Diversity of floral visitors and foraging behaviour of major bee species on buckwheat (*Fagopyrum esculentum* M.)

ABSTRACT

The flowers of buckwheat attracted 46 insect floral visitors during different bloom phases, 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 Berger-Parker dominance index for floral visitors on pin morph and thrum morph of buckwheat varied among different blooming phase with *Apiscerana* F. being the most dominant visitor throughout blooming phase. 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.Among the dominant bee floral visitors, foraging rate of *A.cerana*was highest during maximum blooming phase.The foraging duration of*A. florea*for collection of nectar and pollen from pin and thrum morphs was highest among the major bee floral visitors recorded during maximum bloom phase.

Keyword**:** Floral visitors, diversity, foraging rate, foraging duration, nectar and pollen foraging activity.

1. Introduction

Common buckwheat (*Fagopyrum esculentum*M.) also known as buckwheat, belongs to flowering plants of Polygonaceae family. It is a pseudocereal 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 OldWorld crop which is believed to have originated in China (Ohnishi, 1998). Around 5000–6000 years ago, the first Buckwheat was sown in China (Tang *et al.,* 2009; Luitel*et al*., 2021). It was introduced into the New World by European settlers in 17th century (Treadwell and Huang, 2008). Due to its multifood use as a pseudocereal 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). In 2021, the area of buckwheat cultivation in the world was 19,88,545 ha. with a seed yield of over 18,75,067 tonnes (Plazek*et al*., 2023). The area of buckwheat cultivation varies every year due to unstable seed yield.

A total of 12 insect species, of which three species were from Apidae viz. *A.florea* F., *A.cerana* F., *A.dorsata* F. belonged to Hymenoptera, one species each was from Syrphidae (*Episyrphus* sp.), Muscidae (*Musca* sp.), Calliphoridae (*Lucilia* sp.), Sarcophagidae (*Sarcophaga* sp.) belonged to Diptera, two species from Nymphalidae (*Danaus chrysippus* L. and *Hypolimnasbolina* L.), one species each from Lycaenidae (*Euchrysopscnejus* F.) and Noctuidae (*Helicoverpaarmigera* H.) under Lepidoptera and *Lygaeuskalmii* S. (Lygaeidae) under Hemiptera 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).

Apiscerana F. started their foraging activity during early morning hours (8.24 ± 0.5 AM) which ceased late in the evening (5.18 ± 0.2 PM) compared to *A. mellifera* L. which started foraging at 8.29 ± 0.5 AM and ceased at 4.56 ± 0.5 PM. The maximum foraging duration per day was recorded in *A. cerana* F. (8.34 ± 0.9 hours) compared to *A. mellifera* L. (8.25 ± 0.9 hours). There was no significance difference on the number of buckwheat flowers visited by *A.cerana* F. and *A. mellifera* L. The number of flowers visited by *A. cerana* F. was highest at 10 AM (2.12 ± 0.67) while by *A. mellifera* L., it was highest at 2 PM (2.71 ± 0.49). The number of flowers visited by *A. cerana* and *A. mellifera* was the lowest at 4 PM (1.71 ± 0.30 and 1.93 ± 0.19) for both species of honeybees at Chitwan, Nepal (Aryal*et al.*, 2016).

Apiscerana F. started foraging activity early morning hours (06.14 ± 0.004 h) and ceased at late in the evening (17.28 ± 0.011 h). The total duration of foraging activity was 10:00 h and the average duration of each foraging trip was 4.5 ± 0.146 min. The time spent by *A. cerana* F. on the buckwheat inflorescence at 09.00 AM was found to be longest (24 ± 3 min) and it decreased at 12.00 PM (20 ± 3 min) and it reached to 16 ± 3 min. at 15.00 PM on buckwheat flowers at Kathmandu, Nepal (Singh, 2008).

The highest numbers of *A. cerana* F. (9.28±2.62 and 6.57±2.72) were recorded at 11 AM and 1 PM, with the lowest (0.92±0.83 and 0.85±0.94) at 7 AM and 5 PM. The highest number of *A. dorsata* F. foragers (4.83±1.60 and 3±0.90) were recorded during 1 PM and 11 AM, with the lowest (0.67±0.81 and 0.58±0.69) between 3 PM and 9 AM and none at 7 AM. *A. florea* F. (2.45±0.64 and 1.25±0.72) was most active during 11 AM and 1 PM, with the least (0.99±0.74 and 0.64±0.64) at 9 AM and 3 PM and no activity during 7 AM and 5 PM. *A. mellifera* L. (3.8±1.4 and 1.47±1.31) had the highest numbers from 11 AM to 1 PM, with the lowest (0.82±0.57and 0.8±0.7) at 3 PM and 9 AM and no activity at 7 AM and 5 PMat Dhaka, Bangladesh (Akter*et al.*, 2023).

Dhakal (2003) observed that *A. cerana* F. started foraging on buckwheat at 7.03±0.22 AM and ceased foraging at 4.51±0.15 PM while, *A. mellifera* L. started foraging at 7.29±0.28 AM and ceased at 4.48±0.13 PM.

The foraging activity of *A.cerana* F. was highest during 09:00 to 10:00 hrs with maximum number of 9.2 foragers/ m2/ min. Maximum number of returning foragers (6.2/m^2 /min) and amount of time spent (3.2 sec/floret) were also found in the same period indicating that 09:00 to 10:00 hrs was the best time for foraging. The foraging activity declined gradually during the evening hours of the day attaining minimum of 0.8 at 16:00 hrs at Jorhat, Assam (Rahman and Rahman, 2000).

In Karnataka at Dharwad, Kambrekar, *et al*., (2018) studied only on insect species visiting the buckwheat flowers.Hence the present study aims to record floral visitors, their diversity, foraging rate, foraging duration, nectar and pollen foraging activity.

2. MATERIALS AND METHODS

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 during 2023-24.

Documentation of flower visitors on buckwheat inflorescence

The crop was raised in a Randomized Block Design at NBAIR, Attur in December2023**.** 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 (70 %) to kill the insect floral visitors. Insects collected from sweep samples were brought to the laboratory, mounted by using insect pins, properly dried and preservedfor 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.

