__Original Research Article__

Abundance and diversity of insects caughtin light traps with different light sources in an organic farming system

Abstract

Anexperiment on comparison of two different light traps in an organic farming system was conducted in J-block of Gandhi Krishi Vignana Kendra (GKVK) maintained by research institute on organic farming (RIOF), University of Agricultural Sciences, Bengaluru, Karnataka, India for understanding the abundance and diversity of insects caught in a solar light trap and an electric white LED light trap. The study was conducted over a period of 7 months from February 2022 to August 2022 in 14 days interval.The insects collected in the chamber were collected in butter paper bags, shipped to laboratory and were air dried under mercury vapour lamp and were identified up to the family level. Each taxon collected was given a unique number based on morpho-type of the insect for easy identification and analysis. In solar light trap, among the total of 4713 insects collected, order coleoptera ranked first with 3222 insects (68.36 % of the total insects). In white led light trap, among 2795 insects collected, order Hymenoptera ranked first with 828 specimens (30% of total insects caught). In solarlighttrap, among the different insect orders, Coleoptera included highest number of operational taxonomic units (OTUs) (38 OTUs) contributing to 45% of

total number of OTUs caught, followed by the order Hemiptera with 26 OTUs contributing to 31%. In whiteledlighttrap, Hemiptera included highest number of OTUs (43 OTUs) contributing to 41% of total number of OTUs followed by the order Coleoptera with 25 OTUs (24%). The diversity indices for number of insects, operational taxonomic units and families was highest in white led light trap compared to solar light trap and white led light trap caught less total number of insects but with more diversity, on contradictory solar light trap trapped a greater number of insects but with less diversity.

Keywords: Solar light trap, White LED light trap, Insects, Abundance, Diversity

1. INTRODUCTION

Biodiversity losses globally continue to rise, despite significant efforts to preserve species and wildlands. For the purpose of planning for conservation, quick assessments and monitoring of biodiversity are essential, especially in the tropics. An analysis of the diversity of insects sampled through year-round sampling employing different methods like light traps, net sweeps, pitfall traps and pheromone traps, was carried out by Gadagkar*et al.* (1990) in Karnataka, India. But, in recent years, light traps are used by the farmers in agricultural lands to manage pests. Since, pheromone traps are species-specific, they are advised for managingpests in agriculture. But, light traps, do not differentiate between pestiferous and non-pestiferous species. So, light trap has not been recommended as a stand-alone method in IPM. However, light traps could be one of the helpful tools in IPM, but they should not be employed as control agents, but can be used for monitoring pest abundance, as an early warning system and to determine the Economic Threshold Level (ETL) (Baehaki*et al.,* 2017). Ma and Ma (2012) suggested that light trap catches harmless non-pests as well as beneficial insects and it is necessary to use them cautiously.

Different sources of light such as mercury vapour, incandescent, fluorescent,black light are used in light trap studies. These sources vary in their ability to attract various types of insects of different ecological-functional groups depending on intensity of light and the range of wavelength they emit (Ramamurthy *et al*., 2010, Southwood and Henderson 2000). At present, the solar light trap is widelyused by the farmers of Karnataka with Light Emitting Diodes (LEDs) using solar power. But, farmers are unable to differentiate between beneficial, harmful insect species, pestiferous and non-pestiferous ones and they use light trap without realizing its limitations. They get encouraged whenever they see huge number of insects caught in the trap, thinking that all the trapped insects are pestiferous. As a result, Solar light trap has become popular among farmers besides their cost affordability. This is the present status of light trap in Karnataka and also in many other Indian states. Solar light traps are largely used in pest management because they are considered to be ecologically less harmful. However, impact on the non-target organisms is not known much. Hence, there is a need toknow, what are the types of insects,that are getting attracted to the light traps. Hence, a study was initiated to know the proportion of insects caught in light traps, with different ecological functions, including pest species. Two types of light traps, using different sources of energy *viz*., solar energy and AC electric power emitting different wavelengths were selected and comparison was done to understand the diversity of insects caught.

