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Floral Visitor Profile and Their Relative Abundance on Buckwheat (*Fagopyrum esclentum* M.)

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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

The aim of the present study was to investigate the floral visitor profile, their reward forage from the inflorescence of buckwheat in addition to their abundance in different blooming phases of the crop. Totally 46 insect floral visitors were documented during different bloom phases during 2024, which included both *Apis* and non-*Apis* species, out of which 21 species were from Hymenoptera, 14 species from Diptera, six from Lepidoptera, three from Hemiptera and two from Coleoptera. The overall composition of *A. cerana* was maximum, followed by *A. florea* and *A. mellifera* during different bloom phases of buckwheat. The honey bees ranked first, followed by *Syritta orientalis* which belongs to family Apidae, compared to rest of the insect floral visitors which belonged to different orders. Hymenopterans were more abundant (45.65 %), followed by Dipterans (30.43 %),

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Lepidopterans (13.04 %), Hemipterans (6.52 %) and Coleopterans (4.3 %). The diversity of floral visitors was highest during maximum bloom phase on pin and thrum morph as compared to initial and late blooming phases. Irrespective of blooming phases, the diversity of floral visitors was maximum on thrum morph as compared to pin morph.

Keywords: floral visitor profile; buckwheat; polygonaceae family; functional food.

1. INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* M.) also known as buckwheat, belongs to flowering plants of Polygonaceae family. It is a pseudo cereal used in the same way as cereals but does not belong to the grass family. Buckwheat is cultivated for its grain-like seeds and as a cover crop. Buckwheat is an old World crop which is believed to have originated in China (Ohnishi, 1998). It was introduced into the New World by European settlers in 17th century (Treadwell and Huang, 2008). Due to its Multifood use as a pseudo cereal with a higher nutritional content than many conventional cereals and its use as a functional food with industrial applications, leads to promising future on a global scale (Liu et al., 2008 and Tang et al., 2009). Buckwheat is a cross pollinated crop showing self-incompatible which requires insect to aid effective pollination.

Buckwheat is an annual crop that thrives in cool, damp climates, cultivated as a cereal grain in China and other Eeastern countries (Ahmad and Raj, 2012). Buckwheat is the most important crop in hilly regions of India, widely grown in the western parts of Jammu and Kashmir and Arunachal Pradesh. Its cultivation is confined to high mountains of Ladakh and Udhampur in Jammu and Kashmir, Bharmaur, Pangi, Kulu, Shimla and Kinnaur in Himachal Pradesh, Uttar Kashi, Chamoli, Pauri, Almora and Pithorgarh in Uttar Pradesh, Darjeeling in West Bengal, Lachan and Lachoong in Sikkim, Tawang, Bomdilla and Dirang in Arunachal Pradesh, Meghalaya, and Manipur. It is sporadically grown in the Nilgiris and Palani hills of South India (Joshi, 1999). Studying pollinator diversity in these areas helps to enhance the yield of the crop by conserving the pollinators.

Forty-nine different insect species, belonging to 18 families were recorded on buckwheat (*Fagopyrum esculentum* Moench) flowers of which Diptera and Hymenoptera were the principal visitors. Honey bees were reported to be the most predominant floral visitors. Some syrphids and other Dipteran species act as co-pollinators due to their high relative frequency and activity in Central Belgium during 2001 and 2002 (Jacquemart et al*.,* 2007).

Dhakal (2003) recorded Rock bee, Little bee, European bee, Syrphid fly, Tabanid fly, March fly, Rice skipper, Legume pod bug, Hymenopteran wasp, Lady bird beetle, Mud wasp and Muscid fly as the flower visitors of buckwheat at Nepal.

The abundance of *Apis mellifera* L. (80.1%) accounted to be the dominant on buckwheat followed by *Coccinella transversalis* F. and *C. undecimpunctata* L. (10.10%), *Meangyna viridiceps* M. (2.70%), Blowflies (1.50%), Small flies (1.50%), *Eristalis* sp. (1.40%), *Pieris rapae* L. (1.30%), Beetles (0.10%), Wasps (0.10%), Moths (0.10%) and the lowest of 0.1 per cent with Dragonflies at Smeaton in Central Victoria (Goodman et al., 2001).

Native wasps and other insect flower visitors were active within the buckwheat plots during mornings and afternoons. Native wasps comprised the majority of non-*Apis* flower visitors (81.3%), followed by Diptera (12.5%), native bees (5.8%) and beetles (0.47%). Most of the non-*Apis* flower visitors were parasitoid wasps namely, Scoliidae and Tiphiidae which were the most commonly observed families, with *Scolia nobilitata* F. (Hymenoptera: Scoliidae) being the most common species observed in buckwheat at Gansu Province, Northwest China (Liu et al., 2020).
Dhandapani et al*.* (2023) findings demonstrate that co-creating floral interventions with farmers can deliver context-specific ecological intensification, enhancing both biodiversity and crop production, while also laying the groundwork for widespread practical adoption of these interventions in tropical agricultural systems.

A total of 12 insect species belonged to 4 insect orders Viz. Hymenoptera, Diptera, Lepidoptera and Hemiptera and 9 families such as Apidae, Syrphidae, Muscidae, Calliphoridae, Sarcophagidae, Nymphalidae, Lycaenidae, Noctuidae and Lygaeidae were recorded on

buckwheat flowers. Hymenopterans (61.49%) were the most abundant pollinators followed by Diptera (25.00%), Lepidoptera (12.16%) and Hemiptera (1.35%) at Dharwad, Karnataka (Kambrekar et al., 2018.). This study represents the first investigation into the insect species visiting the inflorescence of buckwheat in Karnataka. Hence the present study aims to investigate the floral visitor profile, their reward forage from the inflorescence of buckwheat in addition to their abundance in different blooming phases of the crop.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in the experimental plot at ICAR-National Bureau of Agricultural Insect Resources, Yelahanka, Bengaluru at 874 MSL, 13°09' N 77°56' E situated in the South Eastern Dry Zone of Karnataka.