Determination of pollen and nectar gatherers

Among the floral visitors, most frequent visiting species and type of floral resource (nectar/pollen) they collected were recognized during these observations for further studies on foraging behaviour (Belavadi and Ganeshaiah., 2013). Those floral visitors collected and

stored the pollen in their corbicula are considered as pollen gatherers and those collected only nectar by inserting their proboscis in to the nectaries of flowers are treated as nectar gatherers.

Shannon-Wiener index of diversity (H)

The frequency of visits by each species was recorded to identify the most abundant insect species effecting buckwheat pollination. Pollinator count data was used to compute the Shannon- Wiener diversity index (H), by using the following formula:

$$H = - \Sigma Pi \times \ln Pi$$

where, 'H' is the Shannon-Wiener Index of diversity

'Pi' is the proportion of thei^{th} species of pollinator.

Berger-Parker dominance index

The dominant species on any given sampling day was determined by the Berger-Parker dominance index 'd', which gives the proportion of the total numbers of individuals in a sample that is due to the dominant species and was calculated by using the following formula:

$$d = ni / NT$$

where, 'd' is the index of dominance

'ni' is the number of individuals of the i^{th} species on sampling date

'NT' is the total number of individuals in the sample.

Foraging rate (number of florets visited per bee per minute) of major bee floral visitors

The fresh individual major beefloral visitors were tracked for collection of floral rewards for the period of one minute and the number of florets visited during this period was counted and expressed in terms of number of florets visited by the individual bees species per minute. The same observation was replicated four times from 06:00 to 18:00 hrs at one-hour interval.

Time spent by individual foragers on each flower

The individual honey bee species during maximumblooming phase were carefully observed at hourly intervals starting from 06:00 upto18:00 hrs and the duration taken starting from arrival on a particular flower till its departure after foraging of pollen and nectar from

pin and thrummorph were recorded by using a digital stop watch. The duration taken by four different honey bee species at hourly intervals was recorded and the mean was calculated. The time spent was expressed in seconds per flower.

3. RESULTS AND DISCUSSION

Documentation of flower visitors on buckwheat inflorescence

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. Of these, twenty-one species were Hymenopteran*sviz., Apiscerana* Fab.,*A. mellifera* L.,*A. dorsata* Fab. and *A. florea* Fab., were the *Apis* species, whereas, *Braunsapis* sp., *Ceratinasutepensis*Cockerell and *Xylocopa* sp. were the non-*Apis* species which belonged to Apidae, foraged for nectar and pollen. *Cercerishortivaga* K., *Cercerisvagans* R. and *Tachysphere* sp. belonged to Crabronidae,which foraged for nectar. *Campsomariellacollariscollaris* F. and *C.annulata* F. belonged to Scoliidae, which foraged for nectar. *Labus* sp., *Delta conoideum* G. and *Polistes stigma tamulus* F. which foraged for nectar and they belonged to family Vespidae. *Chrysis angolensis*R. belonged to familyChrysididaeand foraged for nectar. *Seladonia* sp. and*Hoplonomiawestwoodi* belonged to Halictidae and they foraged for nectar and pollen. *Camponotuspennsylvanicus* (De Geer), *C.cinctellus* G. and *Formica* sp. belonged to family Formicidae and they foraged for nectar (Table 1).

Fourteen species under orderDiptera*viz., Chrysomyamarginallus* W. and *C.megacephala* F. belonged to familyCalliphoridae, which foraged for nectar. *Syrittaorientalis* M., *Eristalisobliqus* W., *Serratoparagus* sp., *Paragus tibialis* F., *Sphaerophoriasulphuripes* T. and *Halophiluspendulus* L. belonged to family Syrphidae, which foraged for nectar. *Odontomyiaochropa* T. and *Hermetiaillucens* L. belonged to familyStratiomyidaeand they foraged for nectar. *Stomorhina* sp., *Rhinia* sp. and *Stomorhinaxanthogaster* W. belonged to familyRhiniidaeand foraged for nectar (Table 1).

Six species of Lepidopteran*sviz., Danaus chrysippus* L., *Phalantaphalantha* D. and *Hypolimnasbolina* L. belonged to familyNymphalidaeand they foraged for nectar. *Euremahecabe*L. belonged to family Pieridae, which foraged for nectar. L*ampidesboeticus* L. and *Castaliusrosimon* F. belonged to family Lycaenidae which foraged for nectar (Table 1).

Three species of Hemiptera among which*Cletus trigonus*T. belonged to family Coreidae, which foraged for nectar,*Riptortuslinearis*L. belonged to family Alydidae, which foraged for nectar and*Halyomorpha*sp.belonged to family Pentatomidae, which foraged for

nectar (Table 1). Two species of Coleopterans*viz.*, *Micraspisdiscolor* F.and *Coccinella* sp.belonged to family Coccinellidae, which foraged for pollen (Table 1). These findings were 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.

Berger-Parker dominance index (d) of floral visitors on pin morph of buckwheat at initial, maximum and late bloom phases during 2024

The Berger-Parker dominance index values for floral visitors on pin morph varied among initial (0.006-0.340), maximum (0.006-0.293) and late (0.010-0.330) bloom phaseof buckwheat.*Apiscerana*F.wasthe most dominant insect floral visitor with the highest 'd' value of 0.340, followed by *A. florea* Fab. (0.240) and *A. mellifera* L. (0.125).*Odontomyiaochropa* T.,*Chrysomyamarginallus*W. and *Euremahecabe*L. (0.006) were the least dominant floral visitors duringinitial bloom phase.The maximum (166.67) abundance (1/d) values were observed in*Odontomyiaochropa* T.,*Chrysomyamarginallus*W. and *Euremahecabe* L. whereas minimum (2.94) abundance (1/d) value was seen in *Apiscerana* F.duringinitial bloom phase. During maximum bloom phase, *A. cerana Fab.* was the most dominant floral visitor with highest 'd' value of 0.293, followed by *A. florea* Fab. (0.261) and *A. mellifera* L. (0.153). *Danaus chrysippus* L. and *Euremahecabe*L. were the least dominant floral visitors with each having 'd' value of 0.006.The maximum (166.67) abundance (1/d) values were observed in*Danaus chrysippus* L. and *Euremahecabe*L. whereas minimum (3.41) abundance (1/d) value was seen in *Apiscerana* F.duringmaximum bloom phase.Similarly, *A. cerana* Fab. was the most dominant floral visitor with the highest 'd' value of 0.330, followed by *A. florea* Fab. (0.231) and *A. mellifera* L. (129). *Micraspisdiscolor*F.,*Hypolimnasbolina*L. and *Coccinella* sp. were the least dominant visitors during late bloom phase, with each having 'd' value of 0.010 (Table 2).The maximum (100.00) abundance (1/d) values were observed in *Micraspisdiscolor*F.,*Hypolimnasbolina*L. and *Coccinella* sp. whereas minimum (3.03) abundance (1/d) value was seen in *Apiscerana* F. during late bloom phase. Ali *et al.* (2023) recorded23 species of buckwheat pollinators belongs to four orders of class Insecta among which highest number of floral visitors on buckwheat was recorded in Hymenoptera (40%) followed by Diptera (33%), Lepidoptera (20%) and Coleoptera (7%).

