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Biodiversity of Phototactic insect pests of chickpea ecosystem and records on population dynamics of *Helicoverpa armigera* (Hubner) and *Agrotis ipsilon* (Hufnagel)

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Abstract
The present experiment was conducted under the study on scope and use of light trap as IPM tool in chickpea ecosystem. Documentation of information was done on biodiversity of phototactic insect pests in chickpea ecosystem at Jabalpur. Standard design of Jawahar light trap with 80 W mercury vapor lamp was used to record the insect catches in chickpea crop from October 2015 to April 2016. Data was classified on taxonomic and economic aspect as crop pests. In all 25 species of insects were collected during the cropping season of chickpea. These insect species belongs to 6 insect orders and 14 families. Lepidoptera was the largest order with 11 species. Other major orders were Hemiptera (7 species), Coleoptera (3 species) and Orthoptera (3 species). Isoptera (1 species) were the other orders of minor significance. *Helicoverpa armigera* and *Agrotis ipsilon* were active from October to April with peak catches during 12th & 15th and 5th, 14th &17th standard meteorological weeks, respectively. Correlation regression study with weather factors exhibited that maximum temperature and minimum temperature had a positive effect while morning relative humidity and evening relative humidity showed a significant negative influence on moth catches of *Helicoverpa armigera*. Maximum temperature, morning and evening relative humidity exhibited the significant positive and significant negative effect, respectively on *A. ipsilon*.

Keywords: chick pea, light trap, bio diversity, and insect pests

Introduction
The Indian region is recognized as one of the leading centre of biodiversity in the world. That the diversity is equally rich at the ecosystem level and at the species level has been well documented by field work carried out by naturalists and professional taxonomist during the past 200 years. The habitat diversity offered by alpine ecosystem to mangrove ecosystem through a wide range of tropical forest ecosystem, freshwater and marine ecosystem, desert and island ecosystem found expression in richness of faunal elements in all groups. Today India, occupying 2 percent of global space, documents nearly 7 percent of global faunal diversity. In Phylum Arthropoda, India has 6.13 percent of total species recorded so far in the world (60,383 species out of 9,83,744). Maintenance of biodiversity & variability within agricultural environments is widely recognized as being essential for their agronomic sustainability Matson *et al*. (1997) [10] and Zhang *et al*. (2013) [27]. Majority of the insect pests nocturnal and few diurnal species are phototropic and are attracted towards light sources. Use of light trap is one of the oldest, traditional technology of pest management for eco-friendly agriculture, which was very common in early decade of 20th century mostly for the management of insect pests. In recent years use of light trap occupied an important place in entomological studies and IPM systems for survey, detection and management of insect pest population. Chickpea (*Cicer arietinum* Linn.) is a major *Rabi* pulse crop. Among the all pulses, chickpea occupies 30 per cent of annual production in India. It has an important place in the diet of Indian people because it gives comparatively more protein, vitamins and minerals than any other food grains. Various delicious dishes made by chickpea and it is pure dominant crop among pulses in Madhya Pradesh. Total area, production and productivity of pulses in India 73.2 lakh ha, 80.38 lakh tones. The most economically significant insect pest of chickpea is the pod borer, *Helicoverpa armigera* Hubner and *Agrotis ipsilon* (Hufnegle) in various chickpea growing areas of India, yield losses in particular fields or plots in the range of 10-85% have been documented (Qadeer and Singh, 1989; Yadava and Lal, 1997) [14, 26].

Solsoly *et al.* 2011 from Phillipins reported 25 to 100 percent reduction chemical insecticides after using light trap in vegetable crops and Mango. Maximization of natural control is an important principle of integrated pest management; is to maximize natural control; therefore, the temporal changes in arthropod abundance, diversity, species richness and community structures are important considerations in designing pest management strategies (Baoyan *et al*. 2013) [3]. Although much work has been done on use of light trap against major pests of Paddy but very little information is available on variability & biodiversity of phototactic insect fauna of chickpea ecosystem particularly in Jabalpur region of M.P. The objective of this study was to identify phototactic harmful arthropod species using light trap in chickpea ecosystem and describe them on the basis of taxonomic and economic aspects, in order to provide theoretical basis for the sustainable management of chickpea pests and also records the population dynamics of *Helicoverpa armigera* Hubner and *Agrotis ipsilon* during experiment.

