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Diversity and Abundance of different Groups of Insects Attracted to Light Traps in Dryland Agro-Ecosystem and Temporal Associations among these Groups

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ABSTRACT

A study was conducted to assess (a) temporal patterns of insect activity and (b) the diversity measures of biological heterogeneity using insects attracted to light at UAS, GKVK. A total of 209,098 individuals belonging to 764 morpho-species or Operational Taxonomic Units (OTUs), representing 101 families from 12 orders were collected through the two years of sampling. The Simpson's index of diversity computed for all insects was (0.9732), the Shannon-Wiener index was 4.4443 and Avalanche index was 1.1693. Insect diversity and abundance exhibited clear temporal patterns through the two-year study. Number of OTUs collected increased nonlinearly with the number of insets collected in the 26 samples from the light trap.Thus, the species richness appeared to exhibit the typical `Specie-Area relation', with the number of individuals collected. Insects were abundant and also diverse during summer and post rainy seasons but decreased during winter and rainy seasons. In fact, all the five speciose orders showed similar trend through the seasons. Our results also showed that the Coleoptera is a good indicator of the total insect diversity perhaps because it is the most predominant component of the collections made in our study; since Coleoptera constitutes about 40 per cent of all insects known, diversity of this group it is not unexpected that it is a good indicator of total diversity. Further, diversity of this group was also correlated with the diversity of Hemiptera and Lepidoptera.

Keywords: Temporal patterns, insect diversity, abundance, good indicator

DIVERSITY and abundance of any taxonomic group could indicate their ecological and functional significance in the ecosystem in which they are found assemblages (Bihn *et al.,* 2010; Mouchet e*t al.,* 2010). For example, while a high diversity and abundant population of the pollinating bee community in the ecosystem may result in an efficient pollination that of dung beetles may indicate the efficiency of scavenging the dung and of cycling the nutrients in the habitat (Klein *et al.,* 2007; Yamada *et al.,* 2007; Hoehn *et al.,* 2008).

In fact, highly diverse ecosystems are known to be more productive and also stable over time (Ives and Carpenter, 2007; Biswas and Mallik, 2010). Therefore, diversity and abundance of taxa may also serve as a good indicator of the health of the ecosystem (Feld *et al.,* 2009; Flynn *et al.,* 2009. However, the species richness and abundance of any group may not be stable over space and time (Devictor *et al.,* 2010; Bolnick *et al.,* 2011). While spatial variations in the habitat features affect the diversity and abundance in space, on the temporal scale, these parameters are bound to be influenced by the circadian weather cycles (Adela *et al.,* 2007). Therefore, it is essential that the functional and ecological significance of a taxonomic group be understood by analyzing the temporal patterns in their diversity and abundance.

In the present study, we examined the diversity and abundance of the insects in a dry land agro-ecosystem for about two years and assessed (a) the temporal patterns in abundance and diversity of all insects and the five most speciose orders, (b) Temporal association among different orders in their diversity and abundance and (c) possible indicator group that reflects the insect diversity in general.

MATERIAL AND METHODS

Study area : Gandhi Krishi Vignana Kendra (GKVK) campus of the University of Agricultural Sciences, Bengaluru, Karnataka State. Geographically, the place is located at 12°58' latitude North and 77°35' longitude East. The centre is at an altitude of 930 meters above sea level.

Data collection

Sampling Method: Insects were collected using a light trap. The source of light used was a mercury vapour lamp of 165 Watts (Philips). Light traps were run every 21 days' interval from 8-05-2015 to 6-12-2016 period. Insects attracted to light were collected in a container placed at the bottom of the trap provided with an insecticide as the killing agent.

Processing of Collections: All collected specimens were air dried and processed. Larger specimens were easily separated and smaller ones sorted under a stereo-zoom microscope. All insects were further sorted into different morpho-types.

Identification of specimens: Each morpho-type was then verified for uniformity based on the external morphology and assigned an Operational Taxonomic Unit (OTU). As a consequence, each morpho-type was in principle, represented as known or unidentified species. Assistance from Agricultural Entomology Department was sought to identify OTUs according to their Taxonomic positions. Identified morpho-types were classified into their respective orders and families and their numbers counted. All the specimens were stored in packets labeled with sampling date, OTU and species count for further examination.

RESULTS AND DISCUSSION

Temporal changes in diversity are usually referred to as "turnover", although the term may be applied to spatial changes as well (Gulland and Cranston, 2010). A total of 209,098 individuals belonging to 764 morpho-species or Operational Taxonomic Units (OTUs), representing 101 families from 12 orders were collected through the two years of sampling (Table I).

From a broader perspective, it is clear from this study that diversity will increase as the similarity in species composition decreases. Insects are the most species-rich taxon with about one million species described worldwide, corresponding to more than half of all known species (Gulland and Cranston, 2010).