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

Sl	Order	Family	Species	Reward

No.				collected
1	Hymenoptera	Crabronidae	*Cercerishortivaga*K.	N
2			*Cercerisvagans*R.	N
3			*Tachyspheres*p.	N
4		Apidae	*Apisceranа*F.	N+P
5			*Apis mellifera* L.	N+P
6			*Apisdorsata*F.	N+P
7			*Apisflorea*F.	N+P
8			*Xylocopa*sp.	N+P
9			*Braunsapis*sp.	N+P
10			*Ceratinasutepensis*Cockerell	N+P
11		Scoliidae	*Campsomariellacollariscollaris*F.	N
12			*Campsomariellaannulata*F.	N
13		Vespidae	*Delta conoideum*G.	N
14			*Labus*sp.	N
15			*Polistes stigma tamulus*F.	N
16		Chrysididae	*Chrysis angolensis*R.	N
17		Halictidae	*Seladonia*sp.	N+P
18			*Hoplonomiawestwoodi*	N+P
19		Formicidae	*Camponotuspennsylvanicus*(De Geer)	N
20			*Camponotuscinctellus*G.	N
21			*Formica* sp.	N
22	Diptera	Calliphoridae	*Chrysomyamarginallus*W.	N
23			*Chrysomyamegacephala*F.	N
24		Syrphidae	*Syrittaorientalis*M.	N
25			*Eristalisobliqus*W.	N
26			*Serratoparagus*sp.	N
27			*Paragus tibialis* F.	N
28			*Sphaerophoriasulphuripes*T.	N
29			*Halophiluspendulus*L.	N
30		Stratiomyidae	*Odontomyiaochropa*T.	N
31			*Hermetiaillucens*L.	N
32		Rhiniidae	*Stomorhina* sp.	N
33			*Rhinia*sp.	N
34			*Stomorhinaxanthogaster*W.	N
35		Muscidae	*Musca* sp.	N
36	Lepidoptera	Nymphalidae	*Danaus chrysippus*L.	N
37			*Phalantaphalantha*D.	N
38			*Hypolimnasbolina*L.	N
39		Pieridae	*Euremahecabe*L.	N
40		Lycaenidae	*Lampidesboeticus*L.	N
41			*Castaliusrosimon*F.	N
42	Hemiptera	Coreidae	*Cletus trigonus*T.	N
43		Alydidae	*Riptortuslinearis*L.	N
44		Pentatomidae	*Halyomorpha*sp.	N
45	Coleoptera	Coccinellidae	*Micraspisdiscolor*F.	P
46			*Coccinella*sp.	P

Note: N-Nectar; P-Pollen

Berger-Parker dominance index (d) of floral visitors on thrum morph of buckwheat at initial, maximum and late bloom phases during 2024

The Berger-Parker dominance index values for floral visitors on pin morph varied among initial (0.006-0.294), maximum (0.008-0.314) and late (0.006-0.284) bloom phase of buckwheat.*Apiscerana* F. was most dominant insect floral visitor with the highest 'd' value of 0.294, followed by *A. florea* Fab. (0.232) and *A. mellifera* L. (0.131). *Odontomyiaochropa* T.and *Paragus tibialis* F.(0.006) were the least dominant floral visitors duringinitial bloom phase. The maximum (166.67) abundance (1/d) values were observed in *Odontomyiaochropa* T.and *Paragus tibialis* F.whereas minimum (3.40) abundance (1/d) value was seen in *Apiscerana* F. during initial bloom phase. During maximum bloom phase, *A. cerana Fab*. was the most dominant floral visitor, with highest 'd' value of 0.314 followed by *A. florea* Fab. (0.235) and *A. mellifera* L. (0.134).*C.marginallus*W.,*M.discolor*F.,*C.hortivaga*K.,P*halantaphalantha*D. and *Euremahecabe*L. were the least dominant floral visitors with each having 'd' value of 0.008.The maximum (125.00) abundance (1/d) values were observed in *C.marginallus*W.,*M.discolor*F.,*C.hortivaga*K.,*Phalantaphalantha*D. and *Euremahecabe*L. whereas minimum (3.18) abundance (1/d) value was seen in *A.cerana* F. during maximum bloom phase. Similarly, *A. cerana* Fab. was the most dominant floral visitor, with the highest 'd' value of 0.284,followed by *A. florea* Fab. (0.238) and *A. mellifera* L. (144). *Micraspisdiscolor*F. was the least dominant visitor during late bloom phase, with 'd' value of 0.006.The maximum (166.67) abundance (1/d) value was observed in *M.discolor*F., whereas minimum (3.52) abundance (1/d) value was seen in *Apiscerana* F. during late bloom phase (Table 3).

Shannon-Wiener Index of diversity (H) of floral visitors (No./4 inflorescence/5mins) in buckwheat during different bloom phase, 2024

The diversity of floral visitors was highest during maximum blooming phase on pin (2.18) and thrum morph (2.29) compared to initial (2.13 & 2.28) and late blooming (2.17 & 2.27) phases. Irrespective of blooming phases the diversity of floral visitors was maximum on thrum morph compared to pin morph (Table 4&5).