2.2 Documentation of Flower Visitors on Buckwheat Inflorescence

The crop was raised in a Randomized Block Design at NBAIR, Attur in December 2023**.** Flower visitors were collected by using sweep net sampling technique at regular intervals and in different times of a day during different phases of flowering period of the crop. The collected flower visitors were transferred to a poison bottle containing cotton wad which was soaked in ethyl acetate to kill the insect floral visitors. Insects collected from sweep samples were brought to the laboratory, mounted by using insect pins, properly dried and preserved for future identification. Identification of floral visitors was done by using the taxonomic keys in consultation with insect taxonomist, Department of Agril. Entomology, UAS, GKVK, Bengaluru.

2.3 Visual Counts of Floral Visitors

'*Ad-libitum*' sampling of floral visitors for sampling time of five minutes, at an hourly interval basis was followed. Variation in the sampling interval accounts for variation in the insect diversity based on the reward preference by insect floral visitors. All the floral visitors per sampling time were recorded to identify the species composition at different time intervals of the day. The frequency of visits by each insect species was recorded to identify the most abundant species effecting buckwheat pollination. The observations were repeated at different phases of flowering.

2.4 Abundance of Insect Floral Visitors

Four inflorescence from four directions each from the plant bearing pin and thrum morph were randomly selected and tagged. The relative abundance of the different insect floral visitors either on pin or thrum morph tagged plants were recorded from 0600 to 1800 hours, at hourly intervals for duration of five minutes in different bloom phases.

3. RESULTS AND DISCUSSION

3.1 Documentation of Floral Visitor Profile on Inflorescence of Buckwheat

The diurnal floral visitors of buckwheat in the experimental plot at ICAR-National Bureau of Agricultural Insect Resources, Attur, Bengaluru, were recorded during different blooming phases from 0600 upto1800hrs at hourly intervals.

Totally fourty-six species of floral visitors, which included *Apis* and non-*Apis* species were collected and documented at different blooming phases of buckwheat during 2023-24 (Plate 1). Of these, twenty-one species were Hymenopterans *viz., Apis cerana* Fab., *Apis mellifera* L**.,** *A. dorsata* Fab*.* and *A. florea* Fab., were the *Apis* species, whereas, *Braunsapis* sp., *Ceratina sutepensis* Cockerell and *Xylocopa* sp. were the non-*Apis* species which belonged to Apidae, were regular visitors, which foraged for nectar and pollen, with the exception of *A. dorsata, Braunsapis* sp. and *Xylocopa* sp. were occasional visitors which foraged for nectar and pollen. *Cerceris hortivaga* K., *Cerceris vagans* R. and *Tachysphere* sp. belonged to Crabronidae and they were regular floral visitors, which foraged for nectar. *Campsomariella collaris collaris* F. and *Campsomariella annulata* F. were also regular visitors which belonged to Scoliidae, which foraged for nectar. *Labus* sp., *Delta conoideum* G. and *Polistes stigma tamulus* F. were regular visitors which foraged for nectar and they belonged to family Vespidae with the exception of *Delta conoideum* G. which was an occasional visitor. *Chrysis angolensis* R. was an occasional visitor, which belonged to family Chrysididae and foraged for nectar. *Seladonia* sp. and *Hoplonomia westwoodi* were regular visitors

which belonged to Halictidae and they foraged for nectar and pollen. *Camponotus pennsylvanicus* (De Geer), *Camponotus cinctellus* G. and *Formica* sp. were regular visitors, which belonged to family Formicidae and they foraged for nectar (Table 1).

Table 1. Floral visitors of buckwheat (*Fagopyrum esculentum* M.) during flowering period (2023-24)

