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## Pollinator diversity and relative abundance of insect pollinators on ridge gourd (*Luffa acutangula*) flowers in Bihar (India)

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**Abstract**

The field experiments were conducted at the University Apiary, Dr. Rajendra Prasad Central Agricultural University Pusa, Samastipur (Bihar) during the *Kharif* season to document the diversity and abundance of insect pollinators on ridge gourd (*Luffa acutangula*). The results indicated that the total eight insect species visited ridge gourd flowers, viz. five hymenopterans, two dipterans and one from odonata. Among these *Apis mellifera* L., *A. dorsata* F., *A. florea* F., *Xylocopa fenestrata* F. and *Polistes* sp. were found to be most frequent pollinators. The relative abundance (no. of insect/m<sup>2</sup>/10 minutes) revealed that *Apis mellifera* was most dominant species and followed by *Apis dorsata*, *Xylocopa fenestrata*, *Apis florea*, *Eristalinus* sp., *Polistes* sp., *Paragomphus* sp. and *Musca domestica*. Irrespective of species, the mean population was maximum at 0700-h and minimum at 1300-h of the day. The coefficient of correlation between mean population of pollinator's species and temperature was found positive and significant while negative correlation was found with relative humidity indicating that temperature plays an important role on activity of insect pollinators.

**Keywords:** insect, pollinator diversity, relative abundance, ridge gourd

**1. Introduction**

Ridge gourd, *Luffa acutangula* (Family: Cucurbitaceae) is one of major vegetable crops in Asia. It can be cultivated throughout the year where the irrigation facility is available. Usually, plants are creeping nature and hence it requires good support for vines and high yields and quality. The flowering normally starts 40-45 days after sowing depending upon the weather conditions. Female flowers are usually solitary arising on the axils. Ridge gourd being a predominantly monoecious in nature and is essentially a cross pollinated crop<sup>[9]</sup>. About 80 per cent of the world's fruits, vegetables, seeds and other agricultural crops depend on insects' pollination. Among the insect pollinators, bees are of prime importance. The presence of diverse forms of pollinators which include insects like bees, butterflies, beetles, moths, flies, ants and wasps that carry pollen from the male to the female parts of flowers for plant reproduction. Without pollination, many plants are unable to reproduce or would produce fruit and seeds at much lower rates. The decline in pollinators and their diversity throw big challenge for better managed pollination and to maintain crop yield and quality. The optimum population of insect pollinators for effective pollination is also influenced by abiotic environmental factors such as temperature, relative humidity, sunshine, wind velocity, etc. However, the combination of temperature and relative humidity is most important factor affecting foraging activity of insect pollinators as insects are poikilothermic. Carpenter bees (*Xylocopa* spp.) are effective pollinators of cucurbitaceous crops, and largely distributed in tropical and subtropical habitats around the world, and occasionally in temperate areas<sup>[8]</sup>. The conservation and management of insect pollinators are gaining importance day by day for which studies on pollinator's diversity, species richness and abundance are essential. Hence, the present investigations have been taken up to generate information about the pollinator diversity and abundance in ridge gourd.

**2. Materials and Methods**

To study the pollinator diversity and relative abundance of insect pollinators on ridge gourd (*Luffa acutangula*), the crop was grown with recommended agronomic packages and practices at University Apiary, Dr. Rajendra Prasad Central Agricultural University (formerly Rajendra

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Agricultural University) Pusa, Samastipur (Bihar) during the *Kharif* season of 2016-17. The crop was grown in RBD with three replications. The numbers of pollinators visited the ridge gourd bloom were counted in an area of one square meter for 10 minutes visual observation which were randomly marked in the experimental plots. The number of foragers were recorded dated from 17/09/2016 to 15/10/2016 at different time intervals, *i.e.* 0700-h, 0900-h, 1100-h, 1300-h and 1500-h and 1700 hour of the day at weekly intervals for 10 minutes. The temperature and relative humidity were also recorded at different times and on different dates simultaneously at the time of observation with the help of thermo-hygrometer. The abundance of pollinators was correlated with temperature and relative humidity to know the influence of weather parameters on population visiting ridge gourd bloom.