2. MATERIAL AND METHODS

The study was conducted in the organic farm which is located in J-block of Gandhi Krishi Vignana Kendra (GKVK) campus,managed by Research Institute on Organic Farming (RIOF), University of Agricultural Sciences, Bengaluru, Karnataka, India. It is located in the 'Eastern Dry Zone' of Karnataka, with latitude 13° 05'' N, longitude 77° 34'' E and at an altitude of 928 meters above the mean sea level. Laboratory observations were carried out at the Department of Entomology, University of Agricultural Sciences, Bengaluru, Karnataka. Average rainfall and temperature during the study period was 132.66 mm and 29.69°C, respectively.

2.1 Design of the light traps

Two light traps were chosen for the studies, namely, Solar light trap and regular white LED light trap. The Solar light trap had of a solar panel to absorb sunlight; an electronic circuit to convert solar to electric power; battery to store electric energy; bulb (5 Watt LED) that emits blue light (370-390 nm); plastic bucket fitted below the bulb on a ring fixed to the stand; baffle fitted around the bulb, which serves as interception; one-meter stand to hold solar panel and the ring and the bulb. Attracted insects die after falling into the plastic bucket containing insecticide. White LED light trap of modified Robinson model consisted of an LED bulb (5 Watt LED) surrounded by baffles; plastic bucket fitted below; the plastic bucket contained insecticide to kill the trapped insects. The wave length of the white LED light was not possible to quantify because it is a mixture of different colours.

2.2 Light trap installation

The traps were placed at a distance of 700 meters and run simultaneously at 14 days interval for seven months from February 2022 to August 2022. Each time, the traps were run for 12 hours *i.e.,* 6:45 PM to 6:45 AM. As far as possible, sampling was avoided on heavy rainy days but was done on immediate following dry days.

Insects attracted to light were collected in a collection chamber placed at the bottom of the trap. A cotton swab dipped in insecticide was put in the light trap collection chamber to anesthetize the insects. The insects were removed from the collection chamber in the early morning in butter paper bags, shipped to laboratory and were air dried under mercury vapour lamp.

2.3 Processing of insects

Air dried insects were identified up to the family level by following Johnson and Triplehorn (2004). Each taxon collected was given a unique number based on morpho-type of the insect for easy identification and analysis. Same identity of the unique code was maintained from first to the last observation and the data were recorded accordingly and tabulated as per the unique identification code. For example, the termite was coded as TER, leafhopper as LH, ground beetle as GB. The same family's taxa that differ morphologically were further divided and coded individually in numerical order. For example, diving beetle, had the unique ID of DB and has two different morpho-types that were named as DB1 and DB2 separately. Each of these taxonomic units, however, was designated as an operational taxonomic unit (OTU) and used for further studies as such.

2.4 Data analysis

The data was utilized to tabulate different orders and families of insects caught in the two traps and used in analyses to determine their diversity and abundance over the period of seven months in the organic farm. Number of insects trapped, number of OTUs recorded and their abundances across the sampling dates were tabulated. The most abundant insects were listed down. The data were used to tabulate abundance and diversity of orders, families and OTUs of insects which were caught in the traps.

2.5 Measures of diversity

Species abundance data were tabulated and analysed suitably to elicit information on patterns. Species richness, Shannon-Weiner Index and Simpson's Index were estimated to ascertain the number of species present and their evenness.

Inter-relationships among the various measures of diversity were also worked out. Diversity indices calculated are as mentioned below,

Simpson index takes into an account the variance of the species abundance and distribution. It can be calculated by formula,

$D = 1-\left(\sum n(n-1)\right)/ N(N-1)$

Where,

D = Simpson Index

n = Total number of organisms of a particular species

N = Total number of organisms of all species

Shannon-Weiner index of diversity accounts for both abundance and evenness of the species present in an ecosystem. It can be represented by the formula,

$H' = -\sum P_i \ln p_i$

Where,

H'= Shannon Weiner index

p_i = Proportion of individuals of species *i*.

