

Research Article

## Nocturnal insect pollinator diversity and species richness in Ridge gourd, *Luffa acutangula*

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### Abstract

Pollinators are rewarding for many wild and agricultural crop plants. The experiments were conducted in the agricultural field of Karad tehsil, Maharashtra, India. The present study concentrated on the diversity and species richness of nocturnal insect pollinators on Ridge gourd *Luffa acutangula* belonging to the family Cucurbitaceae. The Ridge gourd plant is monoecious with a bunch of male flowers and solitary female flower. Anthesis happened in late evening hours (17.00-19.00) and flowers remained for 13 to 14 hours. A total of 830 insect pollinators were sampled from June 2020 to November 2020. Altogether 17 species of insect pollinators belonging to 7 families under 6 orders were recorded. Among the total number of species, the Lepidoptera was the dominant order comprising 11 species belonging to the single family Crambidae followed by Blattodea comprising 2 species belonging to 2 families Ectobiidae and Blattidae. Hymenoptera comprised 1 species belonging to family Formicidae, followed by order Orthoptera comprising 1 species belonging to family Gryllidae, order Diptera comprising 1 species belonging to the family Culicidae, followed by the order Coleoptera comprising 1 species belonging to the family Chrysomelidae. The *Diaphnia hyalinata* belonging to family Crambidae of the order Lepidoptera was the most dominant species and was followed by *Chabula acamasalis*. The nocturnal species imparted pollination services to agricultural crops. The study also observed fundamental mechanisms of plant and nocturnal insect pollinator interaction as well as floral scent and visual signals. The study can be baseline data for conserving and managing the best pollinators for increasing the yield of Ridge gourd.

**Keywords:** Anthesis, Lepidoptera, Pollinator diversity, Ridge gourd, Species richness

## INTRODUCTION

Cucurbits are a plant family consisting of about 965 species in around 95 genera (Christenhusz and Byng, 2016); the most important to humans are squash, pumpkin, ridge gourd, bitter melon, watermelon, cucumber etc. Most of the plants in this family are annual creepers. Most cucurbits have imperfect flowers as the male and female reproductive parts are located in different flowers. Male flowers appear early and produce nectar and pollen; pollen viability in newly opened flowers is 92%. Gradually, it gets reduced while female flowers appear later and produce more nectar and attract the insects. Most of the gourd flowers opens at night and usually last only one night (Nepi and Pacini 1993). The pollen grains of ridge gourd are

large and sticky; therefore, it must be transferred from the anthers in male flowers to the stigma in female flowers, which is most often attained by diverse insect pollinators (Free, 1993; Delaplane and Mayer, 2000). The plant-pollinator relationship is considered as mutualism because as plant benefits from pollinator's transport of male gametes in return of nectar. Flower visitation or pollen transfer by insects is frequently used as a proxy for insect-pollination (King *et al.*, 2013). Thus the absence of these vectors would result in more than 95% fruit production loss in these crops (Klein *et al.*, 2007).

Ridge gourd has many health benefits. It is rich in essential components like vitamin A in the form of beta carotene, dietary fibers, water content, vitamin C, iron, magnesium and abundant vitamin B6. It is naturally low

in cholesterol, calorie content, and unhealthy saturated fats. Also, it is rich in antioxidants and alkaloid compounds, which regulate metabolism and eliminate toxins from the body, and thus it is an important vegetable crop. Being monoecious Ridge gourd have to cross-pollinate and is dependent on other pollinating agents. Most studies to date have focused on diurnal pollinating insects, largely ignoring nocturnal insects. The Ridge gourd flowers bloom in the evening, so nocturnal pollinators play a major role in pollinating the Ridge gourd (Subhakar and Sreedevi, 2015). The conservation and management of insect pollinators are gaining importance daily, so studies related to diversity, abundance, and species richness are essential. Hence the objective of present investigation was to generate information about the diversity, species richness of nocturnal pollinators of Ridge gourd, *Luffa acutangula*.

