

Full Length Research Paper**Entomo-fauna as documented Employing Cage net and light trap in some Sewage irrigated Agro-ecosystems in and around Bikaner, Rajasthan, India****Dheeraj Bhati and Meera Srivastava***Laboratory of Entomology, Post Graduate Department of Zoology, Government Dungar College, Bikaner 334001, Rajasthan, India.***Article history***Received: 15-01-2016**Revised: 10-02-2016**Accepted: 21-04-2016***Corresponding Author:****Meera Srivastava***Laboratory of Entomology, Post Graduate**Department of Zoology,
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India.***Abstract**

During this century, the practice of irrigating agricultural crops with sewage waters in rural and peri-urban areas of our country is becoming a common practice as the soil is very good for cropping. Concern for human health and environment are the most important constraints in the use and before one can endorse this means, a thorough analysis seems to be a pre-requisite from social, economical and ecological standpoint. Looking into this, it was proposed to document information relating to insect status in such sewage irrigated farms and thus the present work was undertaken to study the insect scenario (diversity and density) in some sewage irrigated agro-ecosystems in and around Bikaner, Rajasthan. Indigenously designed cage and light trap were employed for insect collection. The cage net trap collection comprised of twenty one lepidopteran, fifteen coleopteran, twenty one hymenopteran, thirteen hemipteran, ten orthopteran, five odonates, nine dipteran and three dictyopteran insect species while, in light trap collection order Lepidoptera was represented by thirteen species, order Coleoptera was represented by seventeen species, order Hemiptera was represented by seven species, order Hymenoptera, Orthoptera and Diptera by one species each respectively. Based on density (number), the cage net collection comprised of 6 dominant, 63 frequent and 28 rare species, while, in light trap collection, based on density (number), 14 were dominant, 17 were frequent and 9 were rare.

Keywords: *Insects, Cage net, light trap, Sewage irrigation, Agro-ecosystem***Introduction**

The use of wastewater for irrigation is probably as ancient as man under took cultivation and farming. With increasing global population, the gap between the supply and demand for water is widening and is reaching such alarming levels that in some parts of the world it is posing a threat to human existence. Scientists around are working on new ways of conserving water. In both, developed and developing countries, the most prevalent practice is the application of municipal wastewater to land and large scale, controlled waste water use for irrigation, however, only dates back to last century when so-called sewage farms were established in parts of Europe, Australia, United States and India for the purpose of disposing of waste water and preventing river pollution. In developed countries where environmental standards are applied, much of wastewater is treated prior to use, but in developing countries, though standards are set, these are not always strictly adhered to, and in its untreated form water is widely used for agriculture. Thus, wastewater can be considered as both a resource and a problem. During this century, the practice of irrigating agricultural crops with sewage waters in rural and peri-urban areas of our Country is becoming a common practice. Such agro-ecosystems have low pH and high organic matter and due to accumulation of humus the soil is very good as far as cropping is concerned. In a way, it is natural organic farming. Ecologically, insects occupy diverse niches and play many different roles important in sustaining the dynamics of ecosystem process (Walker, 1992). They are now found through out the world in all biogeographical regions and ecological zones (Romoser & Stoffolano, 1998). Concern for human health and environment are the most important constraints in the use and before one can endorse this means, a thorough analysis seems to be a pre-requisite from social, economical and ecological standpoint. A base line study for every aspect is therefore of prime importance. Looking into this, it was proposed to document information relating to insect status in such sewage irrigated farms which are coming up at alarming rates.

The present work therefore was undertaken to study the insect scenario in sewage irrigated agro-ecosystem in and around Bikaner, Rajasthan employing cage net and light trap.

Materials and Methods*The study area*

The state of Rajasthan is located between 23°3'-30°12' N and 69°30'-78°17' E, while, Bikaner district lies in North-Western part of Rajasthan located between 27°11' and 29°03' North latitudes and 71°52' and 74°12' East longitudes. The district has a dry climate with large variation in temperature and has scanty rainfall. The summer months are extremely hot with the day temperature sometimes going up to 49.9°C, May being the hottest month. During winter the minimum temperature sometimes drops up to 0°C, January being the coldest month. The agro-ecosystems in the form of crop fields studied lie about 10 to 15 km away from the city, covering an area of 6 hectares each. These are irrigated by sewage water.

The crops in the agricultural fields comprised of radish, ridged gourd, cucumber during January to August; sugar beet during May to August; mint, pumpkin, brinjal, bottle gourd and sorghum during May to December; while, during September to April crops cultivated comprised of cauliflower, onion and coriander; okra during September to December; while, spinach and amaranthus were cultivated throughout the year.

The insect visitors were surveyed and collected for seventeen months every week from January 2012 to May 2013. For the study, the field area was divided into five stations. An indigenously designed cage (net) of 1m×1m×1m of nylon mesh was used for the purpose as also used by Saigal (2002). The cage covered the 1m³ volume while holding the crop inside. The fauna trapped within the cage was mechanically picked up. Using cage the insects were collected between 7A.M to 11A.M, and again in the afternoon from 4 P.M. to 6 P.M. Sampling was done fortnightly. Light-trap collections were made using 260 Watt mercury bulb (Saigal, 2002) in the field twice during each month and overnight collection was taken.

The insects collected by the above method were transferred to killing bottles, killed and preserved. The fauna were sorted out and identified following pertinent literature, help from the Section of Entomology, Department of Agriculture, Bikaner and Desert regional Station of the Zoological Survey of India, Jodhpur was also taken for identification and for confirmation. Besides, the reference collection in the Department of Zoology, Dungar College was consulted. The count of insect fauna collected using cage was averaged for each month and expressed as no/m³ or number/trap. The collection made through light trap was expressed as number/trap/ night.

Results*Diversity of entomo-fauna*

During the present survey, insects were collected employing cage net and light trap. The diversity of insects as observed in the collection made by employing these two methods has been presented in Table 1.