Due to their high ecological diversification and short generation times, insects are useful indicators of environmental change (Flynn *et al.,* 2009; Feld *et al.,* 2009; Flynn *et al.,* 2011; Schowalter, 2011). The Simpson's index of diversity computed for all insects was (0.9732), the Shannon-Wiener index was 4.4443 and Avalanche index was 1.1693. Clearly the insect diversity and abundance shows distinct temporal patterns and these results are presented in detail elsewhere (Matata *et al.,* 2017). Temporal patterns of five speciose orders were similar among themselves and followed that of the total insect diversity and abundance (Table II and Fig. 1a. and 1b).

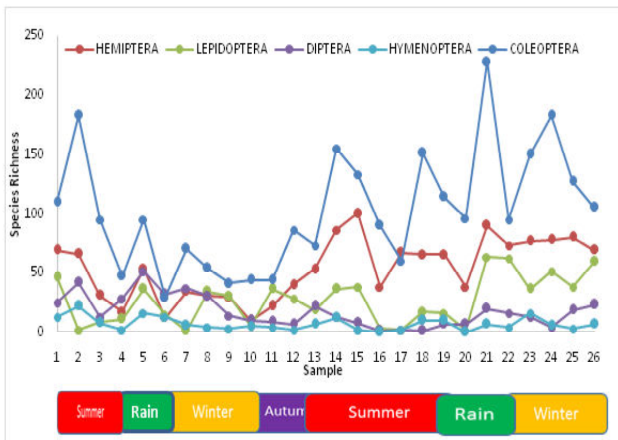

Fig.1a: Species richness of five most speciose orders of insect orders collected from 8th May, 2015 to 6th December, 2016 using mercury vapour light trap at GKVK, Bengaluru.

Insect activity patterns through the year as depicted from the abundance of different orders were not quite different from richness. They showed similar patterns for orders Coleoptera and Hemiptera. Abundance peaks were evident during summer and late rainy seasons. Among the orders Coleoptera and Hemiptera were found to have bemore rich and abundant than the other orders during the sampling period (Fig. 1b).

TABLE I

Number of OTUs and abundance of all insects collected from 8th May, 2015 to 6th December, 2016 using mercury vapour lamp light trap at GKVK, Bengaluru

Sampling Date	Species Richness	Population Size	Simpson's Index	Shannon-Wiener Index	Avalanche Index
08/05/2015	267	9943	0.920	3.435	1.116
08/06/2015	320	7178	0.928	3.815	1.084
08/07/2015	162	6069	0.942	3.457	1.125
29/07/2015	104	410	0.949	3.769	1.179
21/08/2015	256	3055	0.979	4.727	1.084
18/09/2015	102	2323	0.878	3.206	1.203
10/10/2015	147	2184	0.959	3.757	1.234
31/10/2015	160	5430	0.905	3.192	1.164
22/11/2015	119	1487	0.953	3.703	1.255
13/12/2015	73	638	0.849	2.763	0.743
03/01/2016	117	1487	0.919	3.325	1.226
24/01/2016	167	4079	0.947	3.689	1.158
14/02/2016	179	4463	0.960	3.893	1.223
06/03/2016	302	12683	0.958	4.029	1.112
27/03/2016	292	12675	0.938	3.699	1.072
17/04/2016	141	6499	0.938	3.434	1.112
08/05/2016	140	4969	0.897	3.093	1.093
29/05/2016	246	5026	0.978	4.439	1.152
19/06/2016	214	4576	0.974	4.232	1.149
17/07/2016	145	7039	0.877	3.026	0.932
16/08/2016	419	27098	0.938	3.542	1.133
28/09/2016	258	22094	0.931	3.366	1.069
10/10/2016	302	23283	0.954	3.739	1.168
25/10/2016	327	16468	0.941	3.771	1.127
15/11/2016	274	11117	0.970	4.082	1.157
06/12/2016	236	6825	0.911	3.433	1.201
TOTAL	764$	209098	0.9723	4.4443	1.1693

$This represents the total unique OTUs recovered during the study

TABLE II

Relation between species richness of all insects with species richness, abundance, Simpson index and Shannon-Wiener index of each of the five speciose orders

	Coleoptera	Hemiptera	Lepidoptera	Diptera	Hymenoptera
Species richness					
Best Line Fit	$y = 1.6236x + 46.13$	$y = 83.244e^{0.0158x}$	$y = 2.8617x + 135.62$	$y = 0.6317x + 201.09$	$y = 7.0142x + 162.48$
R^2	0.86	0.83	0.41	0.0088	0.193
P<	0.01	0.01	0.01	NS	0.05
Abundance					
Best Line Fit	$y = 104.73x - 2664.8$	$y = 25.691x^{1.3904}$	$y = 235.89x + 1736.7$	$y = 6781.9e^{-0.015x}$	$y = 4067.2e^{0.0364x}$
R^2	0.5427	0.69	0.42	0.033	0.037
P<	0.01	0.01	0.01	NS	NS