Material and Methods

Experiment location: The research work was conducted at JNKVV research farm, Jabalpur during 2015-2016. The climatic conditions prevalent in Jabalpur are essentially semi-arid and sub-tropical. It is situated at 23.9°N latitude, 79.58° E longitude and at an altitude of 411.78 m above the mean sea level.

Design of light trap: Experiment was conducted by using the new low cost hanging type of light trap having attractting device and collection device is made up of 24 gauge iron sheet. Mercury vapor lamp of 80 W. was used as light source. The insects collected in the collection box of light trap are killed by the exposure of Dichlorvos 76 EC vapor (as fumigating agent) which is directly placed in collection tray.

Sampling and sorting for specimen: Light trap was operated every night but collection of single day per week was recorded from October 2015 to March 2016. Division of weeks was based on calendar days (i.e. Ist Week (1-7th day), IInd Week (8th to 15th day) IIIrd Week (16th to 23rd day), IV^{rth} Week (24th to 30th/31st day). Insect pests collected through light trap were first divided and recorded in to different taxonomical categories. Thereafter, the insect-pests are categorized on the basis of their economic importance viz., harmful (crop pests).

Identification of insects: Identification of insects was done on the basis of specimens available in insect museum of the Department and with the help of Zoological Survey of India, Jabalpur and Department of Entomology, UAS, Bangalore. After counting the, dried specimens were prepared by keeping the pinned insects in oven for 24 hours at 30°C while the small insects, such as leaf hoppers are directly mounted over the small pieces of card sheets with the help of gum and thereafter well labeled specimens were stored in insect boxes and show cases. Detail photographic presentation of these species was also made.

Observation and data analysis: Light trap was operated every night but collection of single day per week was recorded from October 2015 to April 2016. In order to study the population dynamics, daily trap catches of all the major phototropic insect pests were observed and converted into monthly totals. Effect of weather factors on seasonal activity of *Helicoverpa armigera* (Hubner) and *Agrotis ipsilon* (Hufnegle) was studied by converting the daily catches into mean per day per week (weekly mean/day). Week divisions were based on standard meteorological week. Observations of weather data (maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, morning, rainfall and number of rainy days etc.) were recorded on daily basis from JNKVV meteorological observatory. The correlation coefficient between *Helicoverpa armigera* (Hubner) and *Agrotis ipsilon* (Hufnegle) and meteorological parameters was calculated using the following formula.

$$R_{xy} = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{N}}{\sqrt{\left[\Sigma x^2 - \frac{(\Sigma x)^2}{N}\right]\left[\Sigma y^2 - \frac{(\Sigma y)^2}{N}\right]}}$$

Where, r_{xy} = Correlation coefficient between insect and a particular weather parameter
Y = Insect population, x = Particular weather parameter

Result and Discussions

Taxonomic analysis on composition of insect pest fauna - Taxonomic analysis revealed that 25 species belonging to 6 orders and 14 families were recorded throughout the period from October 2015 to April 2016. Based on number of species collected, largest collection was represented by order Lepidoptera (11 species) followed by orders Hemiptera (7 species), Coleoptera (3 species), Orthoptera (3 species) in descending order respectively. Orders of minor significance including Isoptera was represented by one species only (Fig.1).

Similarly Sharma *et al.* (2010) [17] also reported a record of 62 species through light trap catches at Jabalpur (2002-03). These species belonging to 6 orders and 14 families. Lepidoptera was the largest order with 11 species, followed by Hemiptera (7 species), Coleoptera (3 species) and Orthoptera (3 species). Isoptera was the minor significance. Govindarajan. (2007a) [7] & Govindarajan (2007b.) [8] Also reported 35 species of Endoptera [Lepidoptera (38.8%), Coleoptera (27.7%), Hymenoptera (17.1%) & Diptera (16.4%)] and 26 species of Exoptera [Hemiptera (20.0%), Orthoptera (18.2%), Dermeptera (16.7%), Isoptera (16.5%), Dictyoptera (14.6%) & Odonata (14.0%)]. Similarly [12] also reported that Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, Diptera, Odonata and other minor order were collected in light trap catches.