$\ln p_i$ = Natural logarithm to base e of p_i

Margalef's (1950) diversity index is a species diversity index to compensate for the effects of sample size by dividing the number of species in a sample by the natural log of the number of organisms collected and is worked out using formula,

$D_{mg} = S-1/ \ln N$

Where,

D_{mg} = Margalef's diversity index

S = Number of genera recorded

N = Total number of individuals in the sample

ln = Natural logarithm.

Rank test for comparing two traps was done using Wilcoxon signed-rank test

The Wilcoxon Matched-Pairs Signed Ranks Test is used to compare two related samples, matched samples or to conduct a paired difference test of repeated measurements on a single sample to assess whether their populations mean ranks differ. It is a nonparametric test and this test doesn't assume normality.Used to tests the ordering of the dataand is worked out using formula,

Wilcoxon value (z) = (T- SD) / Mean

Where,

Mean = [N (N+1)] /4

Standard deviation (SD) = $\sqrt{[\{N (N + 1) (2N + 1)\} /24]}$

z = Wilcoxon value

T= Sum of like signed ranks

N= Number of samples

3. RESULTS AND DISCUSSION

3.1 Abundance of insects caught in light traps

In Solar light trap, among the total of 4713 insects collected, order Coleoptera ranked first in the number of insects caught, represented by 3222 insects amounting to 68.36 % (Figure 1) followed by Hemiptera (459 insects & 9.74%), Trichoptera (427 & 9%), Hymenoptera (204 & 4.33%), Diptera (177 &3.76%), Blattodea (171 & 3.63%), Lepidoptera (23 & 0.49%), Dermaptera (22 & 0.47%) and Orthoptera (5 & 0.11%). The orders Neuroptera, Mantodea and Collembolawere represented by a single specimen each, contributing only 0.02% to the total number of insects caught in the Solar light trap.

In White LED light trap, among 2795 insects collected, order Hymenoptera ranked first with 828 specimens contributing 30% of total insects caught (Figure 2), followed by Hemiptera (742 insects & 26.55%), Coleoptera (634 & 22.68%), Blattodea (414 & 14.81%), Diptera (131 insects & 4.69%) and Lepidoptera (21 & 0.75%), Orthoptera and Dermaptera (10 each & 0.36%), Trichoptera (3 & 0.11%) and Neuroptera (2 & 0.07%).

The Solar light trap had caught 4713 insects and White LED had attracted 2795 insects, clearly suggesting the superiority of the Solar light trap (χ^2 test; $p<0.01$) in attracting greater number of insects, independent of the taxonomic affiliations. Studies involving two or more light traps with variable light sources are naturally expected to vary in their attractiveness to the insects and might provide differences both in terms of the numbers attracted and also in terms of the orders of insects caught. Often, this is related to the wavelengths of the lights emitted. In the present study, it was observed that, the two light sources differed with respect to the wavelengths. Further, the Solar light trap had a light source emitting wavelength in the UV-A range compared to the White light trap which had more of visible range. Similar studies are lacking. However, a study by Briceno-Elizando (2018) indicated wave lengths emitted by the light sources significantly impact the attraction of insects to the traps.

In the present study, pooled data from both the traps indicated that the orders Coleoptera, Hemiptera, Hymenoptera and Diptera represented 85.20 % (6397 out of total 7508 insects). Present findings are on par with the studies of Kimondiu (2019) who also found that these four orders together comprised 98.77 % of the total insect caught in the mercury vapour lamplight trap on theGKVK campus. The studies show that, order Coleoptera dominated the GKVK collections. Singh *et al.* (2018) also indicated greater number of species of Coleoptera being attracted to the light sources in their study, relative to other orders of insects. Considering the greater attraction of Coleoptera among the insects caught, it may also be a result of higher diversity and abundance of Coleoptera in general as beetles constitute more than 40% of all insects (Erwin, 1982).