**MATERIALS AND METHODS**

The study was carried out on the agricultural fields of Karad tehsil Southern part of Indian state of Maharashtra. Karad is located at 17.28°N 74.2°E. It has an average elevation of 566 metres (Fig. 1) with an average temperature of 29.1 °C. Two different fields cropped with ridge gourd were selected. The fields were about 2023.428 square metres each at a distance of 3Km. The study was conducted during peak flowering seasons from June to November 2020. At each site, we delimited 5 x 5 m plots; 3 plots at each field for the survey of nocturnal pollinators.

Flower visitation by pollinators was observed twice in a week in the evening 19.00 to 22.00. The number of insects visiting the ridge gourd flowers (only the insects touching the reproductive whorls of flowers) was also recorded and collected using the following modes.

- Portable light source
- Canon EOS 200 Camera: Photographs were taken and analysed for flower visitation
- Sweep net

After the photography and observation for visitation frequency, species were collected by sweeping with a sweep net. Insects collected through sweeping were transferred to plastic containers. The collected insects were sorted, labelled and preserved as dry pinned or preserved in 70 % alcohol.

**Hand collection**

Some insect pollinators were collected by hand and transferred into killing bottles. The insects were processed for pinning and preserved on a wooden box in dry condition. The data were later averaged time wise to infer insect pollinators as well as species richness of a particular group.

The abundance of different insect pollinators of ridge gourd was studied during their blooming period. Randomly 20 flowers were selected. The total number of

different insect visitors visiting on the number of gourd flowers in a square metre area was observed for two minutes per plant at an hourly interval from 19.00 to 22.00 hour using a stopwatch. The data was recorded for further analysis.

**Identification**

Insect pollinators collected were identified with the help of keys available in Ananthkrishnan and David (2004) and standard manuals.

**Statistical analysis**

The type of diversity used in the present investigation was α -diversity which is the diversity of species within a community. The diversity index was calculated by using Shannon – Wiener diversity index (Shannon – Wiener, 1949)

**Shannon Wiener diversity index**

$$H = -\sum P_i \ln P_i \dots\dots\dots \text{Eq.1}$$

Where  $P_i = S/N$

S=number of species

N= total number of individuals

ln=logarithm of base e

**Measurement of species richness**

Margalef’s index was used to measure the species richness (Margalef, 1958)

$$\text{Margalef's index} = (S-1)/\ln N \dots\dots\dots \text{Eq.2}$$

S= total number of species

N= total number of individuals in sample

ln= logarithm of base e

**RESULTS AND DISCUSSION**

The observation of insect pollinators on Ridge gourd *L. acutangula* revealed the absence of diurnal pollinators as flowers of ridge gourd started blooming in the evening at 17.00 h. The flowers were visited by nocturnal insects. A total of 830 insect pollinators were sampled from June 2020 to November 2020. Altogether 17 species of insect pollinators belonging to 7 families under 6 orders have been recorded in Table 1 and the photographs of all the recorded nocturnal pollinators species on ridge gourd are given in Fig. 2.

Among the total number of species, the Lepidoptera was the dominant order comprising 11 species belonging to the single family Crambidae. The species were *Spoladea recurvalis*, *Diaphnia hyalinata*, *Hydridids ornatalis*, *Glyphodes bicolor*, *Pyncnormon cribata*, *Paraponyx villidalis*, *Botyodes asialism*, *Chabula acamasalis*, *Poliobotys albactis*, *Parotis marginata*, *Elophila sps*; followed by the order Blattodea comprising 2 species belonging to 2 families; *Loboptera decipiens*, *Periplaneta americana*. Hymenoptera comprised 1 species belonging to family Formicidae that was *Mon-*



**Fig.1.** Location map of Karad tehsil.

*omorium minimum*. It was followed by order Orthoptera comprising 1 species *Gryllus personatus* belonging to family Gryllidae that was followed by order Diptera comprising 1 species *Culex pilosus* belonging the Family Culicidae, followed by the order Coleoptera comprising 1 species *Gastrophysa viridula* belonging to the family Chrysomelidae.

