

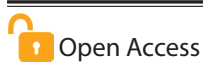


Diversity and Abundance of Insect Pollinators of Cucurbits at Mid-Hills of Meghalaya, India

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Abstract

The current research was carried out at the ICAR-Research Complex for the North Eastern Hill Region (NEH) in Umiam, Meghalaya to investigate the diversity and abundance of insect pollinators of cucurbits at mid-hills of Meghalaya. Ridge gourd, sponge gourd, pumpkin, teasel gourd, chow-chow, bottle gourd and cucumber were taken as a target crop to observe the data on diversity and abundance. Total twenty-five (25) pollinators were observed in different cucurbits belongs to order Hymenoptera, Diptera and Lepidoptera which represents that mid-hills of Meghalaya have rich pollinator fauna. Out of 25 insect pollinators 3 pollinators identified from ridge gourd, 6 from sponge gourd, 4 from pumpkin, 3 from bottle gourd, 4 from cucumber, 3 from chow-chow and 2 from teasel gourd. Efficient pollinator was nominated on the basis of their abundance. During investigation it was found that bumble bee emerged as the most abundant pollinator in ridge gourd, pumpkin and sponge gourd. In sponge gourd carpenter bee also showed almost equal abundance. Indian honey bee abundance was high in cucumber and in chow-chow. Among collected pollinators, hymenopterans were the abundant with 80% relative abundance. It is clear from the recorded observation that native bees are equally contributing in pollination service so conservation of these bees is also a demand of nature. Activity time period of pollinators on flowers guided the farmers to avoid pesticide spray during particular time period.

Keywords: Abundance, Diversity, Honey Bee, Native Bee, Pollination

Introduction

Cucurbits are the key vegetables which are grown extensively in different part of India. In India, North-eastern region, In general, Meghalaya is renowned for producing high-quality vegetables (Kumar and Badal, 2004). Cucurbit flowers are typically monoecious, *i.e.*, they produce male and female flowers on the same plant but at different locations or internodes (Pateel, 2007). Being monoecious cross pollination is essentially required for the cucurbits. Meghalaya have rich biodiversity of some wild and cultivated species of cucurbits which clears the presence of diverse pollinators fauna in this region. Nowadays skilful utilization of domestic honeybees, wild bees and other pollinators including solitary bees as in pollination service is an essential

crop management practice (Pateel, 2007). In crop ecosystem diversity of insect pollinators depends on various factors like flora structure (Free, 1970) corolla depth and most important type and quantity of floral rewards (Dashad *et al.*, 1992; Dutta, 1970). However, population of wild bees and managed bees are reducing year to year due to several abiotic factors like pollution, pesticide spray and human intervention (Wien, 1997) and biotic factors like insect pests and diseases (Pande *et al.*, 2015b). Therefore, it is essential to understand pollinators' diversity, abundance and time period of maximum activity in natural crop ecosystem, so accordingly, strategy can be planned to enhance their number. It will also be helpful for farmers to plan appropriate time for pesticide spray. Therefore,

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considering the aforementioned factors, the current study was undertaken at ICAR-Research Complex for NEH Region in Umiam, Meghalaya, India from year 2011 to 2015 to find out the diversity and abundance of insect pollinators of cucurbits at mid-hills of Meghalaya.

Materials and Methods

The experiment took place at the Division of Entomology and Horticulture farm, ICAR-Research Complex for NEH Region, Umiam, as well as in the surrounding area of ICAR. The initial phase of the study was conducted during the months of June-July-August, and September, specifically at the 10% to 15% flowering stage. This data collection occurred at weekly intervals over the rainy season from 2011 to 2015.

Diversity of Insect Pollinators

While studying the diversity, ridge gourd, sponge gourd, pumpkin, bottle guard, cucumber, chow-chow and teasel gourd were under consideration. For collection and identification of insect pollinators of cucurbits in nature acute visual observation was done at flowering stage throughout the blooming period. Pollinators were collected using collection hand net and vials on flowers itself at their anthesis period. Chloroform in killing jar was used to kill all the collected specimen. Killed insects were pinned and preserved for the identification as per the available literature.