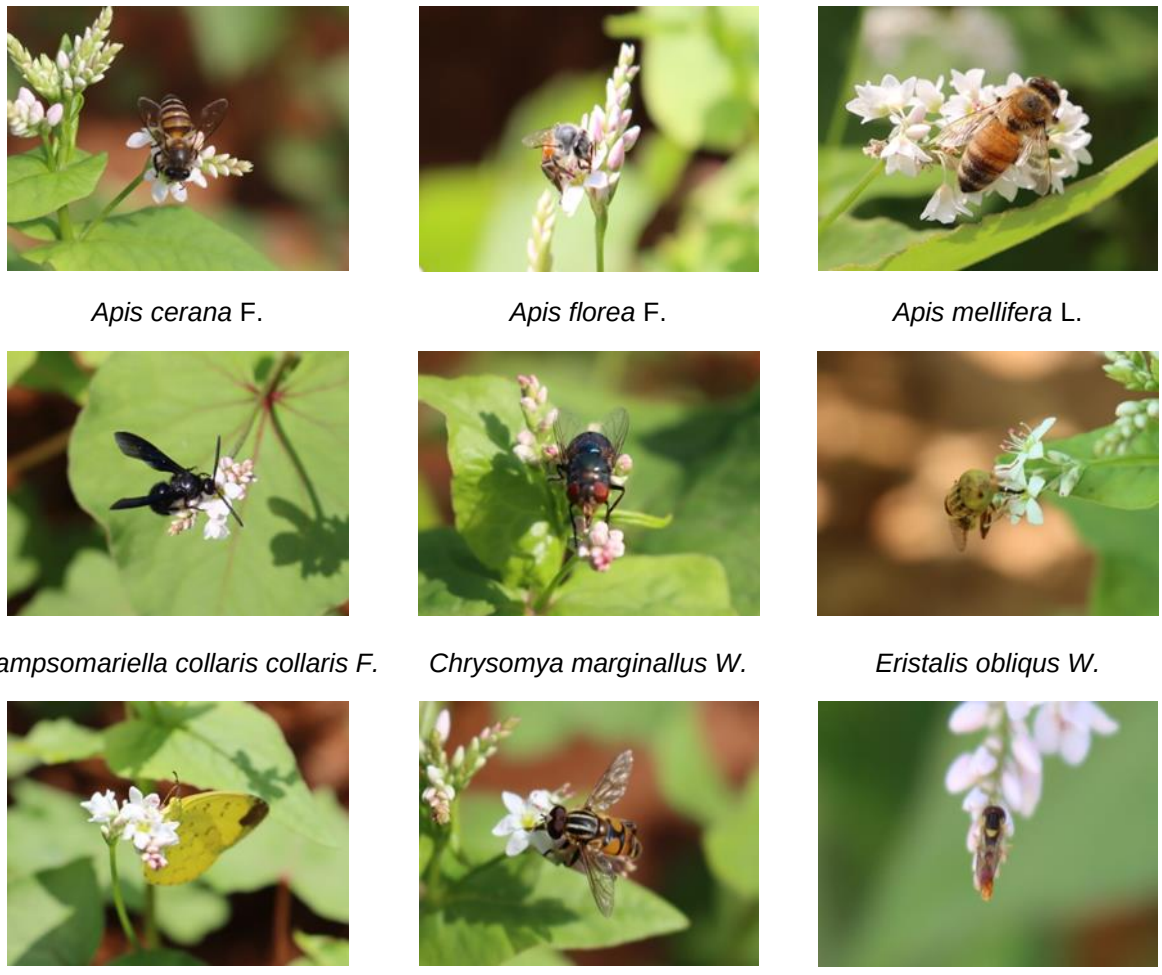
Sl No.	Order	Family	Species	Visiting status	Reward collected
1	Hymenoptera		*Cerceris hortivaga* K.	Regular	N
2		Crabronidae	*Cerceris vagans* R.	Regular	N
3			*Tachysphere* sp.	Regular	N
4			*Apis cerana* F.	Regular	N+P
5			*Apis mellifera* L.	Regular	N+P
6			*Apis dorsata* F.	Occasional	N+P
7		Apidae	*Apis florea* F.	Regular	N+P
8			*Xylocopa* sp.	Occasional	N+P
9			*Braunsapis* sp.	Regular	N+P
10			*Ceratina sutepensis* Cockerell	Regular	N+P
11		Scoliidae	*Campsomariella collaris collaris* F.	Regular	N
12			*Campsomariella annulata* F.	Regular	N
13			*Delta conoideum* G.	Occasional	N
14		Vespidae	*Labus* sp.	Regular	N
15			*Polistes stigma tamulus* F.	Regular	N
16		Chrysididae	*Chrysis angolensis* R.	Occasional	N
17		Halictidae	*Seladonia* sp.	Regular	N+P
18			*Hoplonomia westwoodi*	Regular	N+P
19		Formicidae	*Camponotus pennsylvanicus* (De Geer)	Regular	N
20			*Camponotus cinctellus* G.	Regular	N
21			*Formica* sp.	Regular	N
22	Diptera	Calliphoridae	*Chrysomya marginallus* W.	Regular	N
23			*Chrysomya megacephala* F.	Regular	N
24			*Syritta orientalis* M.	Regular	N
25			*Eristalis obliqus* W.	Regular	N
26		Syrphidae	*Serratoparagus* sp.	Regular	N
27			*Paragus tibialis* F.	Regular	N
28			*Sphaerophoria sulphuripes* T.	Regular	N
29			*Halophilus pendulus* L.	Regular	N
30		Stratiomyidae	*Odontomyia ochropa* T.	Regular	N
31			*Hermetia illucens* L.	Regular	N
32		Rhiniidae	*Stomorhina* sp.	Regular	N
33			*Rhinia* sp.	Regular	N
34			*Stomorhina xanthogaster* W.	Occasional	N
35		Muscidae	*Musca* sp.	Occasional	N
36	Lepidoptera		*Danaus chrysippus* L.	Regular	N
37		Nymphalidae	*Phalanta phalantha* D.	Regular	N
38			*Hypolimnas bolina* L.	Regular	N
39		Pieridae	*Eurema hecabe* L.	Regular	N
40		Lycaenidae	*Lampides boeticus* L.	Regular	N
41			*Castalius rosimon* F.	Regular	N
42	Hemiptera	Coreidae	*Cletus trigonus* T.	Regular	N
43		Alydidae	*Riptortus linearis* L.	Occasional	N
44		Pentatomidae	*Halyomorpha* sp.	Occasional	N
45	Coleoptera	Coccinellidae	*Micraspis discolor* F.	Regular	P
46			*Coccinella* sp.	Occasional	P

Note: N-Nectar; P-Pollen

Fourteen species under order Diptera *viz*., *Chrysomya marginallus* W. and *Chrysomya megacephala* F. were regular visitors, which belonged to family Calliphoridae, which foraged for nectar. *Syritta orientalis* M., *Eristalis obliqus* W., *Serratoparagus* sp., *Paragus tibialis* F., *Sphaerophoria sulphuripes* T. and *Halophilus pendulus* L. were regular visitors, which belonged to family Syrphidae, which foraged for nectar. *Odontomyia ochropa* T. and *Hermetia illucens* L. were regular visitors, which belonged to family Stratiomyidae and they foraged for nectar. *Stomorhina* sp., *Rhinia* sp. and *Stomorhina xanthogaster* W. were regular visitors, with the exception of *Stomorhina xanthogaster* W. which was an occasional visitor, which belonged to family Rhiniidae and foraged for nectar (Table 1).

