthan are the advisors of the research work.

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