3.2 Abundanceofinsectswithrespecttofamilies

In Solar light trap, maximum number of insects attracted belonged to the family Staphylinidae (2013), followed by Dytiscidae (325) (Table 1). The families Pentatomidae, Notonectidae, Mesoveliidae, Naucoreidae, Hemerobiidae, Scelionidae and Entomobryidae were represented by a single specimen each. With respect to the White LED light trap, maximum number of insects attracted belonged to the families Formicidae (800), followed by Termitidae (408) and the least number of the insects attracted belonged to the families Coccinellidae, Cybocephalidae, Veliidae, Nabidae, Alydidae, Derbidae, Achilidae, Hemerobiidae, Mantispidae, Geometridae, Syrphidae, Neriidae and Stratiomyidae each with a single specimen (Table 1).

Several factors determine the differential attraction of insects to the light traps. In the first instance one can envisage the environmental considerations in the vicinity of the traps, which in turn influence the relative abundances of the insects. For example, higher catches of Staphylinidae in the Solar traps may be because of availability of the higher amounts of organic matter in the vicinity, that generally supports large populations of scavenging staphylinids. At the same time incidental rains and the subsequent occasional large-scale emergence of Formicidae in the vicinity of the White LED trap can explain higher collections of these insects in the LED trap. Such variations on day to day basis are not very uncommon in mass emerging insects such as alate ants, alate termites, *etc*. In addition, it is also possible that the weather factors coupled with wind direction can further complicate the abundance of insect catches (Bhatnagar *et al*., 1982). Further, the variation in the number of insects attracted to light source may also be due to the differences in the wavelength range and intensity of the light, which in turn influence the differences in the attraction of insects to different light sources. Differences in the attraction of insects to different light source may also be correlated with the spectral composition.

3.3 Abundance offamiliesindifferentorders

In Solar light trap, highest number of families were recorded from order Coleoptera with 19 families followed by Hemiptera (14 families) while, orders Collembola, Dermaptera, Mantodea, Neuroptera, Orthoptera and Trichoptera had single family each (Figure 3). In White LED light trap, highest number of families were recorded from order Hemiptera with 18 families followed by Diptera (16 families), Coleoptera (15 families), Hymenoptera, Lepidoptera and Orthoptera (3 families each). Orders Blattodea and Neuroptera with 2 families each and Dermaptera and Trichoptera with single family each were next in the order (Figure 3). From the above observation, it can be concluded that, white LED was more efficient in attracting greater number of families, as it caught 63 families, whereas only 46 families were caught in Solar light trap. Walker and Galbreath (1979) reported that, black-light which produced only ultraviolet light caught the narrowest range of insects whereas, the pressure lantern which produces negligible ultraviolet, caught proportionately the widest range of insects and the highest proportion of Diptera were caught by the pressure lantern. In the present study also, the White LED that emits broad spectrum of light, had attracted wide range of insects of different families and the number of families of Diptera that got attracted to White LED was more than that in Solar light trap. It is also to be noted that the UV range of light attracts a high diversity of Coleoptera, which explains the greater attraction of Coleoptera to the Solar trap and the consequent variation in other taxa observed between the two traps.

3.4 AbundanceofOTUsindifferentorderscaughtinthelighttraps

Total number of insects recorded from Solar light trap during the study period werecategorizedinto12orderswhichconsistedof85OTUsandfromWhiteLEDlighttrap,10 orders were recorded, which included106 OTUs. The number of OTUscaught within the order, during thestudyperiod was considered as therichness ofthatparticularorder.