Six species of Lepidopterans *viz*., *Danaus chrysippus* L., *Phalanta phalantha* D. and *Hypolimnas bolina* L. were regular visitors, which belonged to family Nymphalidae and they foraged for nectar. *Eurema hecabe* L. was a regular visitor, which belonged to family Pieridae, which foraged for nectar. L*ampides boeticus* L. and *Castalius rosimon* F. were regular visitors (Family: Lycaenidae) which foraged for nectar (Table 1).

Three species of Hemiptera among which *Cletus trigonus* T. was a regular visitor (Family: Coreidae) which foraged for nectar, *Riptortus linearis* L. was a occasional visitor (Family: Alydidae) which foraged for nectar and *Halyomorpha* sp. was a occasional visitor (Family: Pentatomidae) which foraged for nectar (Table 1). Two species of Coleopterans *viz*., *Micraspis discolor* F. which was a regular visitor and *Coccinella* sp. which was an occasional visitor belonged to family Coccinellidae, which foraged for pollen (Table 1). These findings were



Apis cerana F. | *Apis florea* F. | *Apis mellifera* L.

Campsomariella collaris collaris F. | *Chrysomya marginallus W.* | *Eristalis obliqus W.*

Eurema hecabe L. | *Halophilus pendulus L.* | *Sphaerophoria sulphuripes T.*

Plate 1. Floral visitors of Buckwheat

supported by the reports of Jacquemart et al., (2007) who recorded 49 different insect species, belonging to 18 families, of which Diptera and Hymenoptera were the predominant visitors. Among Hymenoptera, *Apis mellifera* L. accounted for 18.5 – 51.8 per cent of the total visitors, while Diptera were represented by syrphid flies and several other families which accounted for 11.8- 22.7 per cent in buckwheat flowers at central Belgium. In the present study, among the composition of insect floral visitors, Hymenoptera accounted for 45.65 per cent, followed by Diptera (30.43 %), Lepidoptera (13.04%), Hemiptera (6.52%) and Coleoptera which accounted for 4.30 per cent. The present findings were supported by the report of Kambrekar et al. (2018) who stated that Hymenopterans (61.49%) were the most abundant pollinators, followed by Diptera (25.00%), Lepidoptera (12.16%) and Hemiptera (1.35%) at Dharwad, Karnataka.

3.2 Relative Abundance of Insect Floral Visitors of Buckwheat

The relative abundance of insect floral visitors of buckwheat was recorded during three different blooming phases viz., initial, maximum and late bloom phase and the results are discussed hereunder.

Floral visitors abundance on pin morph of buckwheat during initial bloom phase: The abundance of observed insect floral visitors was maximum during 1000-1100 hrs (64 /5 min/4 inflorescence.), followed by 1100-1200 hrs (56 /5 min/4 inflorescence.) and the lowest was recorded during 1700-1800 hrs (3 /5 min/4 inflorescence.). There were no floral visitors from 0600-0700 hrs. The variability in the abundance of floral visitors among different hours of day may be due to availability of open flowers for foraging of floral rewards. Among 20 floral visitors on pin morph, abundance of *A. cerana* Fab. (33.96%), *A. florea* Fab. (23.99%) and *A. mellifera* L. (12.46%) were relatively larger in number and together constituted 70.41 per cent. The rest of the floral visitors (17) ranged from 0.62 (*Chrysomya marginallus* W., *Odontomyia ochropa* T. and *Eurema hecabe* L.) to 3.74 per cent (*Syritta orientalis*) and together they constituted 29.59 per cent during initial bloom phase (Table 2). These findings are supported by those of Raju *et. al*. (2001), who stated that honey bees, represented 54 per cent of the visits, while other bee species collectively contributed 46 per cent on buckwheat at Visakhapatnam, Andhra Pradesh.

Floral visitors abundance on thrum morph of buckwheat during initial bloom phase: The abundance of observed insect floral visitors was maximum during 1000-1100 hrs (74 /5 min/4 inflorescence.), followed by 1100-1200 hrs (63 /5 min/4 inflorescence.) and the lowest was recorded during 1700-1800 hrs (3 /5 min/4 inflorescence.). There were no floral visitors from 0600-0700 hrs. Among 22 floral visitors on thrum morph, abundance of *A. cerana* Fab. (29.41%), *A. florea* Fab. (23.25%) and *A. mellifera* L. (13.17%) were relatively larger in number and together constituted 65.83 per cent. The rest of the floral visitors (19) ranged from 0.56 (*Paragus tibialis* F. and *Odontomyia ochropa* T.) to 4.20 (*Syritta orientalis* M.) per cent and together they constituted 34.17 per cent during initial bloom phase. Total number of insece floral visitors on thrum morphs were (357) comparatively higher than that of pin (321) morphs (Table 3).

Floral visitors abundance on pin morph of buckwheat during maximum bloom phase: The abundance of observed insect floral visitors was highest during 1000-1100 hrs (72 /5 min/4 inflorescence), followed by 1100-1200 hrs (63 /5 min/4 inflorescence.) and the lowest was recorded during 1700-1800 hrs (1 /5 min/4 inflorescence.). There were no floral visitors from 0600-0700 hrs. Among 24 floral visitors on pin morph, abundance of *A. cerana* Fab. (29.34%), *A. florea* Fab. (26.05%) and *A. mellifera* L. (15.27%) were relatively larger in number and together constituted 70.66 per cent. These floral visitors requires pollen and nectar for sustainable development of colony and the crop will produces numerous flowers with pollen and nectar thereby fulfilling the need of floral visitors result in effective pollination. The rest of the floral visitors (21) ranged from 0.30 (*Castalius rosimon* F.) to 4.19 per cent (*Syritta orientalis* M.) and together they constituted about 29.34 per cent, during maximum bloom phase (Table 4). These findings are supported by that of Kambrekar et al., 2018 who reported that, Hymenopterans (61.49%) were the most abundant pollinators followed by Dipterans (25.00%), Lepidopterans (12.16%) and Hemipterans (1.35%) at Dharwad, Karnataka.

