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Temporal Patterns of Insect Diversity in Bengaluru - A Study Using Light Traps

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ABSTRACT

Studied the temporal pattern of all insects attracted to light trap from May 2015 to December 2016 at GKVK, Campus was studied. The results indicated that, both the abundance and richness of insects is high during summer seasons than winter and rainy seasons. Assessed the effect of temperature, relative humidity and rainfall on the species richness and abundance was studied through correlations and multiple regression analysis. Three kinds of analysis were attempted: impact of these parameters on (a) the day of sampling, (b) cumulated over the period of three days, and (c) cumulated over three weeks. Correlation studies indicated that the rainfall and relative humidity over three days before sampling affected the insect diversity significantly and the total insect activity (as reflected by abundance) was affected only by rainfall over three days before sampling. Temperature did not appear to impact on the insect activity and diversity. However, multiple regression analysis showed that temperature cumulated over three week period negatively impacted the species richness and diversity though the abundance was not affected. The temperature on the day of sampling or cumulated over three day period did not have any direct impact. Thus, the study demonstrates that the temperature affect insect activity over long term than short term. Other parameters did not show any direct effect on diversity and abundance of insects. In other words, the insect activity may be reduced by increasing temperatures of the globe- a concern in the context of climate change. This effect however appears to be confounded when analyzed with other parameters.

ASSESSING diversity is central to ecology and conservation. Different methods can be used to assess insect diversity: Sweep netting, light trap, pit fall trap, hand picking etc. Light traps capture highly diverse orders of insects like Coleoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera etc. Efforts to conserve or manage insect communities require some knowledge of the total number of species present, within habitat patches and, perhaps, the relative degree of species turnover among habitats or regions (New, 1999).

Insect activity is important because the movement of insects is associated with various ecological services ranging from pollination (Johnson, 1996), pest control (Johnson, 1992) to seed dispersal (Bond, 1994), but also spread of disease (Epstein *et al.,* 1998) and predation of economically important crops (Ward and Masters, 2007; Sana and Samways, 2015). While, many arthropod species depend on plants for food and are influenced by vegetation structure (Scherber *et al.,* 2014), their activity is also influenced by different abiotic factors like rainfall, altitude, temperature or wind (Addo-Bediako *et al*., 2000; Briers *et al.,* 2003 and Rahbek, 2005). This can result in seasonal peaks in abundance and species richness. The abiotic environment often varies along altitudinal gradients, with consequences for composition and activity of arthropod assemblages. Insects often show specific annual activity patterns frequently linked to phenology often triggered by photoperiod in combination with temperature and humidity (Van Asch and Visser, 2007) causing high insect activity in some seasons than others. In this paper, an attempt has been made to test the impact of temparature on insect species richness.

MATERIAL AND METHODS

Study area

Gandhi Krishi Vignana Kendra (GKVK) campus of the University of Agricultural Sciences, Bengaluru, Karnataka State, India which is located about 15 kms north of Bangalore City. 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. The annual rainfall ranges from 679.1 mm to 888.9 mm.

GKVK falls under the Eastern Dry Agro-climatic zone of Karnataka. Sampling site was 'K' block situated near ZARS, GKVK, Bengaluru and located at 13°081' longitude North and 77°571' East at an altitude of 930 meters above mean 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 once every 21 days 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 Units (OTU). As a consequence, each morpho-type was in principle, represented as a taxonomic species. Assistance from Agricultural Entomology Department was sought to identify OTUs according to their taxonomic positions. Identified morpho-types were classified into their respective families and orders 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

Insect species composition

Samples taken through use of a Mercury vapour lamp light trap at 21 day interval period from 5th May 2015 to 6th December 2016 at GKVK yielded a total of 209,098 individuals (Fig. 1) belonging to 764 morpho-species (Fig. 2), representing 103 families.