### 3. Results and Discussion

#### 3.1 Important insect visitors and pollinators on ridge gourd bloom

The important insect visitors and pollinators on ridge gourd blooms were observed at experimental plots of University Apiary. The insect pollinators visiting ridge gourd bloom were recorded in the open pollinated plots during flowering period. The observations on insect visitors were taken during 10% flowering stage to 90% flowering stage. The insect visitors were collected from ridge gourd flowers by insect collecting net and identified as listed in Table 1. Eight insect species belonging to five families were recorded as the pollinator from ridge gourd flowers out of which, five species were from Hymenoptera, two from Diptera and one from Odonata. Among the insect species hymenopterans (Fam. Apidae) were found most dominant pollinator, *viz.* *Apis mellifera* L., *Apis dorsata* Fab., *Xylocopa fenestrata* Fab. and *Apis florea* Fab. Besides *Polistes* sp. (Fam. Vespidae) was also found visiting ridge gourd. Dipteran, *viz.* *Eristalinus* sp. and *Musca domestica* were identified from family Syrphidae and Muscidae, respectively. In addition, one species, *i.e.* *Paragomphus lineatus* belonging to the Odonata from Gomphidae family was also recorded during the study period on ridge gourd.

The above findings are in agreement with earlier workers results those also reported different insect pollinators of ridge gourd and cucurbits [3]. Observed that two orders Hymenoptera and Diptera as the major pollinators of ridge gourd. [14] reported that the ridge gourd was visited by twenty one species of insect pollinators during flowering, of which twelve species belong to order Hymenoptera, four from Diptera, three from Coleoptera and two from Lepidoptera. Honey bee species, *viz.* *Apis cerana*, *A. florea* and *A. dorsata* constituted more than 78 per cent of the total insect pollinators [4]. Observed that *Xylocopa* sp. was the most frequent visitor of ridge gourd flowers [12]. Also reported honey bees *Apis mellifera* and *Xylocopa* sp. as the major insect pollinators of bitter melon (*Momordica charantia*).

#### 3.2 Relative abundance of different insect pollinators on ridge gourd blooms

The observations were recorded on relative abundance (no. of insect/m<sup>2</sup>/10 minute) of insect pollinators visiting ridge gourd bloom. The recorded data have been presented in Table 2 and Fig. 1. The population of insect visitors was recorded quiet low at the flowering initiation stage in the beginning of bloom and near the maturity of crop but found high during mid flowering period. This might be due to variation in the floral density during the span of blooming on ridge gourd, changes

in climatic conditions and availability of floral rewards to the insect pollinators. The abundance of different insect visitors species revealed that the mean population of *Apis mellifera* (20.0) was highest followed by *Apis dorsata* (16.7) and *Xylocopa fenestrata* (15.9). The least population of *Musca domestica* (2.0) was recorded among different insect foraging complex on ridge gourd bloom. The mean number of insect pollinators in one square meter was found maximum on 1<sup>st</sup> of October 2016 in all the eight pollinator species being 13.5 and minimum on the 15<sup>th</sup> of October 2016 in all the eight pollinator species being 5.8. This might be due to fact that more number of opened flower density were observed during mid flowering period and lower open flower density during initiation of bloom and near maturity of crop. Therefore, the insect pollinator species were getting maximum floral rewards during mid flowering period showing an abundance of insect pollinators.

The present findings are in agreement with earlier workers those also found *Apis* spp. as dominant visitor of ridge gourd. [2] Reported that *Apis cerana* was the most dominant forager of sesamum comprising 32.66 per cent followed by *Apis dorsata* (26.54%). The other foragers recorded were *Xylocopa fenestrata* (7.48%), *Vespa cincta* (6.12%), *Coccinella septempunctata* (6.12%), *Musca domestica* (6.12%), *Apis florea* (4.76%) and *Xylocopa leucothorax* (4.08%). [7] Also recorded the insect forager complex on ridge gourd. They reported that the most common insect pollinators were belonging to the Hymenoptera, Diptera, Lepidoptera and Hemiptera, *viz.* *X. fenestrata*, *X. leucothorax*, *Apis cerana*, *Polystis haebraeus*, *Vespa orientalis*, *Musca domestica*, *Coridius brunneus*, *Papilio demoleus*, *Sphecodes fumipennis*, *Pompilus braccatus* and *Thersilochus* sp. among these insect pollinators, *X. fenestrata* was maximum (29.91%) followed by *X. leucothorax* (24.10%), *A. cerana* (9.37%), *Solenopsis geminate* (6.25%), *P. haebraeus* (5.37%). Besides these, *M. domestica* were also found as frequent visitors (6.69%). Other insect foragers found to visit in less numbers were *P. demoleus* (1.78%), and *C. brunneus* (1.33%).