Table 2. Relative abundance (No. /5 min/4 inflorescence) of floral visitors in Buckwheat (Pin morph) during initial bloom phase, 2024

Time period(hrs) / Floral visitors	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total	Relative abundance (%)	Mean±SD
Apis cerana	0	5	15	19	23	25	10	5	4	3	0	0	109	33.96	9.08±9.17
Apis mellifera	0	0	5	11	8	4	6	3	2	1	0	0	40	12.46	3.33±3.60
Apis florea	0	4	18	11	21	15	3	2	1	2	0	0	77	23.99	6.42±7.69
Rhinia sp.	0	0	0	0	2	1	0	2	0	0	0	0	5	1.56	0.42±0.79
Eristalis obliqus	0	0	0	1	2	2	1	0	0	0	0	0	6	1.87	0.50±0.80
Chrysomya marginallus	0	0	1	0	1	0	0	0	0	0	0	0	2	0.62	0.17±0.39
Campsomariella collaris	0	0	0	1	1	0	1	0	0	0	0	0	3	0.93	0.25±0.45
Serratoparagus sp.	0	0	2	0	0	1	0	0	0	0	0	0	3	0.93	0.25±0.62
Syritta orientalis	0	2	1	1	1	1	2	0	0	1	2	1	12	3.74	1.00±0.74
Sphaerophoria sulphuripes	0	1	2	0	1	1	2	0	1	1	1	0	10	3.12	0.83±0.72
Odontomyia ochropa	0	0	0	1	0	0	1	0	0	0	0	0	2	0.62	0.17±0.39
Cerceris vagans	0	0	0	1	0	2	2	0	0	1	0	1	7	2.18	0.58±0.79
Halophilus pendulus	0	0	2	1	1	0	2	1	0	0	1	1	9	2.80	0.75±0.75
Danaus chrysippus	0	0	0	0	1	1	2	1	0	0	0	0	5	1.56	0.42±0.67
Eurema hecabe	0	0	0	0	1	0	0	1	0	0	0	0	2	0.62	0.17±0.39
Tachysphere sp.	0	0	0	1	0	1	1	0	0	0	0	0	3	0.93	0.25±0.45
Ceratina sutepensis	0	0	2	1	0	1	2	2	0	0	0	0	8	2.49	0.67±0.89
Seladonia sp.	0	0	1	1	0	0	2	1	0	0	0	0	5	1.56	0.42±0.67
Camponotus cinctellus	0	0	2	1	0	1	1	0	0	1	1	0	7	2.18	0.58±0.67
Camponotus pennsylvanicus	0	0	1	2	1	0	0	1	0	1	0	0	6	1.87	0.50±0.67
Total	0	12	52	53	64	56	38	19	8	11	5	3	321	100.00	---

Table 3. Relative abundance (No. /5 min/4 inflorescence) of floral visitors in Buckwheat (Thrum morph) during initial bloom phase, 2024

Time period(hrs) / Floral visitors	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total	Relative abundance (%)	Mean ± SD
Apis cerana	0	5	21	15	23	23	9	3	4	2	0	0	105	29.41	8.75±9.25
Apis mellifera	0	0	8	11	9	4	5	4	5	1	0	0	47	13.17	3.92±3.87
Apis florea	0	5	15	10	23	19	3	4	2	2	0	0	83	23.25	6.92±7.97
Rhinia sp.	0	0	0	1	0	2	0	0	0	0	0	0	3	0.84	0.25±0.62
Eristalis obliqus	0	0	2	0	1	2	2	1	0	0	0	0	8	2.24	0.67±0.89
Chrysomya marginallus	0	1	0	1	2	1	0	0	1	0	0	0	6	1.68	0.50±0.67
Campsomariella collaris	0	0	1	0	2	1	0	0	1	0	0	0	5	1.40	0.42±0.67
Serratoparagus sp.	0	0	1	1	1	0	0	1	0	0	0	0	4	1.12	0.33±0.49
Syritta orientalis	0	1	2	2	1	2	1	1	0	2	2	1	15	4.20	1.25±0.75
Paragus tibialis	0	0	0	1	0	0	1	0	0	0	0	0	2	0.56	0.17±0.39
Sphaerophoria sulphuripes	0	0	1	2	2	0	2	0	2	1	1	1	12	3.36	1.00±0.85
Odontomyia ochropa	0	0	1	0	0	0	1	0	0	0	0	0	2	0.56	0.17±0.39
Stomorhina sp.	0	0	2	0	1	0	1	0	0	1	0	0	5	1.40	0.42±0.67
Cerceris vagans	0	0	1	0	1	2	1	0	1	0	1	1	8	2.24	0.67±0.65
Halophilus pendulus	0	0	1	0	1	1	2	0	1	0	0	0	6	1.68	0.50±0.67
Danaus chrysippus	0	0	0	1	0	1	1	0	1	0	0	0	4	1.12	0.33±0.49
Eurema hecabe	0	0	0	0	1	0	1	0	0	0	1	0	3	0.84	0.25±0.45
Tachysphere sp.	0	0	1	0	1	1	0	0	0	0	0	0	3	0.84	0.25±0.45
Ceratina sutepensis	0	0	2	2	1	2	2	1	2	0	0	0	12	3.36	1.00±0.95
Seladonia sp.	0	0	0	1	1	1	0	2	0	0	0	0	5	1.40	0.42±0.67
Camponotus cinctellus	0	0	1	2	1	0	1	1	0	2	1	0	9	2.52	0.75±0.75
Camponotus pennsylvanicus	0	0	2	1	2	1	0	1	1	0	2	0	10	2.80	0.83±0.83
Total	0	12	62	51	74	63	33	19	21	11	8	3	357	100.00	---