Pattern of insect species richness and abundance

Sampled data on species richness and abundance was analyzed at various levels in relation to seasons. Patterns of both abundance and richness of insects was found to be higher during summer seasons than winter and rainy seasons (Fig. 3). The abundance and

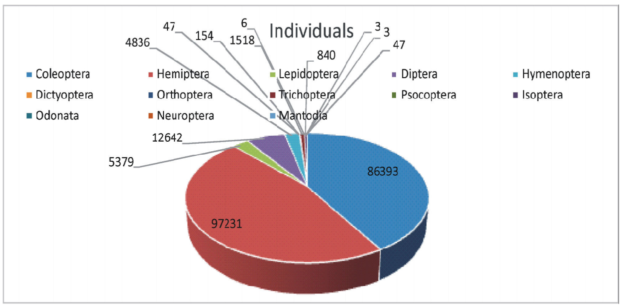

Fig. 1: Proportional distribution of insects attracted to mercury vapour lamp light traps at GKVK, Bengaluru from 8th May, 2015 to 6th December, 2016 (Table I).

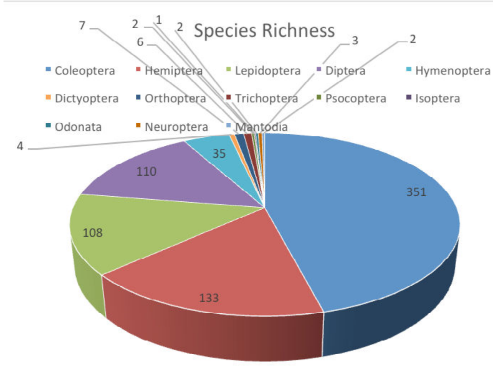

Fig. 2: Proportional distribution of insect species attracted to mercury vapour lamp light traps at GKVK, Bengaluru from 8th May, 2015 to 6th December, 2016 (Table I).

species richness data could not be easily understood when plotted linearly (Fig. 3). This necessitated the study to explore analysis on a circular distribution (Fig. 4) and (Fig. 5), correlation (Table II) and regression (Table III) in an effort to delineate any variations that may exist.

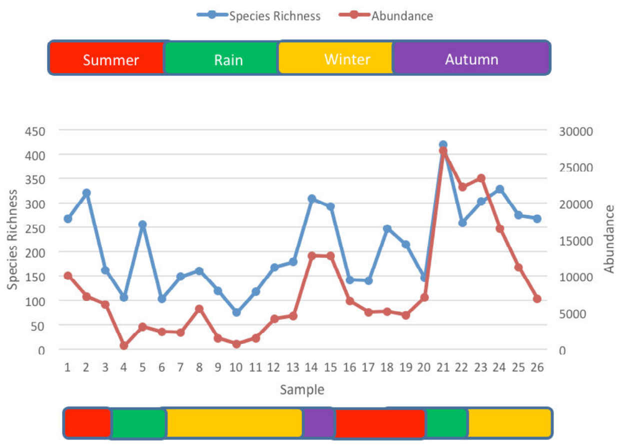

Fig.3: Relative diversity of species richness and individuals' collected from 8th May, 2015 to 6th December, 2016 using mercury vapour light trap at GKVK, Bengaluru (Table I).

Number of Observations	5474
Mean Vector (μ)	250.233°
Length of Mean Vector (r)	0.178
Rayleigh Test (p)	< 1E-12
Watson's U² Test (Uniform, U²)	12.605
Watson's U² Test (p)	< 0.005