Abundance of Insect Pollinators

The study was commenced at the 10-15% flowering stage, with observations made at one-week intervals according to the anthesis period of the crops. The primary objective of the study was to monitor the number of abundance of visiting pollinators and determine which group of pollinators dominated crop visitation during different time periods. Target crop, for studying the abundance of pollinators were ridge gourd, sponge gourd, pumpkin, cucumber, chow-chow. Observations were recorded, using a stopwatch following the method given by Free (1993). Then the data was averaged species wise and then year wise to draw the conclusion about dominant group of particular crops (Pateel, 2007; Pateel and Sattagi, 2007). The abundance of each pollinator was determined by observing the number of visits by each insect m^{-2} per 5 minutes.

Relative Abundance

Relative abundance was computed by aggregating all the data and then expressing it as a percentage using a formula (Nath and Viraktamath, 2010; Pande and Verma, 2016).

Statistical Analysis

In order to calculate the variance across different studies, statistical constants such as the mean, standard error of the mean and critical difference (CD) for each quantitative parameter were determined using the analysis of variance method commonly employed for randomized block designs (RBD) (Pande and Verma, 2016; Snedecor and Cochran, 1968). These results were calculated with a significance level of 5%.

Results and Discussion

Diversity of Insect Pollinators on Cucurbits

The observations on various insect visitors of cucurbits (ridge gourd, sponge gourd, pumpkin, bottle gourd, cucumber, chow-chow, teasel gourd) were done during rainy season from year 2011 to 2015. The insects' pollinators recorded from these crops are listed in table 1.

The flowers of ridge gourd were recorded to be visited by 3 insect's species which includes bumble bee, Indian honey bee and sphingid moth. Among the visitors only bumble bee in general was recorded during the early hours of anthesis, *i.e.*, at 16:00-17:00 hr of the day and gradually declines. Hawk moth was found to be visiting the crops after 17:30 hours of the day. While studying, flowers of sponge gourd were visited by 6 insect's species which includes bumble bee, carpenter bee, Indian honey bee, squash bee and stingless bee among hymenopteran. Syrphid fly was also observed among Dipterans. All the visitors in general were recorded during 9:00-12:00 hrs in sponge gourd which gradually decline after that time period. In pumpkin during 5:00-8:00 hrs total 4 visitors had been recorded from flowers namely; bumble bee, Indian honey bee, little bee and digger bee. Visitations of pollinators were decline after 8:00 hrs. Peak activity of pollinators in cucumber was generally recorded during the 8:00-13:00 hrs of the day. Common pollinators of cucumber were little bee, Indian honey bee, carpenter bee and stingless bee. Total 3 insect pollinators were recorded from the bottle gourd crop, *viz.*, bumble bee, hawk moth and syrphid fly. In chow-chow variation was recorded in number of pollinators. Like during 2014 only 2 pollinators Indian honey bee and syrphid fly was recorded. All the pollinators, *viz.*, Indian honey bee, syrphid fly and squash bee in general were recorded during the 6:00-17:00 hrs of the day. In other years numbers of pollinators were same. Bumble bee was observed from teasel gourd and one unidentified native bee was also collected. Similar findings were also observed by other researchers in different cucurbits and other crops (Atwal, 1970; Devi *et al.*, 2014; Hemanth Kumar, 2006; Mandelika and Roll, 2009; Pande and Verma, 2016; Pande *et al.*, 2015a; Pande *et al.*, 2016; Pande *et al.*, 2017; Pande *et al.*, 2021; Pande *et al.*, 2023; Prakash, 2002).

Abundance of Insect Pollinators

Abundance of insect pollinators on specific plant exhibits the relation of plant-pollinator interaction (Figure 1-5). While taking average data from 2011 to 2015 on abundance of pollinators under consideration in cucurbits, *viz.*, ridge gourd, sponge gourd, pumpkin, cucumber, chow-chow, revealed the fact that preference of insect-pollinator varies from plant to plant under same crop ecosystem due to structural difference of flower, anthesis period and availability of pollen and nectar. In ridge gourd data on abundance of insect pollinators showed that among the insect pollinators hymenopteran were more abundant than dipteran. Bumble bee emerged as the most abundant pollinator with an average population of 4.17 individuals m^{-2} per 5 minutes, followed by sphingid moth, with an average