Table 4. Relative abundance (No. /5 min/4 inflorescence) of floral visitors in Buckwheat (Pin morph) during maximum bloom phase, 2024

Time period(hrs) / Floral visitors	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total	Relative abundance (%)	Mean ± SD
Apis cerana	0	4	14	14	26	25	5	3	4	3	0	0	98	29.34	8.17 ±9.38
Apis mellifera	0	0	6	12	9	4	7	4	7	2	0	0	51	15.27	4.25 ±4.03
Apis florea	0	5	19	13	24	18	2	3	2	1	0	0	87	26.05	7.25 ±8.75
Eristalis obliqus	0	0	1	3	2	2	1	0	0	0	0	0	9	2.69	0.75 ±1.06
Chrysomya marginallus	0	0	0	1	1	1	0	0	0	0	0	0	3	0.90	0.25 ±0.45
Campsomariella collaris	0	0	2	0	0	1	0	0	0	0	0	0	3	0.90	0.25 ±0.62
Micraspis discolor	0	0	0	0	1	0	1	0	1	0	0	0	3	0.90	0.25 ±0.45
Syritta orientalis	0	0	2	1	2	4	0	1	1	0	2	1	14	4.19	1.17 ±1.19
Haplonomia sp.	0	1	2	0	2	1	1	0	2	0	1	0	10	2.99	0.83 ±0.83
Polistes stigma tamulus	0	0	0	1	0	0	1	0	0	0	0	0	2	0.60	0.17 ±0.39
Sphaerophoria sulphuripes	0	0	2	1	1	1	2	0	0	1	2	0	10	2.99	0.83 ±0.83
Labus sp.	0	0	1	0	0	0	1	0	0	1	0	0	3	0.90	0.25 ±0.45
Castalius rosimon	0	0	0	0	0	1	0	0	0	0	0	0	1	0.30	0.08 ±0.29
Cerceris hortivaga	0	0	0	0	1	1	0	0	0	1	0	0	3	0.90	0.25 ±0.45
Halophilus pendulus	0	0	0	0	0	2	0	0	1	0	0	0	3	0.90	0.25 ±0.62
Danaus chrysippus	0	0	0	0	0	0	0	1	0	1	0	0	2	0.60	0.17 ±0.39
Eurema hecabe	0	0	0	0	1	0	0	0	1	0	0	0	2	0.60	0.17 ±0.39
Ceratina sutepensis	0	0	1	1	0	1	2	0	0	1	0	0	6	1.80	0.50 ±0.67
Camponotus pennsylvanicus	0	0	1	2	1	0	1	0	2	0	0	0	7	2.10	0.58 ±0.79
Campsomariella annulata	0	0	0	1	0	0	1	0	1	0	1	0	4	1.20	0.33 ±0.49
Camponotus cinctellus	0	0	0	1	0	0	1	1	0	0	0	0	3	0.90	0.25 ±0.45
Hypolimnas bolina	0	0	1	0	0	0	0	1	0	0	0	0	2	0.60	0.17 ±0.39
Phalanta phalantha	0	0	0	0	0	0	0	1	0	1	0	0	2	0.60	0.17 ±0.39
Braunsapis sp.	0	0	0	0	1	1	2	0	1	0	1	0	6	1.80	0.50 ±0.67
Total	0	10	52	51	72	63	28	15	23	12	7	1	334	100.00	---

Table 5. Relative abundance (No. /5 min/4 inflorescence) of floral visitors in Buckwheat (Thrum morph) during maximum bloom phase, 2024

Time period(hrs) / Floral visitors.	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total	Relative abundance (%)	Mean ± SD
Apis cerana	0	6	17	21	29	27	8	6	5	5	0	0	124	31.39	10.33±10.46
Apis mellifera	0	0	8	13	10	3	6	5	6	2	0	0	53	13.42	4.42±4.36
Apis florea	0	4	18	11	26	20	3	3	3	1	0	0	89	22.53	7.42±9.07
Rhinia sp.	0	0	1	1	2	1	0	0	0	0	0	0	5	1.27	0.42±0.67
Eristalis obliqus	0	0	0	2	3	1	2	0	0	0	0	0	8	2.03	0.67±1.07
Chrysomya marginallus	0	0	0	1	1	1	0	0	0	0	0	0	3	0.76	0.25±0.45
Campsomariella collaris	0	0	1	1	1	0	0	1	0	0	0	0	4	1.01	0.33±0.49
Micraspis discolor	0	1	0	0	0	1	0	0	1	0	0	0	3	0.76	0.25±0.45
Syritta orientalis	0	0	1	2	4	3	1	0	1	1	0	2	15	3.80	1.25±1.29
Haplonomia sp.	0	2	1	1	3	1	2	1	1	2	0	0	14	3.54	1.17±0.94
Polistes stigma tamulus	0	0	1	0	1	1	1	0	0	0	0	0	4	1.01	0.33±0.49
Sphaerophoria sulphuripes	0	1	1	0	2	2	3	0	1	2	1	1	14	3.54	1.17±0.94
Labus sp.	0	0	0	1	2	0	1	0	0	1	0	0	5	1.27	0.42±0.67
Castalius rosimon	0	0	0	1	1	0	0	1	1	0	0	0	4	1.01	0.33±0.49
Cerceris hortivaga	0	0	0	1	0	0	1	0	0	1	0	0	3	0.76	0.25±0.45
Halophilus pendulus	0	0	0	1	0	1	2	1	0	0	0	0	5	1.27	0.42±0.67
Danaus chrysippus	0	0	0	0	1	1	1	0	0	0	1	0	4	1.01	0.33±0.49
Eurema hecabe	0	0	0	0	0	1	0	0	0	1	1	0	3	0.76	0.25±0.45
Ceratina sutepensis	0	0	0	2	1	2	1	0	1	0	0	0	7	1.77	0.58±0.79
Seladonia sp.	0	0	1	0	1	1	2	1	0	0	0	0	6	1.52	0.50±0.67
Campsomariella annulata	0	0	0	0	1	1	2	1	0	0	0	0	5	1.27	0.42±0.67
Camponotus cinctellus	0	0	0	0	1	1	1	0	1	0	0	0	4	1.01	0.33±0.49
Hypolimnas bolina	0	0	0	1	0	0	1	0	0	1	1	0	4	1.01	0.33±0.49
Phalanta phalantha	0	0	0	0	0	1	0	1	1	0	0	0	3	0.76	0.25±0.45
Braunsapis sp.	0	0	0	0	0	2	3	1	0	0	0	0	6	1.52	0.50±1.00
Total	0	14	50	60	90	72	41	22	22	17	4	3	395	100.00	---