Number of flowers visited by *Apis* species of honey bees (No. of florets/4 bees/min) in open plot during different bloomingphases of buckwheat

In all the blooming phases, *A. cerana* started visiting the florets from 07:00-08:00 hrs (51, 52 and 51 florets/4 bees/min) and the number of florets visited increased gradually and reached maximum during 10:00-11:00 hrs (85, 68 and 63 florets/4 bees/min). Thereafter, the number of florets visited declined upto 13:00-14:00 hrs and then number of florets visited

increased at 14:00-15:00 hrs (50, 51 and 50 florets/4 bees/min). Visitation of florets by *A. cerana*completelyceased from 16:00-18:00 hrs.

A. florea started visiting the florets from 07:00-08:00 hrs (12, 14 and 18florets/4 bees/min) and the number of florets visited increased gradually and reached maximum during 09:00-10:00 hrs (53, 50 and 61 florets/4 bees/min). Thereafter, the number of florets visited declined upto 12:00-13:00 hrs and then number of florets visited increased at 13:00-14:00 hrs (36, 40 and 46 florets/4 bees/min).Florets visitation by *A. florea* ceased completelyfrom 16:00-18:00 hrs in all the blooming phases.

Florets visitation by*A. mellifera* started from 08:00-09:00 hrs (5, 49 and 49florets/4 bees/min) and the number of florets visited increased gradually and reached maximum during 10:00-11:00 hrs (92, 92 and 81 florets/4 bees/min). Thereafter, the number of florets visited declined upto 13:00-14:00 hrs and then number of florets visited increased at 14:00-15:00 hrs (57, 57 and 55 florets/4 bees/min).Florets visitation by *A. mellifera* ceasedcompletelyfrom 16:00-18:00 hrs in all the blooming phases.

Irrespective of blooming phases none of the bees from *Tetragonulairidipennis*visited the florets in open plot of buckwheat.

Table 2: Berger-Parker dominance index (d) of floral visitors on pin morph of buckwheat at initial, maximum and late bloom phases during 2024

Floral visitors	'd' value of floral visitors at different Phases of Bloom					
	Pin					
	Initial		Maximum		Late	
	d	1/d	d	1/d	d	1/d
Apiscerana	0.340	2.94	0.293	3.41	0.330	3.03
Apis mellifera	0.125	8.00	0.153	6.54	0.129	7.75
Apisflorea	0.240	4.17	0.261	3.83	0.231	4.33
***Rhinia*sp.**	0.016	62.50	0.000	0.000	0.000	0.000
Eristalisobliqus	0.019	52.63	0.027	37.04	0.015	66.67
Chrysomyamarginallus	0.006	166.67	0.009	111.11	0.013	76.92
Campsomariellacollaris	0.009	111.11	0.009	111.11	0.000	0.000
***Serratoparagus*sp.**	0.009	111.11	0.000	0.000	0.000	0.000
Syrittaorientalis	0.037	27.03	0.042	23.81	0.042	23.81
Sphaerophoriasulphuripes	0.031	32.26	0.034	29.41	0.030	33.33
Odontomyiaochropa	0.006	166.67	0.000	0.000	0.000	0.000
Cercerisvagans	0.022	45.45	0.000	0.000	0.000	0.000
Halophiluspendulus	0.028	35.71	0.009	111.11	0.000	0.000
Danaus chrysippus	0.016	62.50	0.006	166.67	0.000	0.000
Euremahecabe	0.006	166.67	0.006	166.67	0.013	76.92
***Tachysphere*sp.**	0.009	111.11	0.000	0.000	0.000	0.000
Ceratinasutepensis	0.025	40.00	0.018	55.56	0.000	0.000
***Seladonia*sp.**	0.016	62.50	0.000	0.000	0.000	0.000
Camponotuscinctellus	0.022	45.45	0.009	111.11	0.020	50.00
Camponotuspennsylvanicus	0.019	52.63	0.021	47.62	0.023	43.48
Paragus tibialis	0.000	0.000	0.000	0.000	0.000	0.000
***Stomorhina*sp.**	0.000	0.000	0.000	0.000	0.000	0.000
Micraspis discolor	0.000	0.000	0.009	111.11	0.010	100.00
***Haplonomia*sp.**	0.000	0.000	0.030	33.33	0.033	30.30
Polistes stigma tamulus	0.000	0.000	0.006	166.67	0.000	0.000
***Labus*sp.**	0.000	0.000	0.009	111.11	0.000	0.000
Castaliusrosimon	0.000	0.000	0.003	333.33	0.013	76.92
Cercerishortivaga	0.000	0.000	0.009	111.11	0.000	0.000
Campsomariellaannulata	0.000	0.000	0.012	83.33	0.000	0.000
Hypolimnasbolina	0.000	0.000	0.006	166.67	0.010	100.00
Phalantaphalantha	0.000	0.000	0.006	166.67	0.000	0.000
***Braunsapis*sp.**	0.000	0.000	0.018	55.56	0.000	0.000
Chrysomyamegacephala	0.000	0.000	0.000	0.000	0.017	58.82
***Formica* sp.**	0.000	0.000	0.000	0.000	0.013	76.92
Lampidesboeticus	0.000	0.000	0.000	0.000	0.020	50.00
***Coccinella*sp.**	0.000	0.000	0.000	0.000	0.010	100.00

Table 3: Berger-Parker dominance index (d) of floral visitors on thrum morph of buckwheat at initial, maximum and late bloom phases during 2024

