



Pollinator Assemblage and Foraging Ecology of *Apis cerana* on Rapeseed in Mizoram, Northeast India

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Abstract

In Mizoram, rapeseed is an important winter vegetable grown after the harvest of *Jhum* rice. The flowers attract many pollinators and therefore a study was carried out at Experimental farm of College of Horticulture, CAU (Imphal), Thenzawl, Mizoram from 2021-2023 to study the pollinator diversity and foraging activities of major pollinators under open field conditions. The study reveals that a total of 12 pollinators belonging to 5 families and 3 orders (Hymenoptera, Diptera and Lepidoptera) were recorded visiting flowers of rapeseed, with highest foraging activity during 0900 to 1200 hrs. The pollinator assemblage includes *Apis cerana*, *Tetragonula* sp. (red and black abdomen), *Lepidotrigona* sp., *Bombus* sp., *Nomia* sp., hover flies, house fly and pierid butterflies. Interestingly, the stingless bees (*Tetragonula* sp. and *Lepidotrigona* sp.) were recorded pollinating rapeseed flowers in Thenzawl for the first time. Among the pollinators, *Apis cerana* was the dominant forager with a relative abundance of 23%. The number of *A. cerana* m⁻² min⁻¹ was highest 7.00±0.57 during 1100-1200 hrs and lowest, 0.67±0.33 during 1600-1700 hrs. The frequency of flowers visit min⁻¹ was also maximum, 13.67±0.33 during 1100-1200 hrs. However, maximum time spent flower⁻¹ was highest, 5.11±0.21 during 1000-1100 hrs. Among the pollinators, *A. cerana* is the main pollinator on rapeseed and stingless bee under the genus *Tetragonula* and *Lepidotrigona* also observed pollinating the rapeseed for the first time in Mizoram. The finding also highlights the importance of pollinators and provides the baseline data for managing pollinators and sustaining pollinator diversity in the region

Keywords: Diversity, Foraging, Mizoram, Pollinators, Rapeseed

Introduction

Rapeseed, one of the major oilseed crops, is grown as winter vegetables in Mizoram. The crop is used as a leafy vegetable at both vegetative and flowering stages and also as oilseed and is mainly grown after the harvest of *Jhum* Rice in the region. Since the crop is cross-pollinated, sufficient pollinators are required for quality seed production. It is well documented that 95% of flowers are cross-pollinated while only 5% are self-pollinated; therefore, pollination is essential for maintaining the biodiversity. Among 95%, insect pollination accounts 85% for enhancing the crop productivity and bees and syrphids are the major innate pollinators of *Brassica* species (Paudel and Tiwari, 2025; Bora et al., 2020) and their flowers are very attractive to honeybees (Nath et al., 2023). The pollens of *Brassica*

are sticky and heavy in nature due to which long distance dissemination by wind is restricted and thus honeybees play a vital role for pollination (Fairhurst et al., 2022). Their pollens and nectar are highly nutritious to pollinators and among them honeybees are the most abundant and frequent visitors (Mazzilli et al., 2023). A minimum of five bee visits per flower is required for good pollination and among the pollinators, *A. cerana* are the most efficient pollinators to *Brassica* crop in Western Himalaya (Gautam et al., 2022). In Chile, the yield of rapeseed increased to 50.34% in the treatment with bees pollination compared to treatment without bees (Durán et al., 2010). However, Perrot et al. (2018) reported 37.5% higher yield of rapeseed in France pollinated by *A. mellifera*. When insect pollinators access to the *Brassica* flowers, they enhance the yield significantly

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ranging between 27% and 35% without affecting the oil percentage and also contribute to uniform and early pod setting, resulting in an increase in oil yield ha^{-1} (Marinozzi et al., 2025). The flowers of rapeseed are frequently visited by different species of pollinators, including stingless bee in Thenzawl, from morning till evening hours. However, there is no proper documentation of foraging activities by bee fauna on rapeseed especially by the stingless bee from Mizoram and therefore, a study was made to study the diversity of pollinators of rapeseed and the foraging behaviour of the main pollinators under open field conditions at College of Horticulture, CAU (Imphal), Thenzawl, Mizoram.

Materials and Methods

The study on diversity of rapeseed's pollinators was conducted for two rabi-seasons from November, 2021 to January, 2023 during peak flowering period at Experimental Farm of College of Horticulture, CAU (Imphal), Thenzawl, Mizoram. The experiment was conducted at 100 m^2 areas having 3 replications of 30 m^2 areas each, separated by 0.5 m through randomized complete block design. Visual observations were made to record and identify the insect pollinators during the day from 0800 to 1700 hrs. The specimens were collected by net sweeping from morning to evening hours at one hour interval and the captured insects were transferred to killing jar containing chloroform and pinning was done for identification. Insects collected were identified using keys available in Triplehorn and Johnson (2005) and standard manuals. The specimens were also sent to Dr. Shashidhar Viraktamath, Emeritus Scientist, GKVK, UAS, Bangalore, Karnataka for confirmation. The relative abundance was also calculated by counting total number of pollinators observed from 1 m^2 areas from three random places during the study and the number of individual pollinator and expressed in percentage. The honey bee, *Apis cerana* being the main forager in rapeseed, observations on number of *A. cerana*, number of flower visits and time spent per flower on randomly selected 10 plants were also recorded from 0800 to 1700 hrs during peak blooming period from December 2022 to January 2023. The observations on number of *A. cerana* $\text{m}^{-2} \text{ min}^{-1}$, frequency of flower visit and time spent flower^{-1} were recorded. Ten observations at two days interval were made for calculating means, Standard Error of the Mean and Critical difference using Microsoft excel. To determine the frequency of flower visit, methodology of Gogoi et al. (2014) was followed.