Table 6. Relative abundance (No. /5 min/4 inflorescence) of floral visitors in Buckwheat (Pin morph) during late bloom phase, 2024

Time period(hrs) / Floral visitors	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total	Relative abundance (%)	Mean ± SD
Apis cerana	0	4	14	17	20	23	9	4	4	5	0	0	100	33.00	8.33±8.17
Apis mellifera	0	0	6	10	10	3	5	2	2	1	0	0	39	12.87	3.25±3.72
Apis florea	0	5	15	10	19	14	3	1	2	1	0	0	70	23.10	5.83±6.83
Chrysomya megacephala	0	0	1	2	0	0	1	0	0	0	1	0	5	1.65	0.42±0.67
Chrysomya marginallus	0	0	1	1	0	0	1	1	0	0	0	0	4	1.32	0.33±0.49
Camponotus pennsylvanicus	0	1	2	1	0	1	0	1	0	1	0	0	7	2.31	0.58±0.67
Camponotus cinctellus	0	0	1	0	1	1	2	0	1	0	0	0	6	1.98	0.50±0.67
Formica sp.	0	1	1	0	1	0	0	0	1	0	0	0	4	1.32	0.33±0.49
Lampides boeticus	0	0	2	1	0	1	0	0	0	1	0	1	6	1.98	0.50±0.67
Eurema hecabe	0	0	1	0	1	0	1	0	1	0	0	0	4	1.32	0.33±0.49
Castalius rosimon	0	1	0	0	0	1	1	0	0	1	0	0	4	1.32	0.33±0.49
Hypolimnas bolina	0	0	0	0	1	0	0	1	1	0	0	0	3	0.99	0.25±0.45
Coccinella sp.	0	0	1	0	1	0	1	0	0	0	0	0	3	0.99	0.25±0.45
Micraspis discolor	0	1	0	0	0	0	0	1	0	0	1	0	3	0.99	0.25±0.45
Eristalis obliqus	0	0	2	1	0	1	0	1	0	0	1	0	6	1.98	0.50±0.67
Syritta orientalis	0	0	1	1	2	1	0	1	0	1	0	1	8	2.64	0.67±0.65
Haplonomia sp.	0	1	2	1	2	0	2	0	1	1	0	0	10	3.30	0.83±0.83
Ceratina sutepensis	0	0	1	0	1	1	0	1	0	1	0	0	5	1.65	0.42±0.51
Sphaerophoria sulphuripes	0	1	0	1	1	3	2	1	0	1	2	1	13	4.29	1.08±0.90
Campsomariella collaris	0	0	1	0	1	0	1	0	0	0	0	0	3	0.99	0.25±0.45
Total	0	15	52	46	61	50	29	15	13	14	5	3	303	100.00	---

Table 7. Relative abundance (No. /5 min/4 inflorescence) of floral visitors in Buckwheat (Thrum morph) during late bloom phase, 2024

Time period(hrs) / Floral visitors	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total	Relative abundance (%)	Mean ± SD
Apis cerana	0	6	17	16	20	17	4	2	4	5	0	0	91	28.44	7.58±7.63
Apis mellifera	0	0	7	10	9	3	4	5	6	2	0	0	46	14.38	3.83±3.61
Apis florea	0	3	16	12	20	17	2	3	2	1	0	0	76	23.75	6.33±7.60
Chrysomya megacephala	0	0	0	1	1	0	0	1	0	1	0	0	4	1.25	0.33±0.49
Chrysomya marginallus	0	0	1	0	1	1	0	0	1	0	0	0	4	1.25	0.33±0.49
Camponotus pennsylvanicus	0	1	1	2	0	0	1	0	1	1	0	0	7	2.19	0.58±0.67
Camponotus cinctellus	0	1	0	1	2	1	1	1	0	1	1	0	9	2.81	0.75±0.62
Formica sp.	0	1	1	1	0	1	0	1	0	0	0	0	5	1.56	0.42±0.51
Lampides boeticus	0	0	1	2	1	0	1	0	0	0	1	1	7	2.19	0.58±0.67
Eurema hecabe	0	0	1	1	0	1	1	1	0	0	1	0	6	1.88	0.50±0.52
Castalius rosimon	0	1	0	0	1	0	1	1	0	0	1	0	5	1.56	0.42±0.51
Hypolimnas bolina	0	0	0	1	0	0	1	1	0	0	0	0	3	0.94	0.25±0.45
Coccinella sp.	0	0	1	0	0	1	0	0	1	0	0	0	3	0.94	0.25±0.45
Micraspis discolor	0	1	0	0	0	1	0	0	0	0	0	0	2	0.63	0.17±0.39
Halophilus pendulus	0	0	1	0	0	2	1	0	1	0	0	0	5	1.56	0.42±0.67
Eristalis obliqus	0	0	1	2	0	0	1	0	1	1	1	0	7	2.19	0.58±0.67
Syritta orientalis	0	0	1	2	1	0	1	0	1	0	0	1	7	2.19	0.58±0.67
Haplonomia sp.	0	1	1	2	2	1	0	2	0	1	0	0	10	3.13	0.83±0.83
Ceratina sutepensis	0	0	1	1	0	1	1	0	1	0	0	0	5	1.56	0.42±0.51
Sphaerophoria sulphuripes	0	2	1	0	1	2	1	2	0	2	0	2	13	4.06	1.08±0.90
Campsomariella collaris	0	0	1	1	0	0	1	1	0	1	0	0	5	1.56	0.42±0.51
Total	0	17	53	55	59	49	22	21	19	16	5	4	320	100	---