Analysis on composition of insect pest fauna on economic basis

Among the crop pest species order Lepidoptera was represented by the highest number of 4 families including 11 species, in which, family Noctuidae has the highest 6 species (Fig.2). This family includes 5 species as important pests of different crops. [Butler *et al.* 2001] [4] Observed a total of 438 species of Lepidoptera in 13 selected families were identified including Noctuids (222 species), Geometrids (127 species), Notodontids (27 species), Arctiids (26 species), Sphingids (10 species) and Saturniids (9 species).

Comparing the relative size of trap catches of order Lepidoptera the highest catch was observed of *Spodoptera litura* (Linnaeus) (342 moths) Family Arctiidae. El-Mezayyen *et al.* (1997) [6] reported that *Spodoptera litura* Fabricius constituted the highest 53.34% of total trap catches.

Gram pod borer *Helicaverpa armigera* (181), gram cut worm and *Agrotis ipsiton* (153) were recorded in trap catches among the major pests of chick pea. Vaishampayan *et al*. 1995 [22] also reported the activity of the noctuids *Helicoverpa armigera* (Hubner) and *Agrotis ipsilon* Hufnagel), at Varanasi, Uttar Pradesh, India, during 1991-93 using light traps.

Chrysodeixis chalcites (Esper) (119) was the other major polyphagous pests. Verma and Vaishampayan (1983) [24] also reported *Chrysodeixis chalcites* (Esper) in trap catches.

Other major pest species of order Lepidoptera are *Acherontia styx* (Westwood) (64 moths) Family Sphingidae, *Spilosoma obliqua* Walker (264) family Arctiidae, *Palpita vitrealis* (Rossi) (31 moths) family Crambidae. Among major paddy pest *Mythimna separata* (Walker) (139 moths) family Noctuidae *Cnaphalocrocis medinalis* (Guene) was observed as major pest of paddy with highest trap catch (1327) by Sharma, *et al.* (2006) [18].

After Lepidoptera, Hemiptera was the next highest order of pest species in trap catch with 5 families and 7 species. The family Cicadellidae was represented by *Nephotettix virescens (Distant)* with highest trap catch of 7,821 hoppers followed by *Nezara viridula Linnaeus* with a highest trap catch of 754 bugs, *Antestiopsis cruciata* (Fabricius) (69 bugs), *Plautia crossota* (Dallas) (34 bugs), *Pyrilla perpusilla* Walker (987), *Dysdercus koenigii* Fabricius and *Leptocorisa acuta* (Thunberg) (487).

Shama *et al.* (2013) [16] also recorded highest trap catch of *Sogatella furcifera* (Horvath) in light trap catch. Popov (1975). Collected 78 species of Heteroptera in light trap, 45 species being caught regularly. Salem, *et al.* (1999) [15] also observed the population densities of 92 hemipterous insect species by using Robinson light trap at Al-Arish city, North Sinai during 1994-96.

Order Orthoptera was represented by 2 families and 3 species. Among all the pest species of this order highest trap catch was of Field cricket, *Euscyrtus concinnus* (de Haan) (511 crickets) followed by De Geer Gryllid *Gryllus bimaculatus* (81 hoppers) and grass hopper *Trilophidia cristata* (74 hoppers)

In contrast with the present findings Sharma, *et al.* (2006) [18] reported that order Orthoptera was represented by 3 families in which highest trap catch was of *Gryllus* sp. (3854) (fam. Gryllidae) followed by Grass hoppers *Trilophidia cristella* S. (311) & *Gastrimargus transversus* T. (387) and *Gryllotalpa gryllotalpa* Linn. (213) at Jabalpur. While Singh Devinder *et al.* (2007). reported that the nocturnal Orthopteraus were represented by six families viz. Gryllidae, Gryllotalpidae, Tettigoniidae (belonging to Suborder Ensifera) and Acrididae, Tridactylidae, and Tetrigidae (belonging to Suborder Caelifera) in light trap catches.