In Solarlighttrap, among the different insect orders, Coleoptera included highest number of OTUs (38 OTUs) contributing to 45% of total number of OTUs caught during the study period, which was followed by the order Hemiptera with 26 OTUs contributing to 31%. The orders Collembola, Dermaptera, Mantodea, Neuroptera, Orthoptera and Trichoptera included single OTU each, contributing 1% each, of the total number of OTUs trapped in Solar light trap (Figure 4). In WhiteLEDlighttrap, among the different insect orders, Hemiptera included highest number of OTUs (43 OTUs) contributing to 41% of total number of OTUs caught during the study period, which was followed by the order Coleoptera with 25 OTUs contributing to 24%. Trichoptera and Dermaptera included single OTU each, contributing 0.94 % to the total number of OTUs trapped in White light trap (Figure 4).

Several factors are responsible for variations in the attraction of insects to light traps. Factors relating to the general insect activity, weather, lunar phase, agricultural practices *etc.* are all the factors expected to influence the light trap catches and thus it is not very unexpected that the trap catches can show great variations on different dates of catching. Considering the variation between the two traps studied, apart from the type and nature of the traps, their relative placement positions and the conditions in the vicinity will all influence the catches between any two traps.

In the present study, there was variation in number of insects caught in different catch days. The main reason for fluctuation in insect numbers might be due to the regular interventions of pest management *i.e,* ploughing the land using machineries, which might have destroyed the natural habitats and disturbed the insect normal life cycle and activity.

3.5 Diversityindicesfornumberofinsects

Simpson diversity index was more in White LED light trap (0.77), than in Solar light trap(0.51). It shows that the diversity of the insects was maximum in the White LED light trap. Shannon diversity index was more in White LED light trap (1.57) than in Solar light trap(1.15).Inthepresentstudy,more diversitywasseen inWhiteLEDlighttrap. Evenness of the insects caught on the light traps was more in White LED light trap (0.48)than in Solar light trap (0.26). Margalef index was more in Solar light trap (1.30) thanin White LED light trap (1.13). The equitability of the insects caught was more inWhiteLEDlight trap (0.68)than in Solarlighttrap (0.46) (Table 2).

The Wilcoxon value for number of insects caught in Solar and White LED traps is -0.314, which gives p value of 0.36, which means, $p > 0.05$, hence there is no significantdifferencein numberofinsectscaught in SolarandWhiteLEDlight traps (Table 2).

3.6 DiversityindicesfornumberofOTUs

Simpson diversity index was more in White LED light trap (0.75), than in Solar light trap(0.70). It shows that the diversity of the insects was maximum in the White

LED light trap. Shannon diversity index was more in White LED light trap (1.67) than in Solar light trap(1.57).In thepresent studythemorediversitywas seen inWhiteLEDlighttrap. Evenness of the insects caught on the light traps was more in White LED light trap (0.53)than in Solar light trap (0.40). Margalef index was more in Solar light trap (2.48) thanin White LED light trap (1.93). The equitability of the insects caught was more inWhiteLEDlight trap (0.73)than in Solarlighttrap (0.63) (Table 2).

The Wilcoxon value for number of OTUs caught in Solar and White LED traps is -1.127, which gives p value of 0.13, which means, p> 0.05, hence there is no significant differencein numberof OTUs caught inSolarand WhiteLEDlight traps (Table 2).

3.7 Diversityindicesfornumberoffamilies

Simpson diversity index was more in White LED light trap (0.79), than in Solar light trap(0.74). It shows that the diversity of the insects was maximum in the White LED light trap. Shannon diversity index was more in White LED light trap (1.82) than in Solar light trap(1.76).In thepresent studythemorediversitywas seen inWhiteLEDlighttrap. Evenness of the insects caught on the light traps was more in White LED light trap (0.62)thaninSolarlighttrap(0.48).MargalefindexwasmoreinSolarlighttrap(2.86)than inWhiteLEDlighttrap(2.16). TheequitabilityoftheinsectscaughtwasmoreinWhiteLEDlight trap (0.79)than in Solarlighttrap (0.71) (Table 2).