The cage net trap collection comprised of twenty one lepidopteran (*Danaus chrysippus*; *Lampides boeticus*, *Zizina* sp., *Eurema hecabe*, *Anaphaeis aurota*, *Catopsila pomona*, *Colotis vestalis*, *Colias fieldii*, *Hesperilla ornata*, *Leucinodes orbonalis*, *Cnaphalocrocis medinalis*, *Cryptographis indica*, *Hymenia recurvalis*, *Hymenia* sp., *Tephрина* sp., *Acherontia styx*, *Utethesia pulchella*, *Heliothis peltigera*, *Spodoptera exigua*, *Agrotis ipsilon*, *Pericallia ricini*); fifteen coleopteran (*Cicindella* sp., unidentified species A, *Anomala bengalensis*, *Onthophagus catta*, *O. bonasus*, *Peltonotus nasutus*, *Apogonia ferruginea*, unidentified species B, *Melanotus* sp., *Coccinella septempunctata*, *Menochilus sexmaculatus*, *Cylindrothorax pictus*, *Plocaederus* sp., *Hypolixus truncatulus*, *Myllocerus* sp.); twenty one hymenopteran (*Enicospilus* sp., *Campsomeris* sp., *Scoliasoror* sp., *Dolichoderus affinis*, *Formica* sp., *Camponotus vagus*, *Pepsis* sp., *Polistes carolina*, *Polistes* sp., *Prionyx* sp., *Halictus* sp., *Xylocopa fenestrata*, *X. violacea*, *Apis cerana*, *A. mellifera*, *A. dorsata*, *A. florea*, *Amegila cingulata*, unidentified species A, B and C); thirteen hemipteran (unidentified species A, *Dysdercus cingulatus*, *D. koenigii*, *Clavigrella* sp., *Nezara viridula*, *Bagrada hilaris*, *Alcaeus* sp., *Aspongopus janus*, *Andrallus spinidens*, *Piezodorus* sp., *Oncocephalus* sp. and unidentified species B and C); ten orthopteran (*Acheta domesticus*, *Gryllus assimilis*, *Chrotogonus* sp., *Schistocerca gregaria*, *Ochridia* sp., *Oxya chinensis*, *Acrida* sp., *Pyrgomorpha* sp., *Atractomorpha* sp. and unidentified species A); five odonates (*Lestes* sp., *Agriocnemis femina*, *Rhodischnura nursei*, *Bardinopyga geminata*, *Pantala flavescens*), nine dipteran (*Culex quinquefasciatus*, *Stichopogon* sp., syrphid fly, *Chrysomya megacephala*, *C. ruffifacies*, *Dacus cucurbitae*, *Sarcophaga peregrina*, *Musca domestica* and unidentified species A) and three dictyopteran (*Periplaneta americana*, *Mantis religiosa* and *Deiphobe incise*); while, in light trap collection order Lepidoptera was represented by thirteen species, order Coleoptera was represented by seventeen species, order hemiptera was represented by seven species, order Hymenoptera, Orthoptera and Diptera by one species each (*Dorylus* sp., *Acheta domesticus* and *Culex quinquefasciatus* respectively). The lepidopterans not noted were *Danaus chrysippus*; *Lampides boeticus*, *Zizina* sp., *Eurema hecabe*, *Anaphaeis aurota*, *Catopsila pomona*, *Colotis vestalis*, *Colias fieldii*, *Hesperilla ornata* and *Acherontia styx*, the hemipterans not observed included *Clavigrella* sp., *Aspongopus janus*, *Andrallus spinidens*, *Piezodorus* sp., *Oncocephalus* sp. and unidentified species B. No odonates and dictyopteran were observed in light trap collection. Further, the light trap collection comprised of five species viz., unidentified species A and B (Lepidoptera), *Adoretus* sp. and *Ochodeus* sp., (Coleoptera) and *Dorylus* sp. (Hymenoptera) which were never documented in cage net collections.

Table 1. Entomofaunal diversity observed in cage net and light trap collection during the period of study

Insect species	Cage net collection	Light trap collection
Order:Lepidoptera		
Family:Danaidae		
<i>Danaus chrysippus</i> Linn.	+	-
Family:Lycaenidae		
<i>Lampides boeticus</i> Linn.	+	-
<i>Zizina</i> sp.	+	-
Family:Pieridae		
<i>Eurema hecabe</i> Linn.	+	-
<i>Anaphaeis aurota</i> Fab.	+	-
<i>Catopsila pomona</i> Cramer	+	-
<i>Colotis vestalis</i> Butler	+	-
<i>Colias fieldii</i> Menetries	+	-
Family:Hesperiidae		
<i>Hesperilla ornata</i> Leach.	+	-
Family:Crambidae		
<i>Leucinodes orbonalis</i> Guenee	+	+
<i>Cnaphalocrocis medinalis</i> Guenee	+	+
<i>Cryptographis indica</i> Saunders	+	+
<i>Hymenia recurvalis</i> Fab	+	+
<i>Hymenia</i> sp.	+	+
Family:Geometridae		
<i>Tephрина</i> sp.	+	+
Family:Sphingidae		
<i>Acherontia styx</i>	+	-
Family:Arctidae		
<i>Utethesia pulchella</i> Linn.	+	+
Family:Noctuidae		
<i>Heliothis peltigera</i> Schiff	+	+
<i>Spodoptera exigua</i> Hubner	+	+
<i>Agrotis ipsilon</i> Hufnagel	+	+
<i>Pericallia ricini</i> Fab.	+	+
Unidentified sp. A	-	+
Unidentified sp. B	-	+
Order:Coleoptera		
Family:Cicindelidae		
<i>Cicindella</i> sp.	+	+
Family:Carabidae		
Unidentified sp. A	+	+
Family:Scarabaeidae		
<i>Anomala bengalensis</i> Blanch.	+	+
<i>Onthophagus catta</i> Fab.	+	+
<i>Onthophagus bonasus</i> Fab.	+	+
<i>Adoretus</i> sp.	-	+
<i>Ochodeus</i> sp.	-	+
<i>Peltonotus nasutus</i> Arrow	+	+
<i>Apogonia ferruginea</i> Fab.	+	+
Unidentified sp. B	+	+
Family:Elateridae		
<i>Melanotus</i> sp.	+	+
Family:Coccinellidae		
<i>Coccinella septempunctata</i> Linn.	+	+
<i>Menochilus sexmaculatus</i> Fab.	+	+
Family:Meloidae		
<i>Cylindrothorax pictus</i> Fab.	+	+
Family:Cerambycidae		
<i>Plocaederus</i> sp.	+	+