Results and Discussion

About 12 species of insect-pollinators belonging to 5 families under three orders (Hymenoptera, Diptera and Lepidoptera) were observed pollinating the rapeseed flowers with highest foraging activity during 0900-1200 hrs. *Apis cerana*, *Tetragonula* sp. (red abdomen), *Tetragonula* sp. (black abdomen), *Lepidotrigona* sp., *Bombus* sp., *Nomia* sp., *Erisyrphus balteatus*, *Allograpta javana*, *Eristalinus* sp., *Musca domestica*, *Pieris canidia* and *Pieris napi* were observed visiting the flowers of rapeseed. Among them, *A.*

cerana was found to be dominant forager with the relative abundance of 23.00% followed by *Tetragonula* sp. (black abdomen), *Lepidotrigona* sp. and *Tetragonula* sp. (red abdomen) with the relative abundance of 16.43, 14.55 and 14.08% respectively (Table 1; Figure 1). The lowest was observed in *Pieris napi* with the relative abundance of 0.94%. Out of the twelve species of pollinators observed the stingless bee *Tetragonula* sp. (red abdomen), *Tetragonula* sp. (black abdomen) and *Lepidotrigona* sp. were reported for the first time pollinating rapeseed flowers in Thenzawl (Table 1). The data presented in table 2 reveals that the number of *A. cerana* $\text{m}^{-2} \text{ min}^{-1}$ was found to be maximum (7.00 ± 0.57) during 1100-1200 hours and minimum (0.67 ± 0.33) during 1600-1700 hours. The frequency of flower visit was found maximum (13.67 ± 0.33) during 1100-1200 hours and minimum (2.33 ± 0.33) during 1600-1700 hours. However, the maximum time spent flower^{-1} was found to be 5.11 ± 0.21 seconds during 1000-1100 hours and minimum was 0.95 ± 0.03 seconds during 1600-1700 hours of the day.

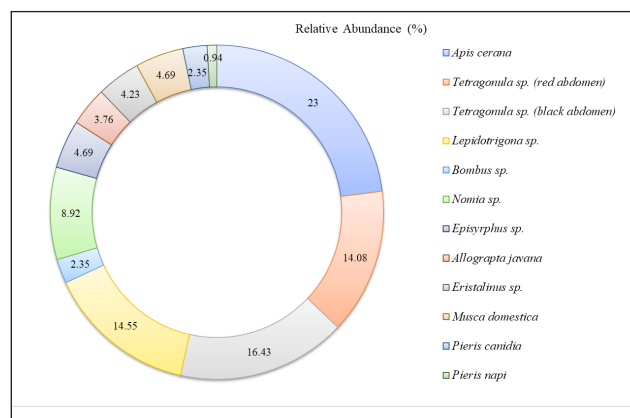


Figure 1: Relative abundance of insect pollinators on rapeseed

Similar results were obtained by Thangjam et al. (2016) and Devi et al. (2023), they reported that the pollinators mainly belonged to the orders Hymenoptera, Diptera and Lepidoptera visiting rapeseed flowers in Assam and Manipur and their foraging activity was highest during 0900-1100 hrs. They observed *Apis cerana* was the main pollinators of rapeseeds. Poonam et al. (2022) also reported 17 pollinators belonging to genus Hymenoptera (9), Diptera (3), Lepidoptera (4) and Coleoptera (1) visiting the early sown rapeseeds in Haryana and among them, *A. florea* was dominating with 8.5 bees m^{-2} per 2 min followed by *A. mellifera* (3.9), *A. dorsata* (3.6) and *A. cerana* (3.1). However, maximum number of flowers per minute was visited by *A. cerana* (18.20), followed by *A. dorsata* (17.57), *A. mellifera* (17.32) and *A. florea* (6.45). Vishwakarma and Chand (2017) also observed 17 insect pollinators, belonging to 5 orders, 12 families and 14 genera visiting rapeseed flowers in West Bengal and however, amongst the pollinators *A. mellifera* was recorded the most dominant pollinator with the highest foraging rate during 1100-1200 hrs. At Pantnagar, Uttarakhand, Chakravarty (2000) observed *Eristalis* sp., *Syrphus* sp., *A. cerana indica*, *A. dorsata*, *A. mellifera*, *Mellipona* sp., *Bombus* sp., *Haliotis armigera*, *Plusia orichalcea* and *Pieris brassicae*