Floral visitors	'd' value of floral visitors at different Phases of Bloom					
	Thrum					
	Initial		Maximum		Late	
	d	1/d	d	1/d	d	1/d
Apiscerana	0.294	3.40	0.314	3.18	0.284	3.52
Apis mellifera	0.131	7.63	0.134	7.46	0.144	6.94
Apisflorea	0.232	4.31	0.235	4.26	0.238	4.20
***Rhinia*sp.**	0.008	125.00	0.013	76.92	0.000	0.000
Eristalisobliqus	0.022	45.45	0.020	50.00	0.022	45.45
Chrysomyamarginallus	0.017	58.82	0.008	125.00	0.013	76.92
Campsomariellacollaris	0.014	71.43	0.010	100.00	0.000	0.000
***Serratoparagus*sp.**	0.011	90.91	0.000	0.000	0.000	0.000
Syrittaorientalis	0.038	26.32	0.026	38.46	0.022	45.45
Sphaerophoriasulphuripes	0.035	28.57	0.043	23.26	0.041	24.39
Odontomyiaochropa	0.006	166.67	0.000	0.000	0.000	0.000
Cercerisvagans	0.022	45.45	0.000	0.000	0.000	0.000
Halophiluspendulus	0.017	58.82	0.013	76.92	0.016	62.50
Danaus chrysippus	0.011	90.91	0.010	100.00	0.000	0.000
Euremahecabe	0.008	125.00	0.008	125.00	0.019	52.63
***Tachysphere*sp.**	0.008	125.00	0.000	0.000	0.000	0.000
Ceratinasutepensis	0.034	29.41	0.018	55.56	0.000	0.000
***Seladonia*sp.**	0.014	71.43	0.015	66.67	0.000	0.000
Camponotuscinctellus	0.025	40.00	0.010	100.00	0.028	35.71
Camponotuspennsylvanicus	0.028	35.71	0.000	0.000	0.022	45.45
Paragus tibialis	0.006	166.67	0.000	0.000	0.000	0.000
***Stomorhina*sp.**	0.014	71.43	0.000	0.000	0.000	0.000
Micraspis discolor	0.000	0.000	0.008	0.000	0.006	166.67
***Haplonomia*sp.**	0.000	0.000	0.035	28.57	0.031	32.26
Polistes stigma tamulus	0.000	0.000	0.010	100.00	0.000	0.000
***Labus*sp.**	0.000	0.000	0.013	76.92	0.000	0.000
Castaliusrosimon	0.000	0.000	0.010	100.00	0.016	62.50
Cercerishortivaga	0.000	0.000	0.008	125.00	0.000	0.000
Campsomariellaannulata	0.000	0.000	0.013	76.92	0.000	0.000
Hypolimnasbolina	0.000	0.000	0.010	100.00	0.009	111.11
Phalantaphalantha	0.000	0.000	0.008	125.00	0.000	0.000
***Braunsapis*sp.**	0.000	0.000	0.015	66.67	0.000	0.000
Chrysomyamegacephala	0.000	0.000	0.000	0.000	0.013	76.92
***Formica* sp.**	0.000	0.000	0.000	0.000	0.016	62.50
Lampidesboeticus	0.000	0.000	0.000	0.000	0.022	45.45
***Coccinella*sp.**	0.000	0.000	0.000	0.000	0.009	111.11

Table 4: Shannon-Wiener Index of diversity (H) of floral visitors (No. /4 inflorescence/5mins) on pin morph of buckwheat during different bloom phases(2024)

Initial blooming phase		Maximum blooming phase		Late blooming phase	
Floral visitors	**Total**	**Floral visitors**	**Total**	**Floral visitors**	**Total**
Apiscerana	109	*Apiscerana*	98	*Apiscerana*	100
Apis mellifera	40	*Apis mellifera*	51	*Apis mellifera*	39
Apisflorea	77	*Apisflorea*	87	*Apisflorea*	70
*Rhinia*sp.	5	*Eristalisobliqus*	9	*Chrysomyamegacephala*	5
Eristalisobliqus	6	*Chrysomyamarginallus*	3	*Chrysomyamarginallus*	4
Chrysomyamarginallus	2	*Campsomariellacollaris*	3	*Camponotuspennsylvanicus*	7
Campsomariellacollaris	3	*Micraspis discolor*	3	*Camponotuscinctellus*	6
*Serratoparagus*sp.	3	*Syrittaorientalis*	14	*Formica* sp.	4
Syrittaorientalis	12	*Haplonomia*sp.	10	*Lampidesboeticus*	6
Sphaerophoriasulphuripes	10	*Polistes stigma tamulus*	2	*Euremahecabe*	4
Odontomyiaochropa	2	*Sphaerophoriasulphuripes*	10	*Castaliusrosimon*	4
Cercerisvagans	7	*Labus*sp.	3	*Hypolimnasbolina*	3
Halophiluspendulus	9	*Castaliusrosimon*	1	*Coccinella*sp.	3
Danaus chrysippus	5	*Cercerishortivaga*	3	*Micraspis discolor*	3
Euremahecabe	2	*Halophiluspendulus*	3	*Eristaliobliqus*	6
*Tachysphere*sp.	3	*Danaus chrysippus*	2	*Syrittaorientalis*	8
Ceratinasutepensis	8	*Euremahecabe*	2	*Haplonomia*sp.	10
*Seladonia*sp.	5	*Ceratinasutepensis*	6	*Ceratinasutepensis*	5
Camponotuscinctellus	7	*Camponotuspennsylvanicus*	7	*Sphaerophoriasulphuripes*	13
Camponotuspennsylvanicus	6	*Campsomariellaannulata*	4	*Campsomariellacollaris*	3
		Camponotuscinctellus	3		
		Hypolimnasbolina	2		
		Phalantaphalantha	2		
		*Braunsapis*sp.	6		
Total	**321**	**Total**	**334**	**Total**	**303**
Shannon Wiener index 'H' value	**2.13**	**Shannon Wiener index 'H' value**	**2.18**	**Shannon Wiener index 'H' value**	**2.17**

Table 5: Shannon-Wiener Index of diversity (H) of floral visitors (No. /4 inflorescence/5mins) on thrum morph of buckwheat during different bloom phases(2024)