Family:Curculionidae		
<i>Hypolixus truncatulus</i> Fab.	+	+
<i>Mylocerus</i> sp.	+	+
Order:Hymenoptera		
Family:Ichneumonidae		
<i>Enicospilus</i> sp.	+	-
Family:Scoliidae		
<i>Campsomeris</i> sp.	+	-
<i>Scoliasoror</i> sp.	+	-
Family:Formicidae		
<i>Dolichoderus affinis</i> Emery	+	-
<i>Formica</i> sp.	+	-
<i>Dorylus</i> sp.	-	+
<i>Camponotus vagus</i>	+	-
Family:Pompilidae		
<i>Pepsis</i> sp.	+	-
Family:Vespidae		
<i>Polistes carolina</i>	+	-
<i>Polistes</i> sp.	+	-
Family:Sphecidae		
<i>Prionyx</i> sp.	+	-
Family:Halictidae		
<i>Halictus</i> sp.	+	-
Family:Apidae		
<i>Xylocopa fenestrata</i> Fab.	+	-
<i>Xylocopa violacea</i> Linn.	+	-
<i>Apis cerana</i> Fab.	+	-
<i>Apis mellifera</i> Linn.	+	-
<i>Apis dorsata</i> Fab.	+	-
<i>Apis florea</i> Fab.	+	-
<i>Amegila cingulata</i> Fab.	+	-
Unidentified sp. A	+	-
Unidentified sp. B	+	-
Unidentified sp. C	+	-
Order:Hemiptera		
Family:Miridae		
Unidentified sp. A	+	+
Family:Pyrrhocoridae		
<i>Dysdercus cingulatus</i> Fab.	+	+
<i>Dysdercus koenigii</i> Fab.	+	+
Family:Coreidae		
<i>Clavigrella</i> sp.	+	-
Family:Pentatomidae		
<i>Nezara viridula</i> Linn.	+	+
<i>Bagrada hilaris</i> Burmeister	+	+
<i>Alcaeus</i> sp.	+	+
<i>Aspongopus janus</i> Fab.	+	-
<i>Andrallus spinidens</i> Fab.	+	-
<i>Piezodorus</i> sp.	+	-
<i>Oncocephalus</i> sp.	+	-
Unidentified sp. B	+	-
Unidentified sp. C	+	+
Order:Orthoptera		
Family:Gryllidae		
<i>Acheta domesticus</i> Linn.	+	+
<i>Gryllus assimilis</i> Fab.	+	-
Family:Acrididae		
<i>Chrotogonus</i> sp.	+	-
<i>Schistocerca gregaria</i> Forskal	+	-

<i>Ochridia</i> sp.	+	-
<i>Oxya chinensis</i> Thunberg	+	-
<i>Acrida</i> sp. Linn.	+	-
Family:Pyrgomorphidae		
<i>Pyrgomorpha</i> sp.	+	-
<i>Atractomorpha</i> sp.	+	-
Unidentified sp. A	+	-
Order:Odonata		
Family:Lestidae		
<i>Lestes</i> sp.	+	-
Family:Coenagrionidae		
<i>Agriocnemis femina</i> Brauer	+	-
<i>Rhodischnura nursei</i> Morton	+	-
Family:Libellulidae		
<i>Bardinyga geminata</i> Ramer	+	-
<i>Pantala flavescens</i> Fab.	+	-
Order:Diptera		
Family:Culicidae		
<i>Culex quinquefasciatus</i> Say	+	+
Family:Asilidae		
<i>Stichopogon</i> sp.	+	-
Family:Syrphidae		
Syrphid fly	+	-
Family:Calliphoridae		
<i>Chrysomya megacephala</i> Fab.	+	-
<i>Chrysomya rufifacies</i> Mucucurt	+	-
Family:Tephritidae		
<i>Dacus cucurbitae</i>	+	-
Family:Sarcophagidae		
<i>Sarcophaga peregrina</i>	+	-
Family:Muscidae		
<i>Musca domestica</i> Fab.	+	-
Unidentified sp. A	+	-
Order:Dictyoptera		
Family:Blattidae		
<i>Periplaneta americana</i> Linn.	+	-
Family:Mantidae		
<i>Mantis religiosa</i> Linn.	+	-
<i>Deiphobe incis</i> Werner	+	-

(+) Presence; (-) Absence

Density of entomo-fauna

The density of insects as observed in the collection made by employing cage net and light traps has been presented in Tables 2 and 3 respectively.

Based on density (number), the cage net collection comprised of 97 insects species, of which based on number 6 were dominant, 63 were frequent and 28 were rare species. Twenty one lepidopteran insect species were documented in cage net collection, of which, 16 were frequent and 5 were rare form; among 15 coleopteran, 9 frequent and 6 rare forms; among 21 hymenopteran, 3 dominant, 15 frequent and 3 rare forms; among 13 hemipteran, 8 frequent and 5 rare species; among 10 orthopteran, 8 frequent and 2 rare forms; among 5 odonates, 2 frequent and 3 rare forms; among 9 dipteran, 3 dominant, 5 frequent and 1 rare form; all 3 dictyopteran species documented were rare forms. Of the total 5040 insects collected through net collections, density wise, hymenopterans were the dominant insects, followed by dipterans, lepidopterans, coleopterans, hemipterans, orthopterans, odonates, while, dictyopterans were the least noted forms.