The above findings are in consent with the results of prior workers who also reported different insect pollinators of ridge gourd and cucurbits. Nocturnal pollinators strongly contribute to pollen transport of different agricultural crops. Predominantly moths visit flowers to obtain nectar, which is a strenuous food source and the main adult food source in the majority of moth species

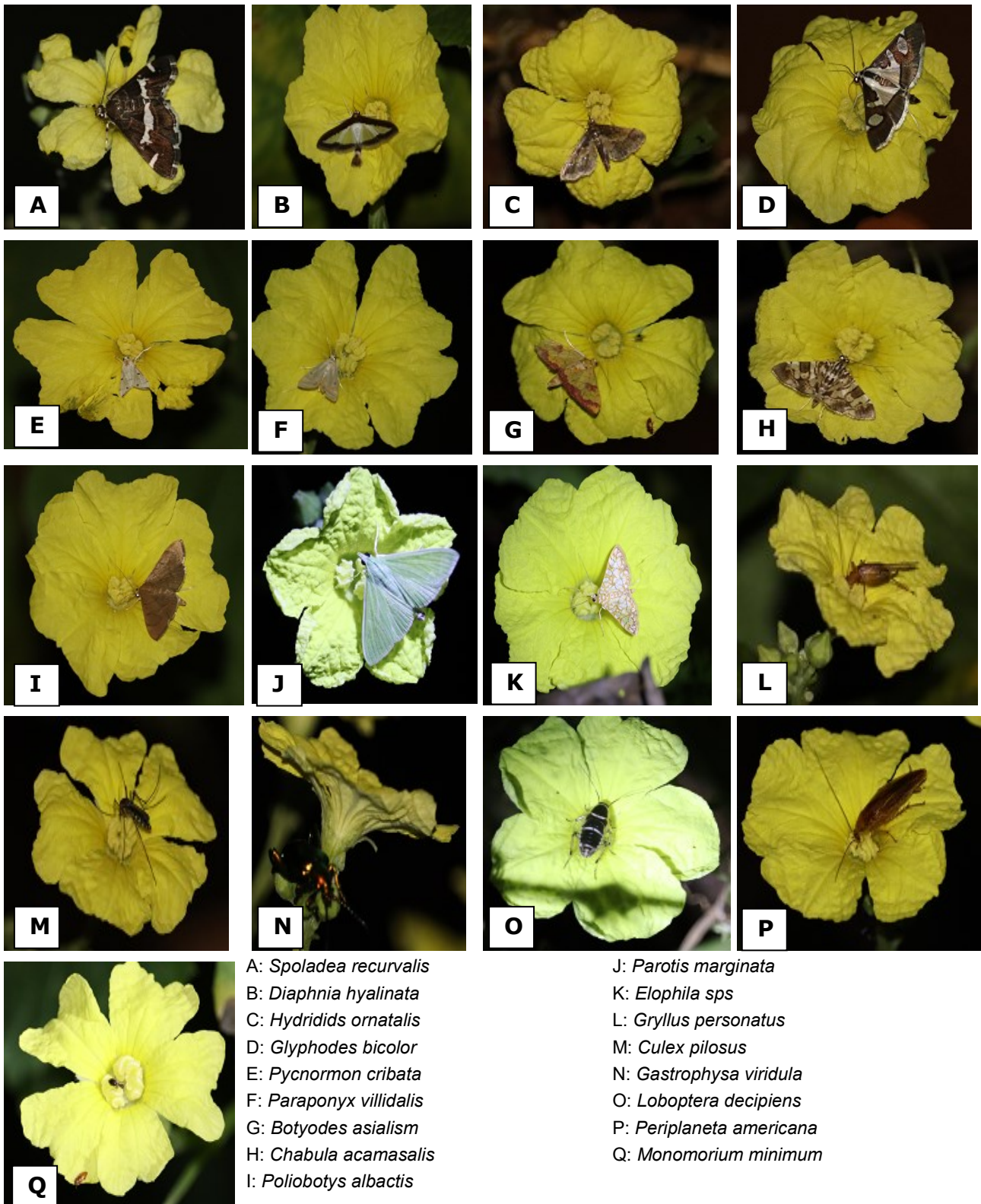
(Willmer, 2011).