The abundance of insect pollinator species, *viz.* *Apis mellifera*, *Apis dorsata*, *Apis florea*, *Xylocopa fenestrata*, *Eristalinus* sp., *Polistes* sp., *Paragomphus* sp. and *Musca domestica* at different hours of the day showed variations in abundance over time. The data recorded have been depicted in Table 3 and Fig. 2. The population of insect visitors on ridge gourd bloom was observed maximum (13.3) at 0700-h which decreased as the day progressed being (11.8) at 0900-h, (10.3) at 1100-h and minimum at 1300-h being (7.4). The population of insect visitors increased in the evening hours which might be due to increased floral rewards and suitable weather conditions. The mean insect species population over different day hours on ridge gourd flower ranged from 2.9 (*Musca domestica*) to 21.2/m<sup>2</sup>/10 minutes (*Apis mellifera*). Irrespective of species abundance of pollinators were lowest at 1500h-1300h (9.8 - 7.4/m<sup>2</sup>/10 minute) and highest at 0700-h and 0900-h (13.3 and 11.8/m<sup>2</sup>/10 minute, respectively). Species abundance revealed that *Apis mellifera* dominated the total insect visitors.

The cumulative mean for abundance of insect pollinator species showed that *Apis mellifera* was the most abundant insect species visiting ridge gourd bloom with a mean population of 21.2/m<sup>2</sup>/10 minute followed by *Apis dorsata* (17.5), *Xylocopa fenestrata* (14.6), *Apis florea* (11.7), *Eristalinus* sp. (6.7), *Polistes* sp. (5.7), *Paragomphus* sp. (4.1) and *Musca domestica* was recorded least being 2.9/m<sup>2</sup>/10 minute in the present investigation.

The present findings are in conformity with the results of earlier workers [6, 11]. Reported the activity of insect visitors was significantly higher during 09:00-10:00, (3.88 insects/m<sup>2</sup>/10 min.) followed by 12:00-13:00 (3.37 insects/m<sup>2</sup>/10 min.) and 15:00-16:00 (2.45 insects/m<sup>2</sup>/10 min.) on cucurbits [13]. Reported that the foraging activity of *Xylocopa fenestrata* and *X. leucothorax* on cucumber continued from 7 AM to 5 PM. It was found that frequency of flower visit by both the species was maximum during 9-10 AM [15]. Reported that no bee population was observed during 1300-1600-hr, mainly due to the closure of flower and partially due to the high temperature (>35°C). The mean bee species population over different day hours on bitter gourd

flowers ranged from 0.37 (*A. florea*) to 10.83 bees/m<sup>2</sup>/5 minutes (*Trigona iridipennis*). For *T. iridipennis*, the maximum bee population was observed at 0900-hr (24.41 bees/m<sup>2</sup>/5 minutes), followed by 1000-hr (21.40 bees/m<sup>2</sup>/5 minutes). Irrespective of species, abundance of bees was lowest at 1200-1300-hr (1.47-0.01 bees/m<sup>2</sup>/5 minutes) and highest at 0900 and 1000-hr (9.22 & 8.17 bees/m<sup>2</sup>/5 minutes, respectively) [7]. Revealed that the peak period of visit of *Xylocopa fenestrata*, *X. leucothorax* and *M. domestica* was during 1000-1100 hours of the day in ridge gourd. Whereas, *P. haebraeus* and *V. orientalis* during 1600-1700 hours; and *A. cerana*, *P. demoleus* were recorded during 0900-1000 hours

**Table 1:** Insect pollinators visiting on ridge gourd (*Luffa acutangula* L.).

Sl. No.	Scientific name	Common name	Order	Family
1.	<i>Apis mellifera</i> L.	Italian bee	Hymenoptera	Apidae
2.	<i>Apis dorsata</i> Fab.	Rock bee	Hymenoptera	Apidae
3.	<i>Xylocopa fenestrata</i> Fab.	Carpenter bee	Hymenoptera	Apidae
4.	<i>Apis florea</i> Fab.	Little bee	Hymenoptera	Apidae
5.	<i>Eristalinus</i> sp.	Hover fly	Diptera	Syrphidae
6.	<i>Polistes</i> sp.	Yellow wasp	Hymenoptera	Vespidae
7.	<i>Paragomphus lineatus</i> Selys	Common Oartail	Odonata	Gomphidae
8.	<i>Musca domestica</i> L.	House fly	Diptera	Muscidae