Order Orthoptera was represented by 2 families and 3 species. Among all the pest species of this order highest trap catch was of Blister beetle *Mylobris pustulata* (de Haan) (149 beetle) followed by Cockchafer beetle, *Anomala viridis* (57 beetles) and grass hopper *Chiloloba acuta* (29 beetles) In contrast with the present findings Sharma *et al.* (2010) [17] also recorded highest trap catch of *Aulacophora foveicollis* (451 beetles) among coleopterous at Jabalpur.

Order Isoptera was represented by only one family i.e. Termitidae with single species Termite, *Odontotermes obesus* (Rambur). The size of catch was 132 adults. Medeiros *et al*. 1999. Reported 24 species of Termites belonging to 3 families including Termitidae through light trap catches at Atlantic forest of North East Brazil.

Population Dynamics of *H. armigera* and *A. ipsilon* in relation to ecological (weather) factors

1. Gram Pod Borer, *Helicoverpa armigera* (Hubner)

The activity period of *H. armigera* was observed from October to April with two distinct peaks during 12 and 15 SW (17.71 & 18.28 moths/sw), respectively. Gupta (2010) observed peak catches of *H. armigera* during 1st to 8rth SW through light trap. El-mezayyen (2014) reported four peaks of *H. armigera* from the 3rd week of May to 2nd week of September.

The highest peak was observed in 15 SW, during this period maximum and minimum temperature were 38.90^{0}C and 19.60^{0}C, respectively, whereas morning & evening relative humidity were 56% & 12%, respectively. There was no rainfall during this week. Correlation between various weather parameters and *H. armigera* catches were found significant, except rainfall and no. of rainy days, which showed a non significant effect on moths catches. In accordance with present findings Sivaprakasam (1996) also reported that relative humidity had a significant impact on moth catches. Verma *et al.* (1982) also reported that rainfall had no effect on moth catches. While Dubey (1980) indicated that similar peak recorded of *H. armigera* were observed when maximum temperature and minimum temperature was 32-34^{0}C and 17-19^{0}C respectively.

2. *Agrotis ipsilon* (Hufnugel)

The activity period of *A. ipsilon* was observed from October to April with three distinct peaks during 5rth, 14rth and 17rth SW (highest) respectively. Gupta (2010) also reported the highest weekly peak trap catches during 8rth SW. Similarly Nirmala Devi *et al.* (1995) also reported the activity of *A. ipsilon* from November to April.

During the highest peak (17rth SW), maximum and minimum temperature were 40.20^{0}C and 20.90^{0}C respectively, whereas morning & evening relative humidity were 46% & 11%, respectively and there was no rainfall recorded during this week. Correlation between *A. ipsilon* and maximum temperature was significantly positive while it was significantly negative with morning and evening relative humidity. On the contrary with this Nag and Nath (1994) reported that temperature exhibited negative influence while relative humidity had significant positive effect on *A. ipsilon* moth catches. In contrast to this Konar *et al*. (2013) observed that relative humidity was negatively correlated with moth catches. Rest of the weather parameters were found non-significant in the present findings. On the contrary Holyoak *et al.* (1997) [9] observed that rainfall exhibited the negative impact on moth catches.

Table 1: Taxonomic distribution of insect pest species collected in light trap in Chickpea ecosystem in *Rabi* 2015-2016