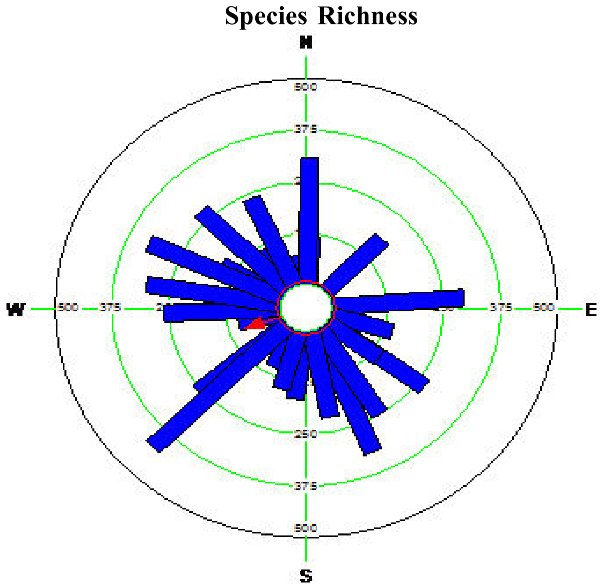

Fig.4: Circular bar graph of insect species and the relative azimuth, 'α', collected in catches attracted to mercury vapour lamp light traps at GKVK, Bengaluru from 8th May, 2015 to 6th December, 2016. Circular bars indicate the number of insect species caught in corresponding days of sampling conside-ring the bimodal distribution plotted at modulo 360° (Table I).

Number of Observations	2124
Mean Vector (μ)	257.065°
Length of Mean Vector (r)	0.197
Rayleigh Test (p)	< 1E-12
Watson's U² Test (p)	< 0.005
95% Confidence Interval (-/+) for μ	248.385°
	265.744°
99% Confidence Interval (-/+) for μ	245.659°
	268.471°

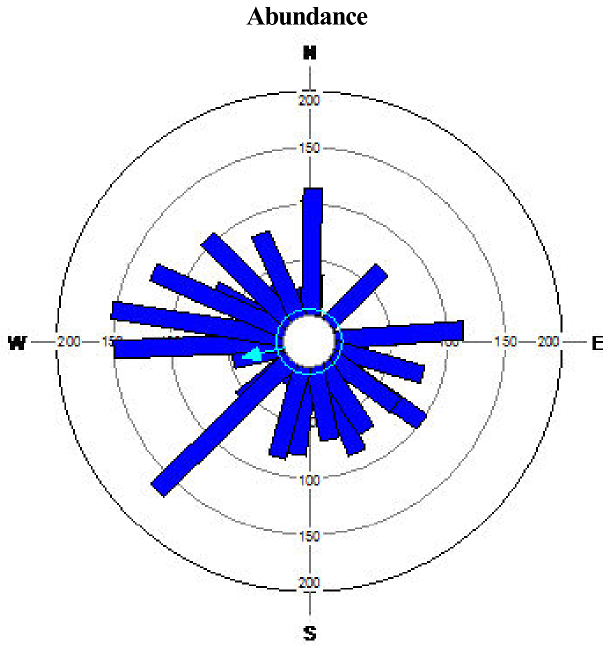

Fig.5: Circular bar graph of insects and the relative azimuth, 'α', collected in catches attracted to mercury vapour lamp light traps at GKVK, Bengaluru from 8th May, 2015 to 6th December, 2016. Circular bars indicate the number of insects caught in corresponding days of sampling considering the bimodal distribution plotted at modulo 360° (Table I).

Correlation analysis

The Pearson product moment correlation coefficient was used to determine the relationship among temperature, relative humidity, rainfall, Simpson's and Shannon-Wiener indices of diversity, species richness and abundance. The results of the correlational analysis as presented in Table II shows that significant correlations were observed between species richness and rainfall ($n=26; r= 0.34, p<0.05$), abundance and rainfall ($n=26; r= 0.34, p<0.05$), species richness and relative humidity ($n=26; r= 0.355, p<0.05$) and abundance and relative humidity ($n=26; r= 0.355, p<0.05$) over three days before sampling. Temperature did not appear to have any impact on the insect activity and diversity. However, results from multiple regression analysis indicate otherwise (Table II).

Multiple regression analysis

We used a multiple linear regression to analyze the relationships between species richness, abundance of insects, Simpson's index of diversity, Shannon-Wiener index of diversity and climate variables. Although correlation studies indicated temperature to have no impact on insect diversity (Table II), multiple regression analysis (Table III) showed that temperature cumulated over three week period was reducing the species richness and diversity and not abundance.