**Table 2:** Relative abundance (No. of insect pollinator/m<sup>2</sup>/10 minute) of insect pollinators on ridge gourd bloom on different date of observation at flowering period

Date of observation	<i>Apis mellifera</i>	<i>Apis dorsata</i>	<i>Apis florea</i>	<i>Xylocopa fenestrata</i>	<i>Eristalinus</i> sp.	<i>Polistes</i> sp.	<i>Paragomphus</i> sp.	<i>Musca domestica</i>	Mean	Av. Temp.	Av. RH
17/09/2016	21.3	17.0	12.7	15.3	7.3	6.0	3.0	2.0	10.5	30.2	86.0
24/09/2016	23.0	19.3	14.0	16.7	8.0	6.7	3.3	2.3	11.6	29.9	92.5
1/10/2016	26.7	21.0	16.0	20.7	9.0	7.0	4.7	3.0	13.5	28.8	82.0
8/10/2016	16.0	15.7	8.0	18.0	4.0	3.0	2.7	1.7	8.6	27.7	78.0
15/10/2016	13.0	10.7	6.0	9.0	3.3	2.7	1.0	1.0	5.8	26.00	72.0
Mean	20.0	16.7	11.3	15.9	6.3	5.1	2.9	2.0	10.0	-	-

Factors	S Em (±)	CD (P=0.05)	CV (%)
Date	0.74	2.15	9.89
Species	0.70	2.05	
Date × Species	0.65	1.92	

**Table 3:** Relative abundance (No. of insect pollinator/ m<sup>2</sup>/ 10 minute) of insect pollinators on ridge gourd bloom at different hours of the day at flowering period.

Time of observation	<i>Apis mellifera</i>	<i>Apis dorsata</i>	<i>Apis florea</i>	<i>Xylocopa fenestrata</i>	<i>Eristalinus</i> sp.	<i>Polistes</i> sp.	<i>Paragomphus</i> sp.	<i>Musca domestica</i>	Mean
0700	24.8	21.4	15.8	18.0	8.4	7.8	5.8	5.0	13.3
0900	22.3	19.4	12.8	17.4	7.4	6.8	5.0	3.8	11.8
1100	21.0	16.8	11.3	13.6	7.0	5.8	4.4	3.0	10.3
1300	16.0	14.4	8.8	10.4	4.4	3.0	1.8	0.8	7.4
1500	20.8	15.7	10.8	13.4	6.4	5.4	3.8	2.4	9.8
1700	22.6	17.3	11.2	14.8	6.8	5.8	3.9	2.6	10.6
Mean	21.2	17.5	11.7	14.6	6.7	5.7	4.1	2.9	10.4

Factors	S Em (±)	CD (P=0.05)	CV (%)
Species	0.72	2.10	8.92
Hour	0.67	1.92	
Species × Hour	0.66	1.96	

**Table 4:** Correlation coefficient between population of different insect pollinators and weather parameters.

Independent variables (X)	Dependent Variables (Y)							
	<i>Apis mellifera</i> (Y <sub>1</sub> )	<i>Apis dorsata</i> (Y <sub>2</sub> )	<i>Apis florea</i> (Y <sub>3</sub> )	<i>Xylocopa fenestrata</i> (Y <sub>4</sub> )	<i>Eristalinus</i> sp. (Y <sub>5</sub> )	<i>Polistes</i> sp. (Y <sub>6</sub> )	<i>Paragomphus</i> sp. (Y <sub>7</sub> )	<i>Musca domestica</i> (Y <sub>8</sub> )
Av. Temperature (°C) (X <sub>1</sub> )	0.821**	0.831**	0.623	0.562	0.306	0.726*	0.319	0.326
Av. Relative Humidity (%) (X <sub>2</sub> )	-0.706*	-0.721*	-0.581*	-0.631*	-0.421	-0.841**	-0.367	-0.426