The pollinator diversity and abundance in major cucurbitaceous crops have been studied by Subhakar and Sreedevi (2015) who recorded 11 insect species from eight families of five orders viz., seven lepidopterans comprised of six species amounting to 76.68%, two orthopterans species comprising 7.92% and one species each from hymenoptera amounting to 7.33%, coleopteran 7.60% and dictyoptera 6.20%. Lepidopteran flower visitors constituted 76.68%. Among these, *Hippotion celerio* and *Diaphania indica* were the most abundant and frequent visitors in ridge gourd and *Glyphodes bivittalis Guenee* on ridge gourd flowers were the specialist. In United Kingdom in Northflok eastern England, near villages of Bodham and Briston, Walton et al. (2020) recorded 103 moth species dominated by Family Noctuidae, Erebidae and Geometridae with 838 individuals swabbed, and 381 moth specimens (45.5%) were found to transport pollen. From pollen transporting moths, 81% moth species carried more than one pollen grain, 30% carried between 2 and 5 pollen grains, 51%  $\geq 5$  pollen grains and 19%  $\geq 10$  pollen grains. Furthermore, 20% of moth species carried pollen arising from various plant species. Of the detected pollen grains, 57% were encountered on the under-thorax of the moths.

The bright colour of the ridge guard flowers is invisible to the insect in the dark when visual signals are of limited use. The nectar and pleasant scent produced by flowers attract and manipulate the nocturnal pollinators. (Andrews et al 2007, Jurgens et al 2009, Riffell et al 2011) The nocturnal pollinators detect flower's scent and track the concentration gradient of chemicals which produces the scent of the flower (Borges et

**Table 1.** List of insect pollinators on Ridge gourd *L. acutangula* flowers at Karad.

Sr No.	Insect Order	Family	Scientific Name	Total No. of individuals
1.	Lepidoptera	Crambidae	1. <i>Spoladea recurvalis</i>	49
			2. <i>Diaphnia hyalinata</i>	278
			3. <i>Hydridds ornatalis</i>	29
			4. <i>Glyphodes bicolor</i>	33
			5. <i>Pycnormon cribata</i>	50
			6. <i>Parponyx villidalis</i>	16
			7. <i>Botyodes asialism</i>	7
			8. <i>Chabula acamasalis</i>	101
			9. <i>Poliobotys albactis</i>	29
			10. <i>Parotis marginata</i>	3
			11. <i>Elophila sps.</i>	5
2.	Orthoptera	Gryllidae	12. <i>Gryllus personatus</i>	19
3.	Diptera	Culicidae	13. <i>Culex pilosus</i>	56
4.	Coleoptera	Chrysomelidae	14. <i>Gastrophysa viridula.</i>	11
5.	Blattodea	Ectobiidae	15. <i>Loboptera decipiens</i>	26
		Blattidae	16. <i>Periplaneta americana</i>	21
6.	Hymenoptera	Formicidae	17. <i>Monomorium minimum</i>	97



**Fig. 2.** Photographs of nocturnal Insect Pollinator species on Ridge gourd.

al.2016). It showed olfaction has major role in pollination. Flowers render the landing platform for the insect to brush against anthers and stigma (Daniel et al 2020). Sourakov (2008) recorded producing scents ylang-ylang trees in Philippines compete for specialized night pollinators among which insects are the most common

pollinators. The pollination biology of ridge gourd has been studied by Rame Gowda (2016), who recorded four species of Hymenoptera (28.15%), seven species of Lepidoptera (50 %), two of Coleoptera (14.28%) and one Diptera (7.14%) visited ridge gourd flowers. The abundance of the pollinators was considered as a

single pollinator cannot transfer sufficient pollen to the stigmatic surface of a flower in one visit to allow for the development of a perfectly formed fruit. This study highlights that Lepidopteran species abundance was 72.28%, Hymenopteran species abundance was 11.68%, Orthopteran species was 2.28%, Dipteran species abundance was 6.74%, Coleopteran species abundance was 1.32%, Blattodean species abundance was 5.66%. Thus, each fruit-producing flower needs multiple pollinator visits. Which is supported by the several other workers that to obtain sufficient amounts of pollen grains on the stigma to set fruit needs multiple pollinators visits ( Stanghellini 2002,Vidal et al., 2010 ). The rise in number of visits per fruit-producing flower will result in cucurbit fruits having greater size, weight, sweetness, firmness, and more seeds (Hossain et al., 2018).