Table 2. Total entomofauna (density) observed in cage net collection during the period of study

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Order:Lepidoptera																		
Family:Danaidae																		
<i>Danaus chrysippus</i> Linn.	4	3	1	3	7	5	4	4	11	10	9	13	4	4	3	2	1	88
Family:Lycaenidae																		
<i>Lampides boeticus</i> Linn.	7	7	4	3	1	2	2	3	4	5	10	10	7	3	3	-	1	72
<i>Zizina</i> sp.	5	4	3	1	4	3	4	6	7	10	9	8	8	6	3	3	3	87
Family:Pieridae																		
<i>Eurema hecabe</i> Linn.	8	8	4	3	3	3	2	5	12	10	9	8	7	3	2	2	3	92
<i>Anaphaeis aurota</i> Fab.	6	2	1	-	2	2	-	1	3	3	5	4	4	2	-	-	2	37
<i>Catopsila pomona</i> Cramer	1	2	4	4	3	2	2	2	7	7	9	9	1	1	-	-	1	55
<i>Colotis vestalis</i> Butler	2	1	2	1	6	5	1	1	5	4	5	5	2	1	1	-	4	46
<i>Colibris fieldii</i> Menetries	3	2	-	-	5	3	2	-	7	5	2	3	2	2	-	-	2	38
Family:Hesperiidae																		
<i>Hesperilla ornata</i> Leach.	-	3	-	-	-	-	-	1	-	-	-	-	6	1	-	-	-	11
Family:Crambidae																		
<i>Leucinodes orbonalis</i> Guenee	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	4
<i>Cnaphalocrocis medinalis</i> Guenee	2	3	2	-	2	2	2	1	2	2	3	1	2	2	1	-	-	27
<i>Cryptographis indica</i> Saunders	5	4	2	-	1	2	2	-	-	-	3	5	4	3	1	-	-	32
<i>Hymenia recurvalis</i> Fab.	-	4	-	2	4	7	5	4	5	5	7	6	-	3	-	-	3	55
<i>Hymenia</i> sp.	2	-	1	1	2	2	1	1	2	-	3	1	2	-	-	-	-	18
Family:Geometridae																		
<i>Tephрина</i> sp.	1	-	-	1	2	2	1	1	6	7	9	5	5	4	2	1	3	50
Family:Sphingidae																		
<i>Acherontia styx</i>	-	-	-	-	-	-	2	-	-	-	-	3	-	-	-	-	-	5
Family:Arctidae																		
<i>Utethesia pulchella</i> Linn.	7	6	5	3	3	3	4	3	3	2	7	8	6	3	1	1	1	66
Family:Noctuidae																		
<i>Heliothis peltigera</i> Schiff	5	4	2	2	3	3	3	3	9	8	5	7	2	2	-	-	-	58
<i>Spodoptera exigua</i> Hubner	6	4	3	1	2	-	-	2	4	5	3	8	4	3	-	-	1	46
<i>Agrotis ipsilon</i> Hufnagel	6	6	1	1	4	2	2	3	4	5	8	12	4	1	1	3	4	67
<i>Pericallia ricini</i> Fab.	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	2
	70	63	35	26	55	49	39	41	92	89	107	117	70	44	18	12	29	956
Order:Coleoptera																		
Family:Cicindelidae																		
<i>Cicindella</i> sp.	3	-	2	-	1	5	-	-	5	3	1	1	4	1	-	-	6	32
Family:Carabidae																		
Unidentified sp. A	5	3	1	3	-	-	2	-	-	2	2	1	-	-	1	1	2	23
Family:Scarabaeidae																		

<i>Anomala bengalensis</i> Blanch.	5	3	3	3	9	2	-	-	5	1	5	4	4	1	-	-	1	46
<i>Onthophagus catta</i> Fab.	6	6	4	3	5	2	5	8	5	6	4	5	-	-	-	-	5	64
<i>Onthophagus bonasus</i> Fab.	-	-	4	3	1	1	2	2	3	1	7	3	5	2	-	-	4	38
<i>Peltonotus nasutus</i> Arrow	3	1	-	-	1	1	-	2	3	-	2	6	5	4	2	-	6	36
<i>Apogonia ferruginea</i> Fab.	-	-	5	7	5	-	4	3	2	3	2	6	3	4	-	-	1	45
Unidentified sp. B	7	3	-	-	2	1	-	-	2	2	-	2	4	1	-	-	-	24
Family:Elateridae																		
<i>Melanotus</i> sp.	-	-	-	-	-	-	-	1	-	-	-	3	-	-	-	-	-	4
Family:Coccinellidae																		
<i>Coccinella septempunctata</i> Linn.	4	2	2	8	2	3	1	-	1	-	4	6	2	1	1	1	3	41
<i>Menochilus sexmaculatus</i> Fab.	-	4	4	1	1	4	1	4	2	4	-	1	5	4	2	-	3	40
Family:Meloidae																		
<i>Cylindrothorax pictus</i> Fab.	4	3	-	-	3	1	2	3	4	4	1	3	4	-	2	1	3	38
Family:Cerambycidae																		
<i>Plocaederus</i> sp.	1	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	4
Family:Curculionidae																		
<i>Hypolixus truncatulus</i> Fab.	1	1	-	-	-	6	-	-	5	4	1	-	2	-	2	-	-	22
<i>Myloccerus</i> sp.	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	3
	40	26	25	29	32	26	17	23	37	30	29	41	39	18	10	4	34	460
Order:Hymenoptera																		
Family:Ichneumonidae																		
<i>Enicospilus</i> sp.	-	-	-	-	6	4	1	1	6	4	8	7	13	10	2	-	5	67
Family:Scoliidae																		
<i>Campsomeris</i> sp.	5	5	-	1	7	6	2	3	2	3	8	10	3	4	1	-	4	64
<i>Scoliasoror</i> sp.	5	3	2	1	4	4	2	-	2	3	5	8	6	5	-	-	4	54
Family:Formicidae																		
<i>Dolichoderus affinis</i> Emery	9	8	-	-	3	3	1	5	6	2	6	8	8	8	3	-	3	73
<i>Formica</i> sp.	10	9	1	-	5	4	-	-	9	7	9	7	9	7	1	1	3	82
<i>Camponotus vagus</i>	-	-	-	-	5	7	1	1	-	-	-	-	-	-	-	-	-	14
Family:Pompilidae																		
<i>Pepsis</i> sp.	6	5	-	-	4	7	1	1	2	2	8	11	3	7	-	-	3	60
Family:Vespidae																		
<i>Polistes carolina</i>	10	8	-	-	6	6	-	-	9	7	14	14	9	8	-	1	5	97
<i>Polistes</i> sp.	-	-	-	-	3	1	2	1	-	-	-	-	1	1	-	-	1	10
Family:Sphecidae																		
<i>Prionyx</i> sp.	7	2	-	-	2	2	1	2	3	3	-	1	5	1	1	-	2	32
Family:Halictidae																		
<i>Halictus</i> sp.	8	7	-	1	5	3	1	2	5	8	9	8	9	3	1	2	2	74
Family:Apidae																		
<i>Xylocopa fenestrata</i> Fab.	12	8	5	3	13	9	2	1	6	11	10	12	14	6	1	3	13	129
<i>Xylocopa violacea</i> Linn.	5	5	2	-	6	9	2	-	9	5	4	7	5	4	-	-	6	69
<i>Apis cerana</i> Fab.	10	10	6	2	5	6	7	5	7	9	7	12	11	12	3	-	8	120