Floral visitors abundance on thrum morph of buckwheat during maximum bloom phase: The abundance of observed insect floral visitors was highest during 1000-1100 hrs (90 /5 min/4 inflorescence), followed by 1100-1200 hrs (72 /5 min/4 inflorescence) and lowest was recorded during 1700-1800 hrs (3 /5 min/4 inflorescence). There were no floral visitors from 0600-0700 hrs. Among 25 floral visitors, abundance of *A. cerana* Fab. (31.39%), *A. florea* Fab. (22.53%) and *A. mellifera* L. (13.42%) were relatively larger in number and together constituted 67.34 per cent. The rest of the floral visitors (22) ranged from 0.76 (*Chrysomya marginallus* W*., Micraspis discolor* F*., Cerceris hortivaga* K*., Eurema hecabe* L*.* and *Phalanta phalantha* D.) to 3.80 per cent (*Syritta orientalis* M.) and together constituted about 32.66 per cent, during maximum bloom phase. Total number of visitors on thrum morph were (395) comparatively higher than that of pin (334) morph (Table 5).

Floral visitors abundance on pin morph of buckwheat during late bloom phase: The abundance of observed insect floral visitors was highest during 1000-1100 hrs (61 /5 min/4 inflorescence), followed by 0800-0900 hrs (52 /5 min/4 inflorescence) and lowest was recorded during 1700-1800 hrs (3 /5 min/4 inflorescence.). There were no floral visitors from 0600-0700 hrs. Of the 20 floral visitors, abundance of *A. cerana* Fab. (33.00%), *A. florea* Fab. (23.10%) and *A. mellifera* L. (12.87%) were relatively larger in number and together constituted 68.97 per cent. The rest of the floral visitors (17) ranged from 0.99 (*Hypolimnas bolina* L., *Coccinella* sp., *Micraspis discolor* F. and *Campsomariella collaris* F.) to 4.29 per cent (*Sphaerophoria sulphuripes* T.) and together constituted about 31.03 per cent during late bloom phase (Table 6). These findings are supported by Jacquemart et al*.* (2007) who reported that honey bees appeared to be the most numerous visitors with some syrphids and other Diptera species which act as co-pollinators due to their high relative frequency and activity in central Belgium.

Floral visitors abundance on thrum morph of buckwheat during late bloom phase: The abundance of observed insect floral visitors was highest during 1000-1100 hrs(59 /5 min/4 inflorescence.) followed by 0900-1000 hrs (55 /5 min/4 inflorescence.) and the lowest was recorded during 1700-1800 hrs (4 /5 min/4 inflorescence.). There were no floral visitors from 0600-0700 hrs. Of the 21 floral visitors, abundance of *A. cerana* Fab. (28.44%), *A. florea* Fab. (23.75%) and *A. mellifera* L. (14.38%) were relatively larger in number and together constituted 66.57 per cent. The rest of the floral visitors (18) ranged from 0.63 (*Micraspis discolor* F.) to 4.06 per cent (*Sphaerophoria sulphuripes* T.) and together constituted about 33.43 per cent, during late bloom phase. Total number of visitors on thrum morph were (320) comparatively higher than that of pin (303) morph (Table 7). The variation in the number of floral visitors on thrum morph (0.17 µl/ flower and 20.62 %) pin morph (0.14 µl/ flower and 19.55 %) may be due to variation in the mean quantity of nectar and its TSS concentration. As the nectar volume and TSS value increased, the number of honey bee visitation increase. This was clearly confirmed by Abrol (2007) that the Brassica cultivars with higher nectar concentration attracted a larger number of bees and there was a highly significant and positive correlation existed between foraging population (*A. cerana* and *A. mellifera*) and nectar volume, sugar concentration and caloric value on different brassica cultivars.

4. CONCLUSION

The research of floral visitor profile and their relative abundance on buckwheat inflorescence discovered a diverse range of floral visitors including 46 species of insects belongs to 5 insect orders and 19 families. The most diversity of floral visitors was seen in the hymenoptera comprising of 7 families of which Apidae family notably *Apis cerana* had the highest abundance throughout the day during different flowering phases of the crop. It also attracted other non-*Apis* bees other than the honeybees hence the conservation strategy for all these floral visitors is also very important for pollination and better crop yield. Since buckwheat attracts diverse floral visitors, cultivation of this crop will ensure the conservation of pollinators. Farmers are recommended to setup *Apis cerana* colony near the vicinity of the crop which will increase the yield of the crop and also benefited bee hive products like honey, wax, etc.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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