The Wilcoxon value for number of families caught in Solar and White LED traps is 1.086, which gives p value of 0.13, which means, p> 0.05, hence there is no significantdifferencein numberof OTUs caught inSolarand WhiteLEDlight traps (Table 2).

From the present studies, it can be concluded that the diversity indices for number of insects, operational taxonomic units and families was highest in white LED light trap compared to Solar light trap and white LED light trap caught less total number of insects but with more diversity, on contradictory solar light trap trapped a greater number of insects but with less diversity. Hence, to monitor the abundance and diversity of insects of a particular area white LED trap can be used.

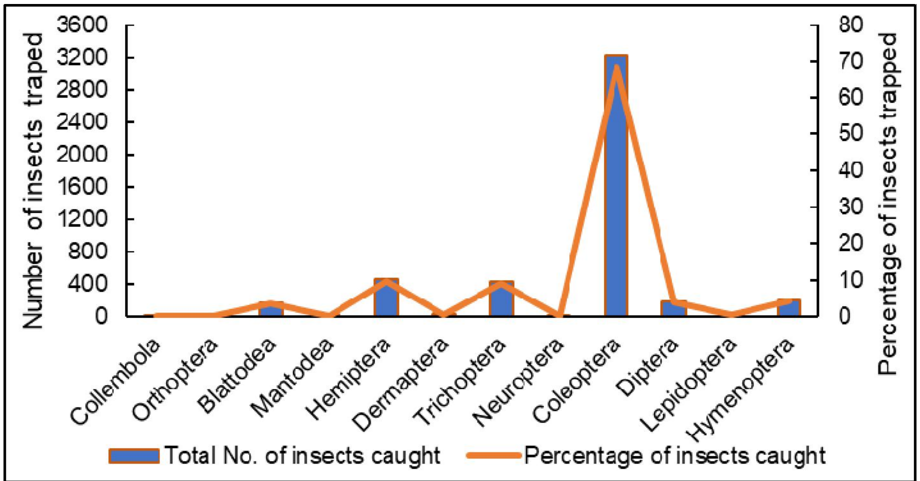

Fig. 1. Abundance of insects caught in Solar light trap

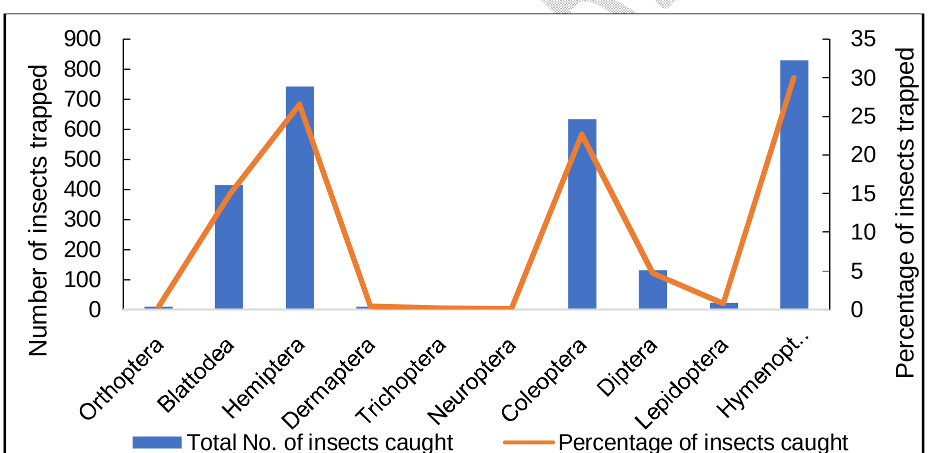

Fig. 2. Abundance of insects caught in White LED light trap

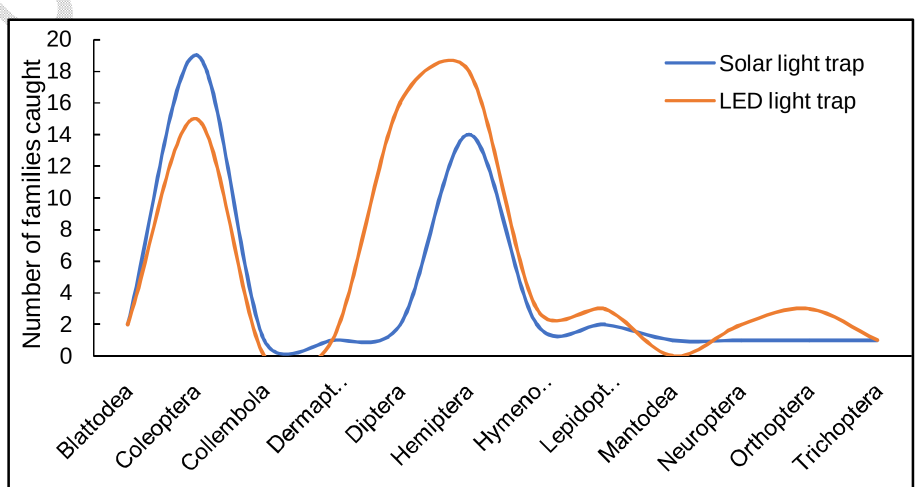