Multiple Regression Equations:

$$Y_1 = 472.8 + 2.009^{**} (0.592) X_1 - 0.536^* (-0.731) X_2 (R^2 = 0.82^{**})$$

$$Y_2 = 274.23 + 0.081^{**} (0.0664) X_1 - 1.042^* (-0.821) X_2 (R^2 = 0.79^{**})$$

$$Y_3 = 140.18 + 0.681 (0.023) X_1 - 0.724 (-0.597) X_2 (R^2 = 0.66^*)$$

$$Y_4 = 88.270 + 0.584 (0.512) X_1 - 0.356 (-0.448) X_2 (R^2 = 0.59^*)$$

$$Y_5 = 65.813 + 0.134 (0.223) X_1 - 0.427 (-0.461) X_2 (R^2 = 0.48)$$

$$Y_6 = 95.020 + 0.327^* (0.413) X_1 - 0.464 (-0.621) X_2 (R^2 = 0.72^*)$$

$$Y_7 = 48.304 + 0.510 (0.467) X_1 - 0.114 (-0.356) X_2 (R^2 = 0.64^*)$$

$$Y_8 = 26.07 + 1.082 (0.512) X_1 - 0.116 (-0.359) X_2 (R^2 = 0.45)$$

\*\* Significant at 5% probability level

\* Significant at 1% probability level

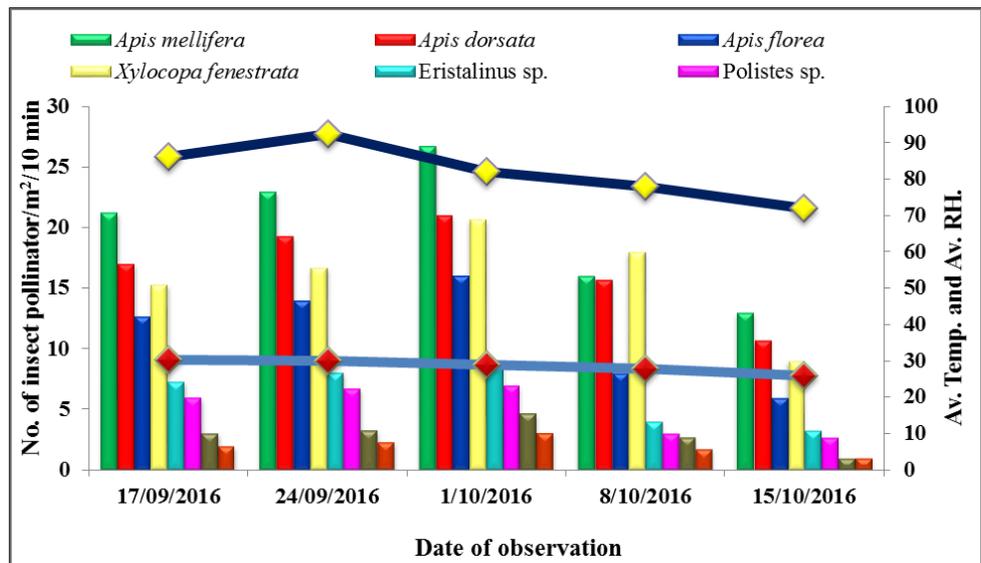


Fig 1: Relative abundance of insect pollinators on ridge gourd bloom on different dates at flowering period