<i>Apis mellifera</i> Linn.	14	11	2	4	14	13	-	1	7	8	14	16	15	13	-	2	9	143
<i>Apis dorsata</i> Fab.	5	4	1	-	10	6	2	1	-	8	9	12	4	4	1	-	6	73
<i>Apis florea</i> Fab.	6	5	1	-	5	6	-	8	11	14	11	13	6	5	-	-	5	96
<i>Amegila cingulata</i> Fab.	5	1	-	-	-	-	-	-	-	-	-	1	5	3	2	-	-	17
Unidentified sp. A	8	7	1	2	5	6	-	1	5	6	3	7	9	6	2	-	4	72
Unidentified sp. B	7	4	-	1	4	4	-	-	5	5	7	6	4	7	-	-	4	58
Unidentified sp. C	8	-	-	-	7	6	-	-	7	6	7	4	1	7	2	-	-	55
	140	102	21	15	119	112	25	33	101	111	139	164	140	121	20	9	87	1459
Order:Hemiptera																		
Family:Miridae																		
Unidentified sp. A	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	4
Family:Pyrrhocoridae																		
<i>Dysdercus cingulatus</i> Fab.	2	4	11	10	5	4	5	2	3	1	3	2	3	-	-	-	2	57
<i>Dysdercus koenigii</i> Fab.	-	2	2	-	-	-	-	-	-	2	2	1	2	2	2	-	5	20
Family:Coreidae																		
<i>Clavigrella</i> sp.	3	2	3	1	6	3	6	5	3	1	1	3	12	4	4	2	4	63
Family:Pentatomidae																		
<i>Nezara viridula</i> Linn.	6	4	9	6	5	1	1	-	7	5	2	2	6	2	1	-	4	61
<i>Bagrada hilaris</i> Burmeister	3	5	4	-	2	2	2	-	2	-	-	-	-	-	-	-	-	20
<i>Alcaeus</i> sp.	1	-	-	1	4	1	1	-	1	1	-	-	-	3	-	-	-	13
<i>Aspongopus janus</i> Fab.	2	1	2	2	2	4	4	2	-	-	-	-	2	2	-	1	1	25
<i>Andrallus spinidens</i> Fab.	-	-	-	-	4	2	2	1	8	3	5	3	-	-	-	-	4	32
<i>Piezodorus</i> sp.	2	-	2	2	1	1	1	1	7	7	3	1	-	-	-	-	3	31
<i>Oncocephalus</i> sp.	1	1	1	1	5	3	2	4	7	3	7	-	1	2	2	-	2	42
Unidentified sp. B	-	1	4	4	6	4	5	5	5	5	1	1	8	2	3	1	3	58
Unidentified sp. C	3	5	-	-	-	-	-	-	2	4	1	-	-	-	-	-	-	15
	24	26	38	27	40	25	29	20	45	32	25	13	34	17	13	4	29	441
Order:Orthoptera																		
Family:Gryllidae																		
<i>Acheta domesticus</i> Linn.	2	2	2	-	2	-	-	2	2	3	1	1	-	-	-	-	-	17
<i>Gryllus assimilis</i> Fab.	3	3	6	4	1	1	1	1	3	2	2	-	7	4	5	1	3	47
Family:Acrididae																		
<i>Chrotogonus</i> sp.	4	3	6	4	6	5	3	2	5	4	-	3	2	-	2	1	2	52
<i>Schistocerca gregaria</i> Forskal	5	4	2	2	2	1	4	2	1	2	2	3	1	-	-	-	-	31
<i>Ochridia</i> sp.	2	2	1	4	-	2	1	1	3	2	5	4	2	1	3	3	7	43
<i>Oxya chinensis</i> Thunberg	2	1	3	3	1	2	7	3	1	1	3	3	4	3	1	-	1	39
<i>Acrida</i> sp. Linn.	-	-	2	-	-	-	-	-	-	-	-	-	1	1	1	1	-	6
Family:Pyrgomorphidae																		
<i>Pyrgomorpha</i> sp.	2	1	2	4	4	1	-	-	4	4	1	3	4	3	1	2	5	41
<i>Atractomorpha</i> sp.	1	-	1	1	3	2	3	1	4	6	3	-	4	3	3	-	-	35
Unidentified sp. A	-	2	1	2	3	1	3	2	-	2	5	3	1	1	1	4	3	34
	21	18	26	24	22	15	22	14	23	26	22	20	26	16	17	12	21	345
Order:Odonata																		