as pollinators of *Brassica napus*. Similarly, Singh *et al.* (1998) also mentioned that the duration between 0900-1100 hours is found to be the peak population of foraging bees. The foraging rate of honeybees was much higher in early morning than evening in ridge gourd (Gogoi *et al.*, 2014). Thangjam *et al.* (2018) reported similar results, they observed *A. cerana* as a dominant forager on Niger with relative abundance of 41.95% followed by *A. florea* (20.13%) and *A. dorsata* (19.80%) and the activity of the pollinators was highest during 0900 hrs to 1100 hrs. The maximum number of *A. cerana* m⁻² min⁻¹ was 8.67±0.33 during 1000-1100 hrs and

minimum was 1.33±0.33 at 1600-1700 hrs. The highest frequency of flower visit min⁻¹ was 14.00±0.58 at 1000-1100 hrs and the lowest was 02.33±0.33 visits min⁻¹ at 1600-1700 hrs. Similarly, maximum time spent flower⁻¹ was found to be 4.99±0.40 seconds during 1000-1100 hrs and minimum time spent was 1.00±0.06 seconds during 1600-1700 hrs. However, Parida *et al.* (2023) reported that *A. cerana indica* started foraging at 0710 hrs in rapeseed and continued till 1725 hrs with the peak activity during 1100-1300 hrs in Odisha and spent maximum time of 6.57±0.43 sec flower⁻¹ with 9.7±2.6 flowers min⁻¹.

Table 1: Diversity of insect pollinators on rapeseed in Thenzawl, Mizoram during 2021-23

Sl. No.	Common name	Scientific name	Order	Family	Peak period of visit (hrs)	Relative Abundance (%)
1	Indian honey bee	<i>Apis cerana</i>	Hymenoptera	Apidae	0900-1200	23.00
2	Stingless bee	<i>Tetragonula sp.</i> (red abdomen)	Hymenoptera	Apidae	0900-1100	14.08
3	Stingless bee	<i>Tetragonula sp.</i> (black abdomen)	Hymenoptera	Apidae	0900-1100	16.43
4	Stingless bee	<i>Lepidotrigona sp.</i>	Hymenoptera	Apidae	0900-1100	14.55
5	Bumble bee	<i>Bombus sp.</i>	Hymenoptera	Apidae	0900-1100	2.35
6	Sweat bee	<i>Nomia sp.</i>	Hymenoptera	Halictidae	1000-1100	8.92
7	Hover fly	<i>Episyrphus sp.</i>	Diptera	Syrphidae	0900-1100	4.69
8	Hover fly	<i>Allograpta javana</i>	Diptera	Syrphidae	0900-1100	3.76
9	Hover fly	<i>Eristalinus sp.</i>	Diptera	Syrphidae	0900-1100	4.23
10	House fly	<i>Musca domestica</i>	Diptera	Muscidae	0800-1500	4.69
11	Cabbage butterfly	<i>Pieris canidia</i>	Lepidoptera	Pieridae	0800-0900	2.35
12	Cabbage butterfly	<i>Pieris napi</i>	Lepidoptera	Pieridae	0800-0900	0.94

Table 2: Foraging behaviour of *A. cerana* on rapeseed during different period of a day in Thenzawl, Mizoram during 2022-23

Time of observations (in hrs)	No. of <i>A. cerana</i> m ⁻² min ⁻¹	Frequency of flower visit min ⁻¹	Time spent flower ⁻¹ (in sec.)
0800-0900	4.33±0.33	10.33±0.33	3.06±0.35
0900-1000	5.67±0.33	10.67±0.67	3.36±0.47
1000-1100	6.67±0.33	11.67±0.33	5.11±0.21
1100-1200	7.00±0.57	13.67±0.33	4.75±0.13
1200-1300	5.33±0.33	12.67±0.33	3.92±0.42
1300-1400	5.00±0.57	11.67±0.67	2.75±0.14
1400-1500	3.67±0.33	7.33±0.33	2.47±0.06
1500-1600	2.67±0.67	4.33±0.67	1.78±0.35
1600-1700	0.67±0.33	2.33±0.33	0.95±0.03
S.Em±	0.47	0.49	0.30
CD at 5%	1.40	1.47	0.89

Conclusion

The present study shows that in Mizoram, the flowers of rapeseed were visited by diverse groups of pollinators belonging to the order Hymenoptera, Diptera and

Lepidoptera. Among them, *A. cerana* is the dominant pollinator and stingless bee under the genera *Tetragonula* and *Lepidotrigona* were observed pollinating the rapeseed for the first time. These findings also highlight the ecological importance of maintaining assemblage of pollinators in

rapeseed for essential pollination services and provide the baseline data for managing pollinators and conservation of native pollinators like stingless bees for enhancing the seed quality and yield for sustainable rapeseed production. Therefore, it is very necessary to focus on conservation of native pollinator's habitat, pesticides free farming system or pollinator- friendly farming system to safeguard these native pollinators. In future, more research should focus on quantifying the comparative studies on pollination efficiency by different pollinators, their contribution to quality and yield of the crop in Mizoram.

Ethical Statement

The authors declare that no generative artificial intelligence tools were used in drafting or preparing this manuscript. The manuscript was written, interpreted and revised solely by the authors, who take full responsibility for its content.

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