Fig. 3. Abundance of families trapped in different insect orders

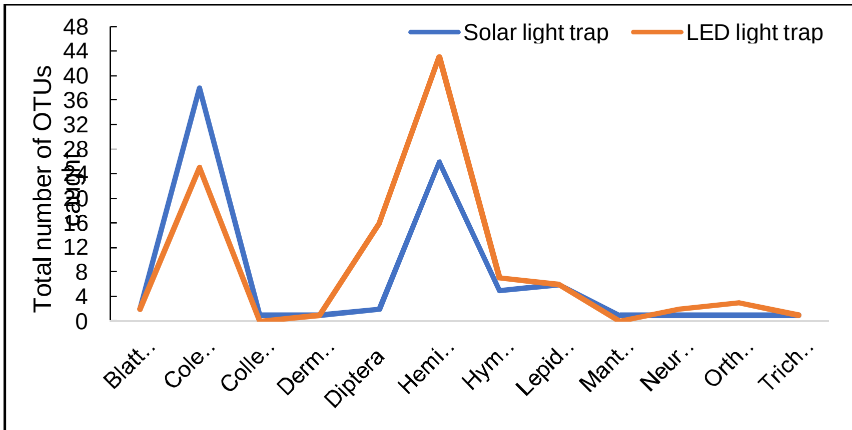

Fig. 4. Abundanceof operational taxonomic units (OTUs)indifferentorderscaughtinthe two lighttraps

Table 1: Number of individuals in different families caught in Solar and White LED light traps during the study period from February to August, 2022

Order	**Family**	**No. of individuals**		**Order**	**Family**	**No. of individuals**	
		Solar light trap	**White LED light trap**			**Solar light trap**	**White LED light trap**
Coleoptera	Anthicidae	7	0	**Lepidoptera**	Erebidae	9	8
	Bostrichidae	2	0		Geometridae	0	1
	Brentidae	0	2		Pyralidae	14	12
	Carabidae	117	2		**Subtotal**	**23**	**21**
	Chrysomelidae	17	8	**Neuroptera**	Hemerobiidae	1	1
	Coccinellidae	3	1		Mantispidae	0	1
	Curculionidae	8	36		**Subtotal**	**1**	**2**
	Cybocephalidae	4	1	**Trichoptera**		427	3
	Dytiscidae	325	3	**Collembola**	Entomobryidae	1	0
	Elateridae	98	31	**Orthoptera**	Acrididae	0	5
	Endomychidae	6	0		Gryllidae	5	2
	Erotylidae	2	0		Tetrigidae	0	3