Table 1: List of insect pollinators of cucurbits at mid-hills of Meghalaya

Sl. No.	Crops	Pollinator	Family: order
1.	Ridge Gourd (<i>Luffa acutangular</i>)	Bumble bee: <i>Bombus</i> sp.	Apidae: Hymenoptera
		Indian honey bee: <i>Apis cerena</i>	Apidae: Hymenoptera
		Hawk moth: <i>Sphinx</i> sp.	Sphingidae: Lepidoptera
2.	Sponge gourd (<i>Luffa cylindrical</i>)	Bumble bee: <i>Bombus</i> sp.	Apidae: Hymenoptera
		Indian honey bee: <i>Apis cerena</i>	Apidae: Hymenoptera
		Carpenter bee: <i>Xylocopa</i> sp.	Apidae: Hymenoptera
		Stingless bee: <i>Trigona</i> sp.	Apidae: Hymenoptera
		Squash bee: <i>Peponapis</i> sp.	Apidae: Hymenoptera
		Syrphid fly: <i>Syrphus</i> sp.	Syrphidae: Diptera
3.	Pumpkin (<i>Cucurbita moschata</i>)	Bumble bee: <i>Bombus</i> sp.	Apidae: Hymenoptera
		Indian honey bee: <i>Apis cerena</i>	Apidae: Hymenoptera
		Little bee: <i>Apis florea</i>	Apidae: Hymenoptera
		Digger bee: <i>Anthophora</i> sp.	Apidae: Hymenoptera
4.	Bottle guard (<i>Lagenaria siceraria</i>)	Bumble bee: <i>Bombus</i> sp.	Apidae: Hymenoptera
		Hawk moth: <i>Sphinx</i> sp.	Sphingidae: Lepidoptera
		Syrphid fly: <i>Syrphus</i> sp.	Syrphidae: Diptera
5.	Cucumber (<i>Cucumis sativus</i>)	Little bee: <i>Apis florea</i>	Apidae: Hymenoptera
		Indian honey bee: <i>Apis cerena</i>	Apidae: Hymenoptera
		Carpenter bee: <i>Xylocopa</i> sp.	Apidae: Hymenoptera
		Stingless bee: <i>Trigona</i> sp.	Apidae: Hymenoptera
6.	Chow-chow (<i>Sechium edule</i>)	Indian honey bee: <i>Apis cerena</i>	Apidae: Hymenoptera
		Squash bee: <i>Peponapis</i> sp.	Apidae: Hymenoptera
		Syrphid fly: <i>Syrphus</i> sp.	Syrphidae: Diptera
7.	Teasel gourd (<i>Momordica subangulata</i> ssp. <i>renigera</i>)	Metallic native bee (Unidentified)	Apidae: Hymenoptera
		Bumble bee: <i>Bombus</i> sp.	Apidae: Hymenoptera

population of 1.22 individuals m⁻² per 5 minutes and Indian honey bee with an average population of 0.95 individuals m⁻² per 5 minutes (Figure 1). On the basis of abundance bumble bee was identified as an efficient pollinator of ridge gourd. Similar to ridge gourd, the observation recorded on abundance of insect pollinators in sponge gourd revealed that among the insect pollinators hymenopteran are more abundant than dipteran (Pande and Verma, 2016). Bumble bee and Carpenter bee were the most prevalent pollinator

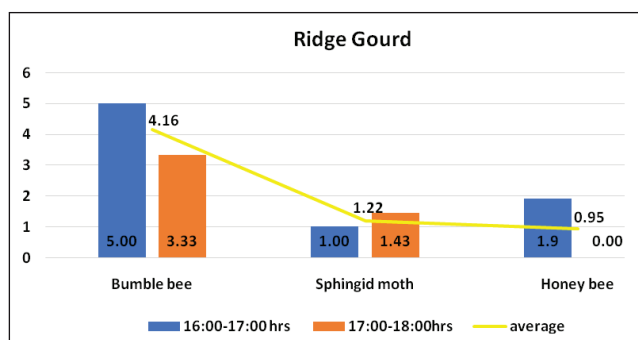


Figure 1: Abundance of insect pollinators in Ridge gourd from year 2011-15

of the target crop with mean abundant population of 9.81 individuals m⁻² per 5 minutes and 9.71 individuals m⁻² per 5 minutes, respectively, followed by Indian honey bee, with mean prevalent population of 2.50 individuals m⁻² per 5 minutes and stingless bee of 1.75 individuals m⁻² per 5 minutes (Figure 2). Mean abundant population of squash bee (0.50 individuals m⁻² per 5 minutes) and syrphid flies (0.44 individuals m⁻² per 5 minutes) were very less on sponge gourd (Figure 2). On the basis of abundance, bumble bee and carpenter bee were identified as the efficient pollinators of sponge gourd.