S. No.	Insect species collected	Total of seasons collection* (Oct. 2015 to April. 2016)	Economic status As crop pest
	Order- Lepidoptera		
	A) Family-Noctuidae		
1	*Helicoverpa armigera* (Hubner) Gram pod borer	181	Major polyphagous pest of pulses, potato, tomato, chilli, okra and cotton
2.	*Agrotis ipsilon* (Hufnagel) Black cut worm	153	Major pest of pulses
3	*Spodoptera litura* Fabricius Tobacco caterpillar	342	Major polyphagous pest of soybean, cabbage, cucurbits, potato, chilli and pea etc.
4	*Chrysodeixis chalcites* (Esper) Green semi looper	119	Pest of soybean, potato, tomato and bean etc
5	*Mythimna separata* (Walker) Army worm	139	Major pest of paddy
6	*Hyblaea puera* Cramer Teak defoliator	71	Major pest of teak
	B) Family- Arctiidae		
7	*Creatonotos gangis* (Linnaeus) Tiger moth	412	Polyphagous pest
8	*Spilosoma obliqua* Walker Bihar hairy caterpillar	264	Major polyphagous pest of sesame, linseed and minor pest of cabbage and sweet potato
9	*Amsacta moorei* Butler Red hairy caterpillar	6	Major pest of sun hemp, maize and jower
	C) Family-Sphingidae		
10	*Acherontia styx* (Westwood) Til hawk moth	64	Major pest of sesame and minor pest of potato
	D) Family- Crambidae		
11	*Palpita vitrealis* (Rossi)	31	Pest of ornamental plant (Jasmine)
	ORDER- HEMIPTERA		
	A) Family- Cicadellidae		
12	*Nephotettix virescens* (Distant)Green leaf hopper	7821	Major pest of paddy
	B) Family-Pentatomidae		
13	*Nezara viridula* Linnaeus Green sting bug	754	Major polyphagous pest of soybean, pigeon pea and vegetable crops
14	*Antestiopsis cruciata* (Fabricius) Coffee plant bug	69	Pest of coffee and jasmine
15	*Plautia crossota* (Dallas)	34	Pest of pulse and cotton crop
	C) Family- Lophopidae		
16	*Pyrilla perpusilla* Walker Sugarcane leaf hopper	987	Major pest of sugarcane, wheat and maize,
	D) Family-Pyrrhocoridae		
17	*Dysdercus koenigii* Fabricius Red cotton bug	388	Major pest of cotton and okra
	E) Family- Coreidae		
18	*Leptocorisa acuta* (Thunberg) Rice gundhi bug	487	Major pest of paddy
	ORDER- COLEOPTERA		
	A) Fam.-Meloidae		
19	*Mylobris pustulata* (Blister beetle)	149	Pest of sorghum and minor pest of chick pea
	B) Fam. : Scarabaeidae		
20	*Anomala viridis* (Cockchafer beetle)	57	Pest of paddy
21	*Chiloloba acuta* (Wiedemann)	29	Pest of maize, sorghum and folder grasses
	ORDER- ORTHOPTERA		
	A) Family- Gryllidae		
22	*Euscyrtus concinnus* (de Haan) Field cricket	511	Pest of paddy and folder grasses
23	*Gryllus bimaculatus* De Geer Gryllid	81	Pest of folder grasses
	B) Family- Acrididae		
24	*Trilophidia cristata* (grass hopper)	74	Major pest of paddy
	ORDER- ISOPTERA		
	A) Family- Termitidae		
25	*Odontotermes obesus* (Rambur) Termite	132	Major pest of Wheat, gram and sugarcane & minor pest of many cereals and pulses crops

*= Insect collection of one day per week

Table 2: Correlation coefficient of weather factors on light trap catches of *Helicoverpa armigera* (Hubner) and *Agrotis ipsilon* Hufnegle

Weather Parameter	*H. armigrera*		*A. ipsilon*	
	r	byx	r	byx
Maximum temp. (ºC)	0.677**	0.778	0.419*	0.420
Minimum temp. (ºC)	0.464*	0.545	0.200NS	-
Morning RH. (%)	-0.779**	-0.345	-0.583**	-0.225
Evening RH. (%)	-0.657**	-0.306	-0.491**	-0.199
Rainfall	-0.011NS	-	-0.035NS	-
Number of Rainy Days	0.153NS	-	0.178NS	-