	Heteroceridae	279	0		**Subtotal**	**5**	**10**
	Hybosoridae	19	100	**Blattodea**	Blattidae	2	6
	Hydrophylidae	17	0		Termitidae	169	408
	Phalacridae	2	8		**Subtotal**	**171**	**414**
	Staphylinidae	2013	192	**Mantodea**		1	0
	Scarabaeidae	288	230	**Dermaptera**		22	10
	Silvanidae	7	0	**Hemiptera**	Achilidae	0	1
	Tenebrionidae	8	11		Alydidae	0	1
	Lampyridae	0	7		Cicadellidae	12	179
	Lycidae	0	2		Coreidae	2	0
	Subtotal	**3222**	**634**		Corixidae	264	37
Diptera	Agromyzidae	0	8		Cydnidae	106	42
	Anthomyidae	0	5		Delphacidae	8	124
	Bibionidae	0	13		Derbidae	0	1
	Calliphoridae	0	9		Lygaeidae	0	14
	Celyphidae	0	2		Meenoplidae	2	8
	Ceratopogonidae	0	7		Mesoveliidae	1	0

	Chironomidae	130	40		Miridae	39	268
	Culicidae	0	2		Nabidae	0	1
	Ephydridae	47			Naucoridae	1	0
	Heleomyzidae	0	3		Notonectidae	1	18
	Muscidae	0	16		Pentatomidae	1	8
	Neriidae	0	1		Psyllidae	0	4
	Platystomatidae	0	4		Reduviidae	3	10
	Stratiomyidae	0	1		Rhyparochromidae	15	21
	Syrphidae	0	1		Tingidae	0	4
	Tabanidae	0	2		Veliidae	4	1
	Tachinidae	0	17		**Subtotal**	**459**	**742**
	Subtotal	**177**	**131**		**Grand Total**	**4713**	**2795**
Hymenoptera	Apidae	0	26				
	Formicidae	203	800				
	Mutillidae	0	2				
	Scelionidae	1	0				
	Subtotal	**204**	**828**				

Table 2. Diversityindicesfortheinsectscaughtintwolighttraps

Orders	For number of Insects		For number of OTUs		For number of families	
	Solar	LED	Solar	LED	Solar	LED
Total	4713	2795	85	106	47	64
Mean	392.75	232.92	7.08	8.83	3.92	5.33
SD	905.86	327.01	12.03	13.13	5.99	6.75
Corr. Coefficient (r)	0.4758 (p>0.05)		0.8231 (p<0.05)		0.7676 (p<0.05)	
Dominance_D	0.49	0.23	0.30	0.25	0.26	0.21
Simpson_1-D	0.51	0.77	0.70	0.75	0.74	0.79
Shannon_H	1.15	1.57	1.57	1.67	1.76	1.82
Evenness_e^H/S	0.26	0.48	0.40	0.53	0.48	0.62
Margalef	1.30	1.13	2.48	1.93	2.86	2.16
Equitability_J	0.46	0.68	0.63	0.73	0.71	0.79
Wilcoxon value	-0.314		-1.127		-1.086	
P	0.36		0.13		0.13	

4. Conclusion

The study overwhelmingly demonstrated that the light traps in general, including the commercial Solar trap, are attracting more of the non-herbivorous then the herbivorous and more often than not, beneficial insects that included large numbers of predators, parasites, mycophages and scavengers. The present findings also suggest potential harm to the local beneficial fauna and a consequent damage to the balanced agro-ecology. In this context, deployment of any type of light trap for the sole purpose of pest management is not a tenable option. Secondly, light traps are by nature being generalist insect samplers, are ideal for short term insect sampling for purposes such as faunal enumeration and ecological studies. The results of the present study, as indicated above, are also vociferously supported by many earlier studies.

COMPETING INTERESTS

"Authors have declared that no competing interests exist".

CONSENT

Not applicable

ETHICAL APPROVAL

Not applicable

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