Initial blooming phase		Maximum blooming phase		Late blooming phase	
Floral visitors	**Total**	**Floral visitors**	**Total**	**Floral visitors**	**Total**
Apiscerana	105	*Apiscerana*	124	*Apiscerana*	91
Apis mellifera	47	*Apis mellifera*	53	*Apis mellifera*	46
Apisflorea	83	*Apisflorea*	89	*Apisflorea*	76
*Rhinia*sp.	3	*Rhinia*sp.	5	*Chrysomyamegacephala*	4
Eristalisobliqus	8	*Eristalisobliqus*	8	*Chrysomyamarginallus*	4
Chrysomyamarginallus	6	*Chrysomyamarginallus*	3	*Camponotuspennsylvanicus*	7
Campsomariellacollaris	5	*Campsomariellacollaris*	4	*Camponotuscinctellus*	9
*Serratoparagus*sp.	4	*Micraspis discolor*	3	*Formica* sp.	5
Syrittaorientalis	15	*Syrittaorientalis*	15	*Lampidesboeticus*	7
Paragus tibialis	2	*Haplonomia*sp.	14	*Euremahecabe*	6
Sphaerophoriasulphuripes	12	*Polistes stigma tamulus*	4	*Castaliusrosimon*	5
Odontomyiaochropa	2	*Sphaerophoriasulphuripes*	14	*Hypolimnasbolina*	3
*Stomorhina*sp.	5	*Labus*sp.	5	*Coccinella*sp.	3
Cercerisvagans	8	*Castaliusrosimon*	4	*Micraspis discolor*	2
Halophiluspendulus	6	*Cercerishortivaga*	3	*Halophiluspendulus*	5
Danaus chrysippus	4	*Halophiluspendulus*	5	*Eristaliobliqus*	7
Euremahecabe	3	*Danaus chrysippus*	4	*Syrittaorientalis*	7
*Tachysphere*sp.	3	*Euremahecabe*	3	*Haplonomia*sp.	10
Ceratinasutepensis	12	*Ceratinasutepensis*	7	*Ceratinasutepensis*	5
*Seladonia*sp.	5	*Seladonia*sp.	6	*Sphaerophoriasulphuripes*	13
Camponotuscinctellus	9	*Campsomariellaannulata*	5	*Campsomariellacollaris*	5
Camponotuspennsylvanicus	10	*Camponotuscinctellus*	4		
		Hypolimnasbolina	4		
		Phalantaphalantha	3		
		*Braunsapis*sp.	6		
Total	**357**	**Total**	**395**	**Total**	**320**
Shannon Wiener index 'H' value	**2.28**	**Shannon Wiener index 'H' value**	**2.29**	**Shannon Wiener index 'H' value**	**2.27**

The mean number of flowers visited by*A. cerana* Fab (55.89, 58.56 and 54.56florets/4 bees/min) was highest compared to*A. mellifera* L. (44.63, 55 and 52.50florets/4 bees/min)and *A.florea* Fab(29.44, 34.11 and 33.67florets/4 bees/min), this might be due to variation of foraging rate in terms of handling of floral rewards by the *Apis* species (Table 6).

Number of flowers visited by *Apis* species of honey bees (No. of florets/4 bees/min) in caged plot during different bloomingphases of buckwheat

In all the blooming phases, *A. cerana* started visiting the florets from 07:00-08:00 hrs (52, 52 and 50florets/4 bees/min) and the number of florets visited increased gradually and reached maximum during 10:00-11:00 hrs (102, 92 and 90 florets/4 bees/min). Thereafter, the number of florets visited declined at 13:00-14:00 hrs and then number of florets visited increased at 14:00-15:00 hrs (51, 69 and 79 florets/4 bees/min). Visitation of florets by *A. cerana*completelyceased from 16:00-18:00 hrs.

Florets visitation by*A. mellifera* started from 08:00-09:00 hrs (47, 56 and 51florets/4 bees/min) and the number of florets visited increased gradually and reached maximum during 10:00-11:00 hrs (89, 92 and 91 florets/4 bees/min). Thereafter, the number of florets visited declined at 12:00-13:00 hrs and then number of florets visited increased at 13:00-14:00 hrs (61, 66 and 60 florets/4 bees/min).Florets visitation by *A. mellifera* ceasedcompletelyfrom 16:00-18:00 hrs in all the blooming phases.

Irrespective of blooming phases none of the *Tetragonulairidipennis*beesvisited the florets in caged plot of buckwheat.

The mean number of flowers visited by*A. cerana* Fab (62.44, 75.11 and 68.78florets/4 bees/min) was highest compared to*A. mellifera* L. (52.75, 63 and 58.88florets/4 bees/min),this might be due to variation of foraging rate in terms of handling of floral rewards by the *Apis* species. Non visitation of florets by *Tetragonulairidipennis*either in open or in caged plot might be due to emitence of volatile compounds either from floral rewards or from parts of the plant (Table 7).

Table 6: Number of florets visited by major bee floral visitors (No. of florets/4 bees/min.) in open plot during different blooming phase of buckwheat, 2024

***Apis* species**	**Initial bloom phase**				**Maximum bloom phase**				**Late bloom phase**			
Time (hrs)	***A. c***	***A. f***	***A. m***	***T. i***	***A. c***	***A. f***	***A. m***	***T. i***	***A. c***	***A. f***	***A. m***	***T. i***
06:00-07:00	0.00	0.00	0.00	---	0.00	0.00	0.00	---	0.00	0.00	0.00	---
07:00-08:00	51.00	12.00	0.00	---	52.00	14.00	0.00	---	51.00	18.00	0.00	---
08:00-09:00	65.00	21.00	5.00	---	67.00	24.00	49.00	---	62.00	45.00	49.00	---
09:00-10:00	65.00	53.00	12.00	---	99.00	50.00	51.00	---	79.00	61.00	50.00	---
10:00-11:00	85.00	36.00	92.00	---	68.00	39.00	92.00	---	63.00	45.00	81.00	---
11:00-12:00	49.00	35.00	65.00	---	49.00	38.00	65.00	---	51.00	35.00	62.00	---
12:00-13:00	46.00	34.00	46.00	---	47.00	36.00	46.00	---	47.00	26.00	43.00	---
13:00-14:00	46.00	36.00	43.00	---	46.00	40.00	43.00	---	45.00	46.00	41.00	---
14:00-15:00	50.00	33.00	57.00	---	51.00	32.00	57.00	---	50.00	20.00	55.00	---
15:00-16:00	46.00	5.00	37.00	---	48.00	34.00	37.00	---	43.00	7.00	39.00	---
16:00-17:00	0.00	0.00	0.00	---	0.00	0.00	0.00	---	0.00	0.00	0.00	---
17:00-18:00	0.00	0.00	0.00	---	0.00	0.00	0.00	---	0.00	0.00	0.00	---
Mean	**55.89**	**29.44**	**44.63**	**---**	**58.56**	**34.11**	**55.00**	**---**	**54.56**	**33.67**	**52.50**	**---**
SE (m)±	**4.43**	**4.83**	**9.92**	**---**	**5.76**	**3.41**	**6.09**	**---**	**3.82**	**5.73**	**4.88**	**---**
Florets visited/bee	**13.97**	**7.36**	**11.15**	**---**	**14.64**	**8.52**	**13.75**	**---**	**13.63**	**8.41**	**13.13**	**---**