Family:Lestidae																		
<i>Lestes</i> sp.	-	-	-	-	-	-	-	-	1	2	1	-	-	-	-	-	-	4
Family:																		
Coenagrionidae																		
<i>Agriocnemis femina</i> Brauer	3	2	-	3	3	1	2	-	3	1	-	5	2	-	2	3	-	30
<i>Rhodischnura nursei</i> Morton	-	4	-	2	1	-	-	1	2	-	-	-	-	1	-	1	3	15
Family:Libellulidae																		
<i>Bardinopyga geminata</i> Ramer	-	-	3	5	1	1	-	1	-	-	3	3	2	4	3	-	7	33
<i>Pantala flavescens</i> Fab.	-	-	3	-	-	-	-	-	2	2	3	3	3	2	1	-	-	19
	3	6	6	10	5	2	2	2	8	5	7	11	7	7	6	4	10	101
Order:Diptera																		
Family:Culicidae																		
<i>Culex quinquefasciatus</i> Say	34	33	30	34	36	44	41	38	46	37	36	35	30	31	35	38	59	637
Family:Asilidae																		
<i>Stichopogon</i> sp.	8	4	5	5	2	2	7	7	4	6	6	1	-	4	6	5	5	77
Family:Syrphidae																		
Syrphid fly	1	1	6	4	4	2	5	4	3	7	2	1	-	3	1	-	3	47
Family:Calliphoridae																		
<i>Chrysomya megacephala</i> Fab.	5	5	2	1	4	7	4	3	-	-	-	-	2	3	1	-	-	37
<i>Chrysomya rufifacies</i>	2	4	4	4	4	7	6	1	-	-	-	-	6	-	4	2	2	46
Mucucurt																		
Family:Tephritidae																		
<i>Dacus cucurbitae</i>	5	2	3	2	6	6	3	1	5	5	1	1	3	4	4	3	-	54
Family:																		
Sarcophagidae																		
<i>Sarcophaga peregrina</i>	7	10	14	9	9	5	6	7	14	11	15	7	8	10	10	9	4	155
Family:Muscidae																		
<i>Musca domestica</i> Fab.	14	9	9	10	16	16	13	11	18	15	11	7	10	11	6	3	4	183
Unidentified sp. A	-	-	1	1	-	-	-	-	2	2	2	-	2	2	3	2	-	17
	76	68	74	70	81	89	85	72	92	83	73	52	61	68	70	62	77	1253
Order:Dictyoptera																		
Family:Blattidae																		
<i>Periplaneta americana</i> Linn.	5	-	3	-	-	-	-	5	2	-	-	-	-	-	-	2	-	17
Family:Mantidae																		
<i>Mantis religiosa</i> Linn.	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	5
<i>Deiphobe incise</i> Werner	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	3
	6	1	4	1	-	-	-	5	3	-	-	-	-	-	1	2	2	25
Total density	380	310	229	202	354	318	219	210	401	376	402	418	377	291	155	109	289	5040

D-Dominant, F-Frequent, R-Rare
 D>100 100 >D>25 R≤25

Table 3. Total entomofauna (density) observed in light trap collection during the period of study

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Order:Lepidoptera																		
<i>Leucinodes orbonalis</i> Guenee	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	6
<i>Cnaphalocrocis medinalis</i> Guenee	-	3	3	2	6	10	6	10	14	12	5	-	-	-	-	-	2	73
<i>Cryptographis indica</i> Saunders	2	2	2	-	2	1	1	5	4	-	-	3	3	5	4	6	6	46
<i>Hymenia recurvalis</i> Fab.	-	3	3	13	20	16	22	20	10	8	6	2	-	3	-	-	4	130
<i>Hymenia</i> sp.	3	-	10	8	12	8	-	-	4	-	-	-	2	-	3	-	-	50
Family:Geometridae																		
<i>Tephrina</i> sp.	2	2	5	4	-	-	8	16	14	18	20	-	3	2	4	4	3	105
Family:Arctidae																		
<i>Utethesia pulchella</i> Linn.	8	8	18	16	15	15	3	2	1	1	3	2	3	3	12	18	16	144
Family:Noctuidae																		
<i>Heliothis peltigera</i> Schiff	3	4	4	5	15	15	14	12	14	10	6	4	3	4	3	3	4	123
<i>Spodoptera exigua</i> Hubner	3	5	2	2	2	-	-	-	10	10	16	18	-	6	3	2	3	82
<i>Agrotis ipsilon</i> Hufnagel	6	5	-	18	12	-	10	12	18	24	-	5	7	-	2	-	4	123
<i>Pericallia ricini</i> Fab.	-	3	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	7
Unidentified sp. A	8	8	-	6	9	-	20	25	25	20	-	7	6	-	6	-	5	145
Unidentified sp. B	-	-	-	6	-	-	-	-	-	8	-	-	-	-	-	4	-	18
	35	43	47	80	93	67	84	102	117	114	56	41	27	25	37	37	47	1052
Order:Coleoptera																		
Family:Cicindelidae																		
<i>Cicindella</i> sp.	1	2	4	7	8	10	16	7	6	14	14	2	2	6	5	3	2	109
Family:Carabidae																		
Unidentified sp. A	5	6	-	-	-	8	10	-	-	-	7	6	6	4	4	6	-	62
Family:Scarabaeidae																		
<i>Anomala bengalensis</i> Blanch.	4	3	5	2	7	-	-	10	11	7	12	4	2	4	5	7	6	89
<i>Onthophagus catta</i> Fab.	5	6	-	2	10	14	16	10	10	5	-	4	7	6	10	1	2	108
<i>Onthophagus bonasus</i> Fab.	5	3	6	-	6	-	14	16	16	7	7	6	-	8	4	3	3	104
<i>Adoretus</i> sp.	3	6	8	8	5	7	12	10	4	8	8	3	5	6	9	7	7	116
<i>Ochodeus</i> sp.	4	9	8	7	10	8	9	4	4	3	6	10	3	2	5	9	8	109
<i>Peltonotus nasutus</i> Arrow	2	6	-	8	-	-	14	12	10	8	-	4	6	2	6	-	4	82
<i>Apogonia ferruginea</i> Fab.	7	2	2	5	6	2	6	10	10	8	10	4	6	-	3	3	6	90
Unidentified sp. B	5	4	-	7	-	-	-	-	-	8	4	-	-	7	8	-	4	47
Family:Elateridae																		
<i>Melanotus</i> sp.	-	-	-	4	-	-	-	1	-	-	12	12	-	-	-	-	-	29
Family:Coccinellidae																		
<i>Coccinella septempunctata</i> Linn.	2	4	3	4	2	6	2	16	16	8	7	15	14	12	4	2	3	120
<i>Menochilus sexmaculatus</i> Fab.	3	5	6	-	4	5	4	-	4	2	-	2	2	6	7	5	5	60
Family:Meloidae																		
<i>Cylindrothorax pictus</i> Fab.	6	4	6	6	5	-	10	12	14	14	11	8	-	-	2	1	3	102