The diversity of nocturnal insect pollinators was calculated by Shannon-Wiener index and Species richness of pollinators calculated by Margalef's index is given in Table 2. This study highlights the richness of nocturnal insect pollinators on Ridge gourd, comprising 830 individuals belonging to the 17 species. The results showed that Lepidoptera was the most dominant species representing 600 individuals belonging to family Crambidae with 11 species. It was analysed that order Lepidoptera recorded the highest species richness (1.5632) and Shannon Wiener index (0.0733) and the order Coleoptera was the lowest order with the species richness (0.5829) and the Shannon Wiener index 0.2179. The variation in species richness was due to variety of crops and microhabitats in surrounding of the field.

The present study showed that among all the species, *Diaphnia hyalinata* was the dominant species and showed less sensitivity to artificial light. Nocturnal insect species adapt to light after minute exposure to light (Walcott 1969) and show typical daytime behaviours such as cessation of movements and settling down. Artificial light has an influence on the sensitivity of the compound eyes of moths (Frank, 2006). In addition to compound eyes, most insects (including moths) have simple eyes (dorsal ocelli) that are sensitive to

changes in light intensity (Mizunami, 1995) and appear to have a role in organizing flight initiation at dark in moths (Eaton et al., 1983). It is possible that artificial night lighting could delay or even prevent the onset of nocturnal activity. The visual capacity of moths could also be indirectly affected by artificial night lighting altering the spectrum of background illumination. Ultraviolet (UV) radiation (10–400 nm), mostly at longer wavelengths close to visible light (Eguchi et al., 1982), is important to pollinate moths, as moths comply themselves to flowers by a combination of olfactory and visual signals (Robert et al., 2005). It has been observed for many years that shorter wavelengths are more attractive to moths (Frank 2006). The spectral content of artificial lights will affect flower-visiting moths ( Davies et al.,2013). The rate of attraction and wavelength both vary between moth taxa (Merckx and Slade 2014).

The present study observed diverse insect pollinators were due to flower abundance and vegetation structure of the study area. Though the insect pollinators visited ridge gourd flowers for feeding, the surrounding vegetation might be supportive for the completion of their life cycle. Being nocturnal, they utilized nocturnal light for orientation, navigation, location of food, reproduction and avoidance of predators. The study area was less intensive of agricultural practices and light intensities from artificial sources were less, which proved good for insect diversity and population. Also, the pollinators could recognise and respond to environmental differences, which allowed them to exploit environmental heterogeneity.

## Conclusion

The present investigation has revealed that the Ridge gourd flowers were visited by seventeen insect pollinator species belonging to the seven families of six orders. The lepidopterans were the diverse and major flower visitors by eliminating diversity, abundance and species richness of nocturnal pollinators on Ridge gourd. There was the existence of wide and rich pollinators on ridge gourd in Karad tehsil. The assessment

**Table 2.** Diversity indices for insect pollinators collected from ridge gourd field of Karad .

Sr. No.	Insect Order	Total number of families	Total number of species	Total number of individuals	Margalef's index	Shannon-Wiener index
1	Lepidoptera	1	11	600	1.5632	0.0733
2	Hymenoptera	1	1	97	0.7814	0.0471
3	Orthoptera	1	1	19	0.6603	0.1549
4	Diptera	1	1	56	0.7515	0.0717
5	Coleoptera	1	1	11	0.5829	0.2179
6	Blattodea	2	2	47	1.4805	0.1342
	Total	7	17	830		

of ecological parameters affecting the life history of insect pollinators and the studies on larval host plants must be done to record moth host plants that are endemic to this region which will add a new record to host plant databases. The efforts should be made to conserve existing pollinators in agricultural farm and enhance their abundance and diversity as a provision for increased service demand.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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