This study demonstrates that temperature on the day of sampling may not have any impact on insect activity and diversity but cumulative temperature does. Among the abiotic factors (rainfall, temperature, relative humidity, wind speed, etc.), temperature is an important force to drive the insect population dynamics a reason as to why multiple regression analysis were undertaken to elucidate this confounding effect of

TABLE I

Circular statistical measures of species richness and abundance of insects collected from 8th May, 2015 to 6th December, 2016 using mercury vapour lamp light trap at GKVK, Bengaluru

Basic statistics	Species richness	Abundance
Number of observations (N)	5474	2124
Mean vector (μ)	250.233°	257.065°
Length of mean vector (r)	0.178	0.197
Concentration	0.362	0.401
Circular standard deviation	106.471°	103.342°
Standard error of mean	3.054°	4.427°
Rayleigh test (Z)	173.225	82.097
Rayleigh test (p)	p< 0.001	p< 0.001
Watson's U^2 test (Uniform, U^2)	12.605	5.907
Watson's U^2 test (p)	p< 0.005	p< 0.005

TABLE II

Relationship between species richness, abundance, simpson index of diversity, shannon index and meteorological variables

Parameters	Species richness	Abundance	Simpson index of diversity	Shannon index of diversity
Temperature 21days before sampling	0.0646	-0.0054	0.0791	0.0530
Temperature three days before sampling	0.1446	0.0594	0.0936	0.0989
Temperature at time of sampling	0.2130	0.1666	0.0833	0.0656
Relative humidity 21days before sampling	-0.2702	-0.0329	-0.1502	-0.1805
Relative humidity three days before sampling	-0.3551*	-0.2173*	-0.2510	-0.2232
Relative humidity at day of sampling	-0.0694	-0.0278	-0.0450	0.0109
Rainfall 21days before sampling	0.0769*	-0.0008*	0.1041	0.1214
Rainfall three days before sampling	-0.3397	-0.3399	0.1869	0.1350
Rainfall at day of sampling	-0.1005	0.0038	-0.2405	-0.1502

* Correction is significant at p=0.05 level.

TABLE III

Multiple regression analysis of species richness, abundance, Simpson index of diversity, Shannon index and meteorological variables

Dependent variable:	Species richness	Meteorological variables	Coeff.	Std.err.	t	p	R^2
N:	26	Constant	1065.4	604.51	1.7625	0.097082	
Multiple R:	0.66293	Temperature 21days before sampling	-28.236	24.413	-1.1566	2.64E-01	0.0041733
Multiple R2:	0.43947	Temperature three days before sampling	9.2672	27.923	0.33189	0.74428	0.020912
Multiple R2 adj.:	0.12418	Temp Temperature at time of sampling	8.2816	18.738	0.44197	0.66443	0.045384
		Relative humidity 21days before sampling	-2.5738	6.4756	-0.39746	0.69628	0.073059
ANOVA		Relative humidity three days before sampling	-12.307	7.1959	-1.7102	0.10654	0.12611
F:	1.3938	Relative humidity at day of sampling	5.8647	5.5978	1.0477	0.31036	0.00483
df1, df2:	9, 16	Rainfall 21days before sampling	12.668	7.8563	1.6125	0.12641	0.0059153
p:	2.69E-01	Rainfall three days before sampling	-4.5722	7.0732	-0.6464	0.52718	0.11546
		Rainfall at day of sampling	-0.83162	1.4551	-0.5715	0.5756	0.010112
Dependent variable	Abundance		Coeff.	Std.err.	t	p	R^2
N:	26	Constant	-3801.9	54977	-0.069155	0.94572	
Multiple R:	0.55533	Temperature 21days before sampling	261.97	2220.2	0.11799	0.90754	2.95E-05
Multiple R2:	0.30839	Temperature three days before sampling	-1920.7	2539.4	-0.75637	0.46042	0.0035395
Multiple R2 adj.:	-0.080644	Temperature at time of sampling	1991.9	1704.1	1.1689	0.25958	0.027785
		Relative humidity 21days before sampling	698.17	588.92	1.1855	0.25313	0.0010887
ANOVA		Relative humidity three days before sampling	-967.36	654.44	-1.4782	0.15878	0.047222
F:	0.79271	Relative humidity at day of sampling	329.07	509.1	0.64638	0.5272	0.00077803
df1, df2:	9, 16	Rainfall 21days before sampling	194.49	714.49	0.27221	0.78895	6.59E-07
p:	0.62781	Rainfall three days before sampling	-762.07	643.28	-1.1847	0.25345	0.11556
		Rainfall at day of sampling	-61.851	132.34	-0.46737	0.64653	1.49E-05
Dependent variable	Shannon		Coeff.	Std.err.	t	p	R^2
N:	26	Constant	10.421	2.9917	3.4832	0.0030704	
Multiple R:	0.67648	Temperature 21days before sampling	-0.27339	0.12082	-2.2628	3.79E-02	0.0028139
Multiple R2:	0.45763	Temperature three days before sampling	0.24785	0.13819	1.7935	0.091806	0.0097946