Family:Cerambycidae																		
<i>Plocaederus sp.</i>	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	1	4
Family:Curculionidae																		
<i>Hypolixus truncatulus Fab.</i>	-	-	-	3	7	-	6	-	10	7	-	-	2	2	-	2	-	39
<i>Mylocerus sp.</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	2	-	5
	52	60	49	65	70	60	119	109	115	99	98	80	55	65	74	51	54	1275
Order:Hymenoptera																		
Family:Formicidae																		
<i>Dorylus sp.</i>	5	5	6	6	-	-	-	8	9	8	8	9	-	-	-	-	-	64
	5	5	6	6	-	-	-	8	9	8	8	9	-	-	-	-	-	64
Order:Hemiptera																		
Family:Miridae																		
Unidentified sp. A	-	4	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	6
Family:Pyrrhocoridae																		
<i>Dysdercus cingulatus Fab.</i>	2	2	3	4	1	1	2	1	1	3	5	4	4	4	2	3	4	46
<i>Dysdercus koenigii Fab.</i>	2	3	-	4	-	-	1	2	2	3	4	2	-	-	-	4	-	27
Family:Pentatomidae																		
<i>Nezara viridula Linn.</i>	1	5	2	-	-	4	4	5	5	5	2	-	2	2	5	2	-	44
<i>Bagrada hilaris Burmeister</i>	-	1	1	-	-	2	-	2	-	-	2	1	-	3	-	1	-	13
<i>Alcaeus sp.</i>	-	2	3	-	-	2	5	1	-	1	3	-	-	-	2	2	-	21
Unidentified sp. C	-	-	1	1	-	-	-	-	2	2	3	-	-	1	1	2	-	13
	5	17	10	9	1	9	12	13	10	14	19	7	6	10	10	14	4	170
Order:Orthoptera																		
Family:Gryllidae																		
<i>Acheta domesticus Linn.</i>	2	-	2	-	1	-	2	2	-	-	1	1	-	-	1	1	1	14
	2	-	2	-	1	-	2	2	-	-	1	1	-	-	1	1	1	14
Order:Diptera																		
Family:Culicidae																		
<i>Culex quinquefasciatus Say</i>	5	4	10	3	11	7	5	2	18	18	10	2	4	3	6	10	4	122
	5	4	10	3	11	7	5	2	18	18	10	2	4	3	6	10	4	122
Total density	104	129	124	163	176	143	222	236	269	253	192	140	92	103	128	113	110	2697

D-Dominant,
D>100

F-Frequent,
100 >D>25

R-Rare
R≤25

Forty insect species were documented in light trap collection, of which based on density (number), 14 were dominant, 17 were frequent and 9 were rare. In this collection, 13 lepidopteran species were observed, of which, 6 were dominant, 4 were frequent and 3 were rare forms; among 17 coleopteran, 7 were dominant, 8 were frequent and only 2 were rare forms; only one hymenopteran species observed was a frequent form; among 7 hemipteran, 4 were frequent forms and 3 were rare; one orthopteran observed was a rare form, while, the one dipteran observed was a dominant form. Of the total insects collected through light trap, density wise, coleopterans were the dominant insects, followed by lepidopterans, hemipterans, dipterans, hymenopterans, orthopterans, while, odonates and dictyopterans were not at all documented.

Conclusion

Overall, diversity wise, the cage net collection was dominated by lepidopteran and density wise by hymenopteran fauna, while, in the light trap collection, diversity as well as density wise, coleopterans super ceded the other insect groups.