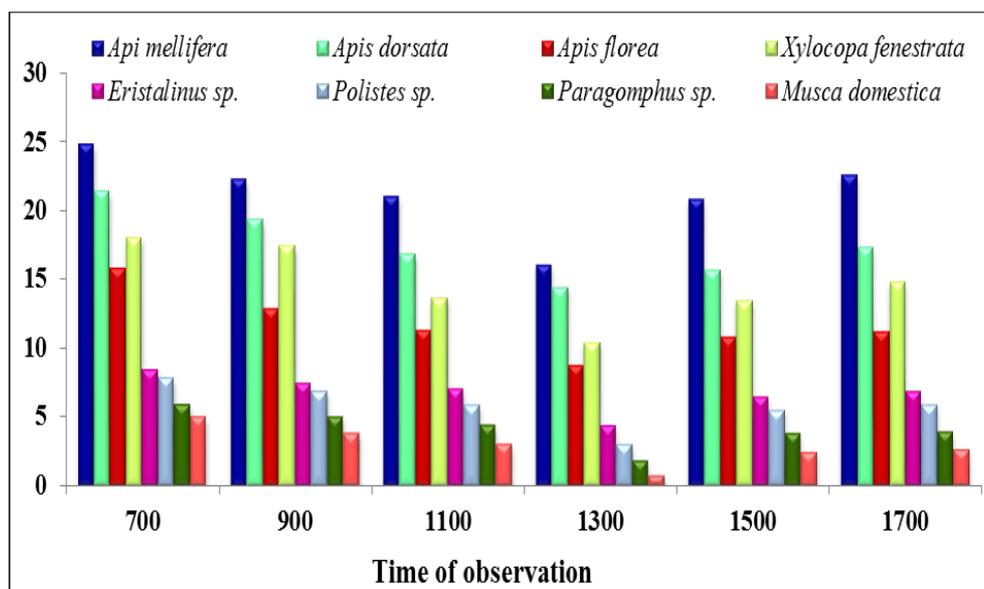


Fig 2: Relative abundance of insect pollinators on ridge gourd bloom on different time at flowering period

### 3.3 Correlation coefficient between population of insect pollinators and weather parameters on ridge gourd

The effect of weather parameters on the visitation of different insect pollinators on the ridge gourd flower, the correlation coefficients and multiple regression equations were worked out between the mean population of insect pollinators and weather parameters and results have been presented in Table 4 and Fig. 1. The correlation coefficient of insect pollinators abundance with temperature was found positive and highly significant in case of *Apis mellifera* (0.821\*\*) and *Apis dorsata* (0.831\*\*) while *Polistes sp.* showed positive and significant correlation with temperature (0.726\*). The correlation coefficient between mean population and relative humidity showed negative and highly significant (-0.841\*\*) in *Polistes sp.*, while *Apis mellifera*, *Apis dorsata*, *Apis florea* and *Xylocopa fenestrata* showed negative and significant correlation with relative humidity being -0.706\*, -0.721\*,

-0.581\* and -0.631\*, respectively. Hence, it might be concluded that the temperature had significant effect on foraging activity of pollinators and the foraging increases with an increase in temperature while the relative humidity suppress the foraging activity of pollinators.

The standard regression coefficient (R<sup>2</sup>) revealed that the temperature was dominant factor influencing abundance of pollinator species on the ridge gourd flower. The value of R<sup>2</sup> in case of *Apis mellifera* (0.82\*\*) and *Apis dorsata* (0.79\*\*) were found highly significant while in case of *Apis florea* (0.66\*), *Xylocopa fenestrata* (0.59\*), *Polistes sp.* (0.72\*) and *Paragomphus sp.* (0.64\*) were found significant. This observation indicated that temperature plays important role in the abundance of pollinator species.

The results were in an agreement with earlier workers those reported the effect of weather parameters on the abundance of insect pollinators [7]. Reported that the peak period of visit of

*X. fenestrata*, *X. leucothorax* and *M. domestica* were during 1000-1100 hours when temperature was higher [5]. Reported that in the vegetable crops the peak foraging activity was early in the morning which largely decreases at noon due to hot weather in May-June [1]. Also observed that the pollinator activity was higher in the morning which was affected by temperature and relative humidity [10]. Reported that *X. olivacea* foraged on flowers throughout the day, with a peak activity between 10.00 and 13.00-hr. The activity of *X. olivacea* was influenced by climatic conditions. The correlation between the number of *X. olivacea* visits on *P. vulgaris* flowers and the temperature was positive and highly significant, but was negative and significant with relative humidity. This might be due to fact that the insects are poikilothermal and ambient temperature influences their body temperature and body metabolism to a greater degree while relative humidity affects nectar secretion of flower influencing the availability of floral rewards to insect pollinators.

#### 4. Conclusion

This study has revealed the existence of wide and rich pollinator diversity in Pusa, Bihar. Ridge gourd flowers were visited by eight insect pollinator species belonging to five families of three orders. The hymenopterans were the major flower visitors. The populations of insect visitors were observed quiet low at the flowering initiation stage in the beginning and near the maturity of crop but found higher during the mid-flowering period at morning and evening hours. The pollinator diversity and abundance was significantly influenced by the weather parameters, viz. temperature and relative humidity.

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