*.= Significant at 0.05 level ** = Significant at 0.01 level NS= Non Significant

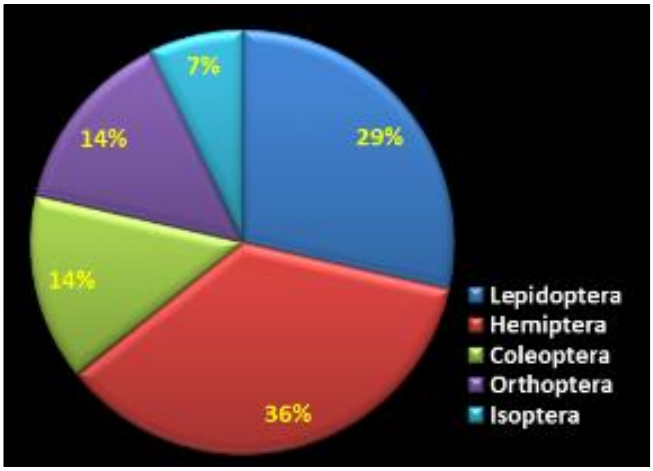

Fig 1: Percentage Shared by Different Insect Pest Orders in Total Trap Catch (2015-2016)

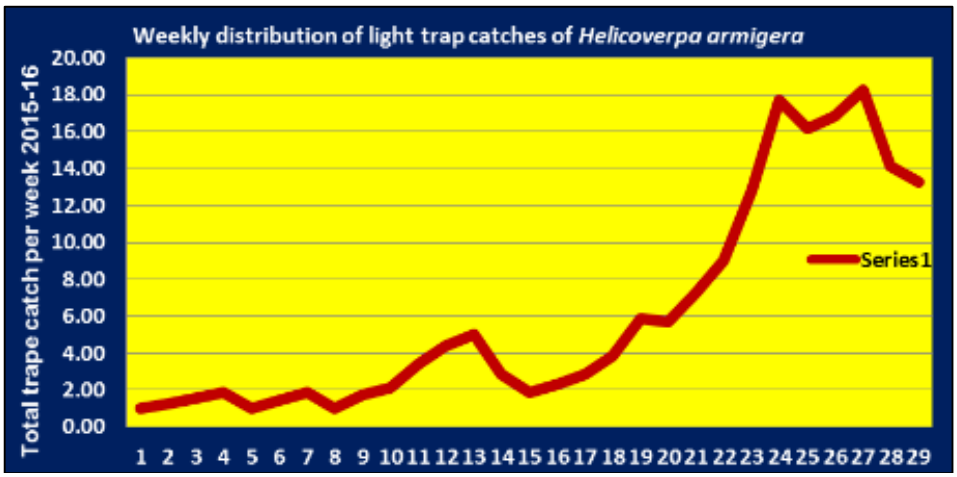

Fig 2: Weekly distribution of light trap catches of *Helicoverpa armigera* during 2015-16

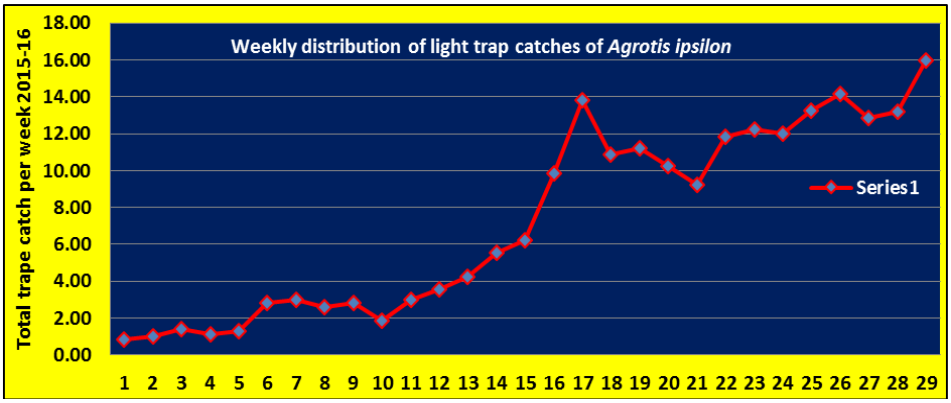

Fig 3: Weekly distribution of light trap catches of *Agrotis ipsilon* during 2015-16

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