Discussion

Kundu et al. (1961) have also earlier studied the insect populations including Lepidoptera on light trap at Pilani (Rajasthan). A large number of species of butterflies and moths were found to be attracted towards the mercury lamps in Gujarat by Shull & Nadkerny (1964). Southwood (1996) observed that the size of light trap catch is influenced not only by the actual population of the adults present in the environment but also by the changes in the activity of the insects and their responsiveness towards the trap. Shull & Nadkerny (1967) and Nadkerny & Shull (1968) observed a large number of species of butterflies and moths attracted to the mercury vapour lamps in Gujarat. Brightness of moon was found to suppress the light trap catch in a number of noctuid species including *Heliothis* by Nemas (1971), Persson (1971) and Agee et al. (1972). Vaishampayan & Shrivastava (1978) studied the effect of moon phase and lunar cycle on the light trap catch of tobacco caterpillar *Spodoptera litura* (Fabr.) Coleopterans were found to be attracted more abundantly towards the light trap as compared to other insect orders by Pal & Sachan (1972). The highest catches (927) of *Rhinyptia meridionalis* through light trap were recorded by Pal (1977) when temperature and relative humidity ranged from 30 to 33°C and 52 to 65 per cent respectively. He further reported *Schizonycha ruficollis* on light from second fortnight of June coinciding with the onset of rainfall *Adoretos lesiophygus* highest during month of April, *Serica assanensia* during August and *Aserica* sp. from June to September. Three weather factors viz., temperature, relative humidity and rain fall were studied to affect the flight activity and size of light trap catch of *Heliothis armigera* by Verma et al. (1982) at Jabalpur. The authors revealed that temperature and relative humidity had no significant effect on flight activity of insects and therefore no influence on trap catches while the trap catch on rainy days was considerably higher as compared to that before and after the rainy day. Vaishampayan & Verma (1982) studied the effect of moon light on light trap catches of *Heliothis armigera* by using mercury vapour lamp. The authors observed that in all the lunar cycles the trap catch was consistently very low on moonlit nights around full moon. They further suggested a significant linear and negative correlation between the degree of moon phase and light trap catches. Gregg et al. (1993) operated light traps on mountain tops during September to April in Australia and found that the catch consisted mostly of noctuid and sphingid species. The noctuid species included *Agrotis infusa*, *Mythimna convecta*, *Helicoverpa punctigera*, *Heliothis armigera*, *Dasygaster nephelistis* and *Agrotis munda* while sphingids mostly included *Hippotion scrofa*. Gregg et al. (1994) studied the catches of moths in tower mounted light traps in Northern New South Wales in relation to local and synoptic weather and found catches to be correlated with wind speed, relative humidity and rainfall. They further observed no correlation of catches with temperature but were found to be associated with wind shifts. Nowinszky et al. (2012) studied the influence of illumination and polarized moonlight on light-trap catch of caddis flies (Trichoptera). Vaishampayan & Singh (1995) made studies using light trap on *Heliothis armigera* at Varanasi and revealed that the adult insects remain active during the period of December to May while during June to November the trap collection was either found to be nil or rare. Population status of some major pests of cotton crop such as *Amrasca biguttula biguttula* Ishida, *Spodoptera litura* (Fab.), *Helicoverpa armigera* (Hubner), *Earias* sp., *Pectinophora gossypiella* (Saunders) and *Dysdercus cingulatus* (Fab.) was monitored by Murugesan et al. (2005) using 100w incandescent yellow and blue light traps during vegetative, flowering and boll development stages of cotton crops in a field at Sivakasi, South Tamil Nadu. The pests were surveyed and statistically analyzed with reference to lower rhythmic light, night mean temperature and rainfall. The number of insects trapped in full night collection of both the yellow blue light traps during new moon period was significantly higher than that during other lunar cyclical periods such as quarter, last quarter and full moon periods. The night catches were positively correlated with a unit change in night mean temperature of the survey days during vegetative stage and negatively correlated with that during flowering and boll developing stages of the cotton crops. Rainfall negatively influenced the catches of *A. biguttula biguttula*, *S. litura*, *Earias* sp. and *H. armigera* as well as positively influenced *P. gossypiella* and *D. cingulatus*. Moreover, the difference of crop damages in between the light trap region and shadow region was also analyzed and determined as factor for trapping efficiency of the light traps. Bogush (1936) used light trap in determining the insect fauna and controlling the pests. Sima & Srivastava (2014) have also conducted such a study at Jhunjhun, Rajasthan. Nowinszky & Pusk'as (2011) have studied the light trapping of *Helicoverpa armigera* in India and Hungary in relation with the moon phases. Puttarudriah (1958) reported that the beetles are attracted towards light. Prasad & Thakur (1959) reported that the beetles are attracted towards light. An analysis of factors affecting catches of insects in light-traps has been done by Bowden (1982). Ramamurthy et al. (2010) studied the efficiency of different light sources in light traps in monitoring insect diversity. Insect orientation to various color lights in the agricultural biomes of Faisalabad was recorded by Khan et al. (2005). Studies on catches of certain species of nocturnal coleoptera as indicated by two different light traps at two different levels in Qena Governorate has been done by Mohammed et al. (2010). Vora & Ramakrishnan (1991) studied the phototactic response of *Holotrichia consanguinea*. The authors observed that the beetles *H. consanguinea* were positively phototactic towards lower intensity of light and both sexes were

attracted to different colours of light. All these earlier studies give support to the present findings. Nagand & Nath (1991) studied the effect of moonlight and lunar periodicity on the light trap catches of cutworm *Agrotis ipsilon*. Effects of lunar phases on light-trap collections and populations of bollworm moth have been studied by Nemeč (1971). Dadmal & Khadakkar (2014) carried out investigations to study the species composition of insect fauna attracted towards light trap and observed that order Coleoptera showed a rich population followed by Hemiptera and Lepidoptera. In all they documented 10 orders viz., Coleoptera, Hemiptera, Lepidoptera, Hymenoptera, Orthoptera, Diptera, Isoptera, Neuroptera, Odonata and Dermaptera. They further reported 19 species of Scarab beetles belonging to 10 genera to be prominent visitors which included *Holotrichia serrata*, *H. nagpurensis*, *H. akolana*, *H. fissa*, *H. reynaudi*, *Schizonycha ruficollis*, *Rhinyptia indica*, *R. nigrifrons*, *Anomala varicolor*, *A. dimidiata*, *A. ruficapilla*, *Adoertus bicolor*, *Protaetia aurichalcea*, *P. teracea*, *Oxycetonia jucunda*, *O. versicolor*, *Clinteria klugi*, *Heterorrhina micans* and *Onthophagus gazelle*. These reports support the present findings.

Ethics

All the authors read and approved the manuscript and no ethical issues involved.

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