A. c*- *Apiscerana* *A. f*- *Apisflorea* *A. m*- *Apis mellifera* *T. i*- *Tetragonulairidipennis

Table 7: Number of florets visited by major bee floral visitors (No. of florets/4 bees/min.) in caged plot during different blooming phase of buckwheat, 2024

***Apis* species** **Time (hrs)**	**Initial bloom phase**			**Maximum bloom phase**			**Late bloom phase**		
	A. c	***A. m***	***T. i***	***A. c***	***A. m***	***T. i***	***A. c***	***A. m***	***T. i***
06:00-07:00	0.00	0.00	---	0.00	0.00	---	0.00	0.00	---
07:00-08:00	52.00	0.00	---	52.00	0.00	---	50.00	0.00	---
08:00-09:00	68.00	47.00	---	54.00	56.00	---	52.00	51.00	---
09:00-10:00	99.00	49.00	---	90.00	88.00	---	65.00	85.00	---
10:00-11:00	102.00	89.00	---	92.00	92.00	---	90.00	91.00	---
11:00-12:00	49.00	37.00	---	88.00	63.00	---	83.00	61.00	---
12:00-13:00	47.00	43.00	---	85.00	35.00	---	81.00	34.00	---
13:00-14:00	46.00	61.00	---	83.00	66.00	---	54.00	60.00	---
14:00-15:00	51.00	55.00	---	69.00	58.00	---	79.00	47.00	---
15:00-16:00	48.00	41.00	---	63.00	46.00	---	56.00	42.00	---
16:00-17:00	0.00	0.00	---	0.00	0.00	---	0.00	0.00	---
17:00-18:00	0.00	0.00	---	0.00	0.00	---	0.00	0.00	---
Mean	**62.44**	**52.75**	**---**	**75.11**	**63.00**	**---**	**68.78**	**58.88**	**---**
SE (m)±	**7.52**	**5.85**	**---**	**5.36**	**6.84**	**---**	**5.17**	**7.10**	**---**
Florets visited/bee	**15.61**	**13.19**	**---**	**18.77**	**15.75**	**---**	**16.94**	**14.72**	**---**

A. c*- Apiscerana* ***A. f****- Apisflorea* ***A. m****- Apismellifera****T.i****- Tetragonulairidipennis*

Nectar foraging duration of *Apis* species of honeybees on pin and thrum morphs of buckwheatduring maximum bloom phase

The times spent for collection of nectar from pin and thrum morphs of buckwheat by the honey bees varied significantly during different hours of the day (Table 8).

The foragers of *A. cerana* spent least foraging duration (3.25sec/flower) on the pin morph during 09:00-10:00 hrs for nectar collection. The duration for nectar foraging gradually increased and reached a maximum (4.50sec/flower) during 12:00 to 13:00 hrs and then declined to 3.00seconds per flowerduring15:00-16:00 hrs. The foragers of *A. florea*spent least foraging duration (3.50sec/flower) on the pin morph during 08:00-09:00 hrs for nectar collection. The duration for nectar foraging gradually increased and reached a maximum (12.75sec/flower) during 12:00 to 13:00 hrs and then declined to 7.00 seconds per flowerduring15:00-16:00 hrs. Similarly, the foraging duration of *A. mellifera* for nectar collection gradually increased from 08:00-09:00 hrs (3.25sec/flower) and reached a maximum (6.75sec/flower) during 11:00 to 12:00 hrs and then declined to 3.00seconds per flower during 15:00-16:00 hrs. The *A.florea* Fab. spent maximum mean foraging duration for the collection of nectar (8.06±2.91sec/flower) compared to *A. mellife*ra L. (4.25±1.41sec/flower) and *A.cerana* Fab.(3.59±0.48sec/flower).

The foragers of *A. cerana* spent least foraging duration (4.00sec/flower) on the thrum morphduring 08:00-09:00 hrs for nectar collection. The duration for nectar foraging gradually increased and reached a maximum (5.00sec/flower) during 09:00 to 10:00 hrs and then declined to 4.25seconds per flowerduring15:00-16:00 hrs. The foragers of *A. florea*spent least foraging duration (8.75sec/flower) on the thrum morph during 09:00-10:00 hrs for nectar collection. The duration for nectar foraging gradually increased and reached a maximum (10.50sec/flower) during 10:00 to 11:00 hrs and then declined to 8.75seconds per flowerduring15:00-16:00 hrs. Similarly, the foraging duration of *A. mellifera* gradually increased from 08:00-09:00 hrs (3.25sec/flower) and reached a maximum (5.00sec/flower) during 12:00 to 13:00 hrs and then declined to 4.25seconds per flower during 15:00-16:00 hrs. *A.florea* Fab. spent maximum mean foraging duration for the collection of nectar (8.44±1.22sec/flower) compared to *A. mellife*ra L. (4.13±0.68sec/flower) and *A.cerana*Fab.(4.09±0.55 sec/flower). The variation in the nectar foraging duration of honey bee species either from pin/thrum morph among different hours might be due to the variation in size of proboscis of honey bee species for sucking of nectar from the flowers and also due to preferential quantity and TSS concentration of nectar or the bigger species (*A. mellife*ra L.)

may be more efficient/quicker compared to the smaller species (*A.florea* Fab.) in gathering the nectar.

Pollen foraging duration of *Apis* species of honeybees on pin and thrum morphs of buckwheatduring maximum bloom phase (2024)

The time spent for collection of pollen from pin and thrum morphs of buckwheat by the honey bees varied significantly among the different hours of the day (Table 9).

The foragers of *A. cerana* spent least foraging duration (2.50sec/flower) on the pin morphduring 09:00-10:00 hrs for pollen collection and maximum (4.50sec/flower) during 10:00 to 11:00 hrs. The foragers of *A. florea*spent least foraging duration (5.25sec/flower) on the pin morphduring 07:00-08:00 hrs for pollen collection and maximum (7.75sec/flower) during 08:00 to 09:00 hrs. The foragers of *A. mellifera* spent least foraging duration (3.50sec/flower) on the pin morphduring 08:00-09:00 hrs for pollen collection and maximum time (5.00sec/flower) during 10:00 to 11:00 hrs.The *Apisflorea* Fab. spent maximum mean foraging duration for the collection of pollen(6.65±0.91sec/flower) compared to *Apis mellife*ra L. (4.15±0.55sec/flower) and *Apiscerana* Fab. (3.60±0.82sec/flower).