During the study on the basis of abundance, hymenopteran are the only abundant pollinators, visited pumpkin flower and bumble bee was identified as an efficient pollinator as having maximum mean abundant population of 23.37 individuals m⁻² per 5 minutes followed by little honey bee with mean abundant population of 9.11 individuals m⁻² per 5 minutes (Figure 3). Indian honey bee and Digger bee contributed very less with mean abundant population of 1.13 individuals m⁻² per 5 minutes and 0.79 individuals m⁻² per 5 minutes, respectively. In cucumber also again, hymenopterans were the only pollinator visited the crop

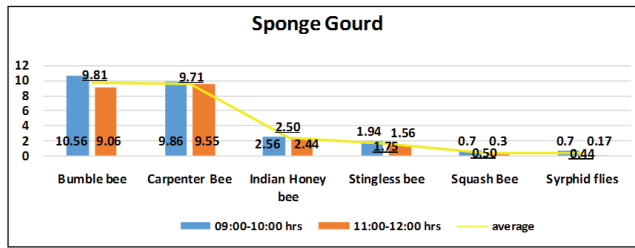


Figure 2: Abundance of insect pollinators in Sponge gourd from year 2011-15

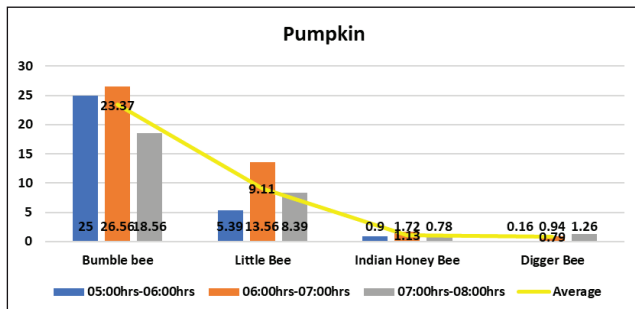


Figure 3: Abundance of insect pollinators in Pumpkin from year 2011-15

in significant number (Figure 4). Among them Indian honey bee was the most abundant pollinator with mean abundant population of 6.94 individuals m^{-2} per 5 minutes followed by little honey bee with mean abundant population of 4.98 individuals m^{-2} per 5 minutes, carpenter bee with mean abundant population of 2.63 individuals m^{-2} per 5 minutes and stingless bee with mean abundant population of 1.42 individuals m^{-2} per 5 minutes. On the basis of abundance Indian honey bee and little honey bee were identified as an efficient pollinator of cucumber.

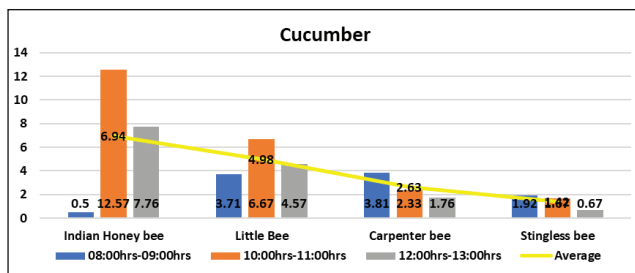


Figure 4: Abundance of insect pollinators in Cucumber from year 2011-15

Average data on abundance of insect pollinators in chow-chow revealed that among the insect pollinators of chow-chow hymenopteran were the dominant pollinator visited the crop in significant number. Among them Indian honey bee was the most abundant pollinator with mean abundant population of 10.57 individuals m^{-2} per 5 minutes. Mean abundant population of syrphid fly (0.80 individuals m^{-2} per 5 minutes) and squash bee (0.54 individuals m^{-2} per 5 minutes) was very low in comparison to Indian honey bee (Figure 5). Pande *et al.* (2016) found that Indian honey bee was the major pollinator of chow-chow in Meghalaya (Pande and Verma, 2016). In 2009, Julier and Roulston recorded that Italian bees (*Apis mellifera*), ground nesting