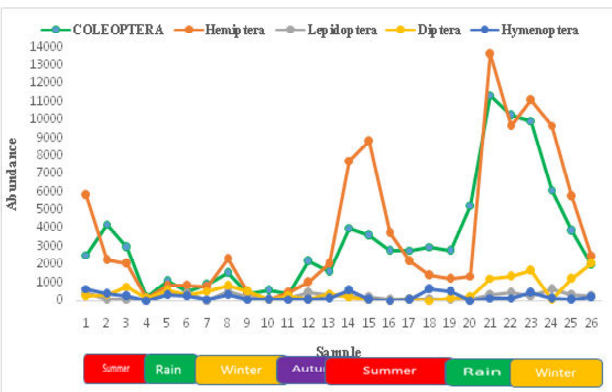

Fig.1b: Abundance of five most speciose orders of insect orders collected from 8th May, 2015 to 6th December, 2016 using mercury vapour light trap at GKVK, Bengaluru.

Number of OTUs collected increased nonlinearly with the number of insets collected in the 26 samples from the light trap ($y = 8.8334x^{0.3597}$; r = 0.8464; p< 0.01; Table III, Fig. 2). Thus, the species richness appeared to exhibit the typical 'Specie-Area relation', with the number of individuals collected. Similar relationship was found between the species richness and abundance in five most speciose groups (Table IV). However, the power function defining the rate at which species richness increases with the abundance was 0.36 for all insects (Table III, Fig. 2).

Except Diptera, the other four orders showed significant temporal association with the pooled species richness of all insects (Table II), though the strength of relation was high for Coleoptera and Hemiptera. Similarly, the abundance of Coleoptera and Hemiptera was strongly associated with that of all the insects (Table II).

Among the five most speciose orders, temporal associations were very strong between Coleoptera and Hemiptera for both species richness (r = 0.80; p<0.01) and abundance (0.86; p<0.01; Table IV).

TABLE III

Relation between diversity and abundance of the five speciose orders with those of all the insects

	All insects	Coleoptera	Hemiptera	Lepidoptera	Diptera	Hymenoptera
Best Line Fit $8.8334x^{0.3597}$	$y = 4.0145x^{0.4067}$	$y = 3.7616x^{0.3345}$	$y = 0.7732x^{0.6693}$	$y = 8.1062e^{0.0008x}$	$y = +3.3844$	$y = 0.0199x$
R^2	0.7165	0.6926	0.7056	0.7669	0.1826	0.5345
P<	0.01	0.01	0.01	0.01	0.05	0.01

TABLE IV

Relationships species richness (above the diagonal) and abundance (below the diagonal) between insect speciose orders. Values in bold are significant at 5 %(*) or at 1 % (**).

	Coleoptera	Hemiptera	Lepidoptera	Diptera	Hymenoptera
Coleoptera	1	0.80**	0.40*	-0.08	0.39*
Hemiptera	0.86**	1	0.55**	-0.15	0.22
Lepidoptera	0.24	0.43*	1	0.03	0.04
Diptera	0.45*	0.39*	0.24	1	0.54**
Hymenopterea	0.11	0.13	0.12	0.02	1

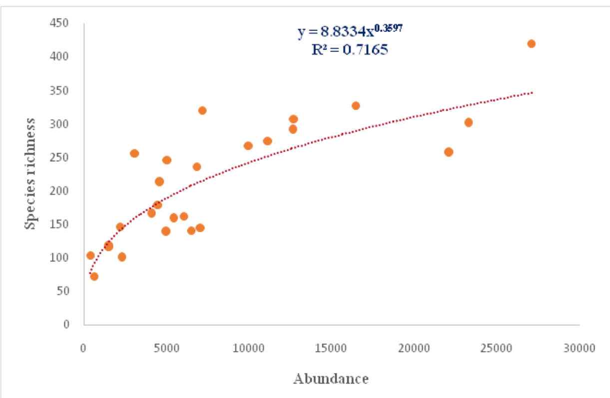

Fig. 2: Relationship between abundance and species richness among all insects collected from the light trap catches during the study period.

Similarly, Lepidoptera and Hemiptera also were strongly correlated in their diversity and abundance (r = 0.55; p<0.001; and 0.43; p<0.05, respectively). Coleoptera also showed significant association with Lepidotera and Hymenoptera in species richness (Table IV).

The results also showed that the Coleoptera is a good indicator of the total insect diversity perhaps because it is the most predominant component of the collections made in our study; since Coleoptera constitutes about 40 per cent of all insects known (Stork *et al.,* 2015) diversity of this group it is not unexpected that it is a good indicator of total diversity. Further, diversity of this group was also correlated with the diversity of Hemiptera and Lepidoptera.

The dominance of Coleoptera in this study stems exceptionally from its high species richness (348) represented in 29 rich families. Studies on Coleoptera by (Susilo *et al.,* 2009; Gullan and Cranston, 2014) have shown Coleoptera to be a potential bio-indicator for moist habitats due to its preference for moist soil, litter and rotting wood.

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