The foragers of *A. cerana* spent least foraging duration (2.75sec/flower) on the thrum morphduring 11:00-12:00 hrs for pollen collection and maximum (3.75sec/flower) during 09:00 to 10:00 hrs. The foragers of *A. florea*spent least foraging duration (5.75sec/flower) on the thrum morph during 07:00-08:00 hrs for pollen collection and maximum (7.75sec/flower) during 09:00 to 10:00 hrs. The foragers of *A. mellifera* spent least foraging duration (3.25sec/flower) on the thrum morph during 07:00-10:00 hrs for pollen collection and maximum (4.25sec/flower) during 11:00 to 12:00 hrs.The *Apisflorea* Fab. spent maximum mean foraging duration for the collection of pollen(6.60±0.78sec/flower) compared to *Apis mellife*ra L. (3.55±0.41sec/flower) and *Apiscerana* Fab. (3.10±0.38sec/flower).The variation in the pollen foraging duration of honey bee species either from pin/thrum morph during different hours of the day might be due to variation in the amount of pollen offered by the flowers to bee species.

Table 8: Nectar foraging duration of *Apis* species of honeybees on pin and thrum morphs during maximum blooming phase of buckwheat

***Apis* species** **Time (hrs)**	**Pin morph**			**Thrum morph**		
	A. cerana	***A. florea***	***A. mellifera***	***A. cerana***	***A. florea***	***A. mellifera***
06:00-07:00	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{c}	0.00^{d}	0.00^{d}
07:00-08:00	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{c}	0.00^{d}	0.00^{d}
08:00-09:00	3.50^{ab}	3.50^{cd}	3.25^{bc}	4.00^{ab}	9.00^{ab}	3.25^{bc}
09:00-10:00	3.25^{b}	7.00^{bc}	4.00^{bc}	5.00^{a}	8.75^{ab}	4.75^{ab}
10:00-11:00	4.00^{ab}	10.50^{ab}	3.25^{bc}	3.50^{b}	10.50^{a}	4.25^{abc}
11:00-12:00	3.50^{ab}	9.75^{ab}	6.75^{a}	4.50^{ab}	8.25^{abc}	4.25^{abc}
12:00-13:00	4.50^{a}	12.75^{a}	5.25^{abc}	4.25^{ab}	8.50^{abc}	5.00^{a}
13:00-14:00	3.75^{ab}	8.25^{abc}	5.50^{ab}	4.00^{ab}	6.25^{c}	3.00^{c}
14:00-15:00	3.25^{b}	5.75^{bc}	3.00^{c}	3.25^{b}	7.50^{bc}	4.25^{abc}
15:00-16:00	3.00^{b}	7.00^{bc}	3.00^{c}	4.25^{ab}	8.75^{ab}	4.25^{abc}
16:00-17:00	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{c}	0.00^{d}	0.00^{d}
17:00-18:00	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{c}	0.00^{d}	0.00^{d}
Mean±SD	**3.59±0.48**	**8.06±2.91**	**4.25±1.41**	**4.09±0.55**	**8.44±1.22**	**4.13±0.68**
F test	*	*	*	*	*	*
SE (m)±	**0.43**	**1.77**	**0.80**	**0.46**	**0.83**	**0.59**
CD @5%	**1.23**	**5.10**	**2.29**	**1.32**	**2.40**	**1.70**
CV	**35.73**	**65.96**	**56.14**	**33.66**	**29.62**	**43.09**

Note: *-Significant at p=0.05

Table 9: Pollen foraging duration of *Apis* species of honeybees on pin and thrum morph during maximum blooming phase of buckwheat

***Apis* species Time (hrs)**	**Pin morph**			**Thrum morph**		
	A. cerana	***A. florea***	***A. mellifera***	***A. cerana***	***A. florea***	***A. mellifera***
06:00-07:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
07:00-08:00	3.00^{b}	5.25^{b}	4.25^{ab}	3.00^{ab}	5.75^{b}	3.25^{a}
08:00-09:00	4.00^{a}	7.75^{a}	3.50^{b}	3.00^{ab}	6.00^{ab}	3.50^{a}
09:00-10:00	2.50^{b}	6.50^{ab}	4.00^{ab}	3.75^{a}	7.75^{a}	3.25^{a}
10:00-11:00	4.50^{a}	7.00^{ab}	5.00^{a}	3.00^{ab}	6.75^{ab}	3.50^{a}
11:00-12:00	4.00^{a}	6.75^{ab}	4.00^{ab}	2.75^{b}	6.75^{ab}	4.25^{a}
12:00-13:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
13:00-14:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
14:00-15:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
15:00-16:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
16:00-17:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
17:00-18:00	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
Mean±SD	**3.60±0.82**	**6.65±0.91**	**4.15±0.55**	**3.10±0.38**	**6.60±0.78**	**3.55±0.41**
F test	*	*	*	*	*	*
SE (m)±	**0.34**	**0.76**	**0.38**	**0.31**	**0.68**	**0.47**
CD @5%	**0.96**	**2.19**	**1.08**	**0.91**	**1.96**	**1.35**
CV	**44.70**	**54.96**	**43.52**	**48.75**	**49.51**	**63.40**

Note: *-Significant at p=0.05

4. CONCLUSION

Forty-six insect floral visitors were documented during different bloom phases, which werebelonged to 5 insect orders and 19 families. *Apiscerana* F. being the most dominant visitorthroughout blooming phase. The diversity of floral visitors was highest during maximum bloom phase on pin and thrum morph as compared to initial and late blooming phases. Among the dominant bee floral visitors,*A. cerana*visited more number of florets followed by *A. mellifera*and *A. florea*during maximum blooming phase.The foraging duration of *A. florea*for collection of nectar and pollen from pin and thrum morphs was highest among the major bee floral visitors recorded during maximum bloom phase. Based on foraging rate,it is suggested for the farmer to keep *A. cerana* and *A. mellifera* bee hives for better pollination.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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