(contd....)

TABLE III (Contd.)

Dependent variable:	Species richness	Meteorological variables	Coeff.	Std.err.	t	p	R^2
Multiple R2 adj.:	0.15255	Temperature at time of sampling	-0.11444	0.092736	-1.234	0.23501	0.0043054
		Relative humidity 21days before sampling	-0.019196	0.032048	-0.59898	0.55757	0.032588
ANOVA		Relative humidity three days before sampling	-0.082373	0.035613	-2.313	0.034355	0.049824
F:	1.5	Relative humidity at day of sampling	0.049395	0.027704	1.7829	0.093576	0.00011892
df1, df2:	9, 16	Rainfall 21days before sampling	0.039748	0.038881	1.0223	0.32185	0.014743
p:	2.30E-01	Rainfall three days before sampling	0.079275	0.035006	2.2646	0.037777	0.018236
		Rainfall at day of sampling	-7.92E-03	7.20E-03	-1.1003	0.28746	2.26E-02
Dependent variable:	Simpson	Meteorological variables	Coeff.	Std.err.	t	p	R^2
N:	26	Constant	1.335	0.21973	6.0754	1.61E-05	
Multiple R:	0.68519	Temperature 21days before sampling	-0.015727	0.0088738	-1.7723	0.095378	0.006265
Multiple R2:	0.46948	Temperature three days before sampling	0.013301	0.01015	1.3105	0.20853	0.008765
Multiple R2 adj.:	0.17107	Temperature at time of sampling	-0.0062662	0.0068111	-0.92	0.37124	0.0069503
		Relative humidity 21days before sampling	0.00080279	0.0023538	0.34106	0.7375	0.022565
ANOVA		Relative humidity three days before sampling	-0.0074454	0.0026157	-2.8465	0.011666	0.063008
F:	1.5733	Relative humidity at day of sampling	0.0037194	0.0020348	1.8279	0.086266	0.0020275
df1, df2:	9, 16	Rainfall 21days before sampling	0.001668	0.0028557	0.5841	0.5673	0.01084
p:	0.20557	Rainfall three days before sampling	0.0060641	0.0025711	2.3586	0.031397	0.034954
		Rainfall at day of sampling	-0.00093018	0.00052893	-1.7586	0.097754	0.057853

temperature. Temperature might affect any stage of the insects' lifecycle and therefore limit distribution and abundance through the effects on survival, reproduction and development (Tauber and Tauber, 1981). Temperatures above the specific optimum range will lead to decreased growth rates, reduced fecundity and increased rates of mortality (Van Asch and Visser, 2007). Temperature thresholds for insect flight vary both among and within species, with season and also with region (Chambers *et al.,* 2013). Cumulative temperature and therefore climate change can cause major changes to the dynamics of insect individual species and to those communities in which they interact. Climate change is likely to involve a higher frequency of biotic disturbance. Depending on the dimension of disturbance, local to regional dynamics of insect populations and species composition may be affected. Thus our study demonstrates that the temperature affected insect activity over long term than short term. Other parameters did not show any direct effect on diversity and abundance of insects. In other words, the insect activity may be reduced by increasing temperatures of the globe- a concern in the context of climate change. This effect however appears to be confounded when analyzed with other parameters.

The results suggest the importance of weather parameters and stratification based on period when sampling insects is paramount to understanding the insect structure and composition and further recommend that conservation biologists should exercise caution when attempting to predict total species diversity of insects in ecosystems that are characterized by significant effects of seasonality.

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