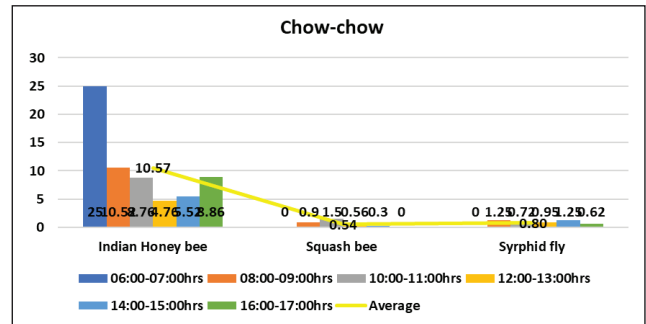


Figure 5: Abundance of insect pollinators in Chow-chow from year 2011-15

bees (*Peponapis pruinosa*) and bumble bees (*Bombus impatiens* Cresson) were the most abundant bee pollinators of pumpkin. Likewise, similar trend of insect pollinators' abundance in pumpkin was recorded by Pande and Verma (2016). Hemanth Kumar (2006) reported that *A. cerana indica* and *A. dorsata* as abundant pollinator of pumpkin. Similarly, with mean abundant population of 2.62 individuals m^{-2} per 5 minutes during 16:00-17:00 hrs, bumble bee was the most abundant pollinator visiting ridge gourd blossom (Anonymous, 2014). Ramesh (2007) reported honey bees as an efficient pollinator of ridge gourd. Alex (1957) reported that honey bees reign supreme when it comes to pollinating cucumber flowers, while only a handful of solitary bees from the *Melissodes communis* species appeared to be effective pollinators (Pateel, 2007). Thakur and Rana (2009) and Susan *et al.* (2019) observed honey bees as a prominent pollinator of cucumber and ridge gourd respectively. Similarly, Gautam and Kumar (2018) reported the hymenopteran as a dominant pollinator of ridge gourd. Seyman *et al.* (1969) reported that for the pollination of cucumber, honey bees seem to be the most effective pollinators (Ramesh, 2007). In present investigation as far as frequency of pollinators concerned it was cleared from the above discussion that, the most abundant pollinator (and sometimes only abundant) of the cucurbits were hymenopterans (80%) followed by lepidopteran (12%) and dipteran (8%) (Figure 6). Devi *et al.* (2014) reported that hymenopterans were most abundant (60%) followed by lepidoptera, diptera in onion; Prakash

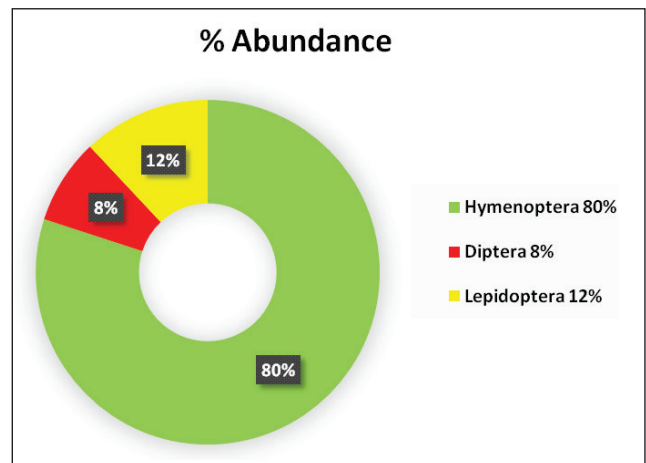


Figure 6: Relative percent abundance of different pollinators group

(2002) reported 82% hymenopteran in cucumber; Pande and Verma (2016), in pumpkin; Pande *et al.* (2016), in chow-chow and Pande *et al.* (2016) in crucifers reported same results.

Conclusion

Cucurbits are the vegetables, contributes in economy of north-eastern part of India. The present study represents the presence of 25 insect pollinators in natural crop ecosystem. Insect pollinator diversity and their abundance declared the status of key pollinator of the cucurbits crop at mid-hills of Meghalaya. Their activity time period revealed the different activity period of different pollinators on flower of cucurbits which gives the idea to shift the time of application of insecticides on target crop. Contribution of native bees like bumble bee, carpenter bee encourages their conservation for proper pollination of cucurbits at present as well as in near future.

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