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Diversity and Relative Abundance of Lepidoptera in an oak forest of Kumaun Himalaya

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Abstract: Species richness, abundance and biomass and species diversity of Lepidoptera in an oak forest of Kumaun Himalaya, Uttarakhand were investigated during August 2013 to July 2015. A total of 38 species belonging to 8 families were collected. Maximum abundance and biomass were 38 ind. ha^{-1} and 3580 mg ha^{-1}, respectively. Family Nymphalidae was dominant both terms of number of species (44.8%) and number of individuals (42.7%) collected. Shannon-Wiener diversity index H' ranged from 0 to 0.32 and Evenness (E) from 0 to 0.035 indicating lower values were due to lower number of species and individuals recorded.
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Key words: Lepidoptera; species richness; abundance; species diversity; oak forest; Kumaun Himalaya

Introduction

Species diversity is used to explain the variety of different species within a given area (Anonymous, 2000). In forestry, diversity is a combination of species richness and species evenness (Vanclay, 1992).

Insects constitute more than half of the world's identified animal species (Zhang, 2011), of which Lepidoptera is the second largest and most diverse order of class Insecta (Benton, 1996). Butterflies have been studied systematically since early 18th century. 19,238 lepidopteran species are documented worldwide so far (Chowdhuri and Chowdhuri, 2007), of which 1504 species occur in India (Chowdhuri and Das, 2007). Butterflies serve as an important plant pollinator, environmental indicator and have great commercial and aesthetic value (Ahsan and Javaid, 1975).

Lepidoptera are one of the most important group of insects for making quantitative comparision among insect fauna and to predict the different biological issues such as impact of global and local climatic changes, disturbance of habitat, controlling practices on forest and natural ecosystems (Axmacher *et al*., 2004). Butterflies are affected both by abiotic and biotic factors (Pollard, 1988).

The main objectives of the present investigation were to determine the species richness, abundance and species diversity of lepidopterans in an oak forest in Kumaun Himalaya from August 2013 to July 2015.

Materials and Methods

Study area

The site is designated as Naina Devi Himalayan Bird Conservation Reserve and is located at Kilbury (29° 39 'N and 79° 44'E longitude ; altitude 2528m) about 13 km from Nainital. The area studied is approximately 2 ha and is dominated by *Q. leucotrichophora, Q. floribunda, Q. semecarpifolia, Q. lanuginosa and Q. giauca* tree species.

Sampling methods

Insects were collected by "Sweep sampling method" of Gadagakar *et al.* (1990) and Hand picking (Jonathan, 1990) at an interval of 30 days. The collected insects were killed in jars containing ethyl acetate and oven–dried to constant weight (60^0C for 24 h). Each specimen was weighed in a single pan electric balance (0.01 mg accuracy) for biomass estimation. Insects were identified in the Department of Zoology laboratory, Gurukul Kangri University, Haridwar and Forest Research Institute, Dehradun.

Species Diversity and Evenness

Species diversity H' (P) was calculated using Shannon-Wiener (1963) expression:

$$\text{Species diversity:} \quad H'(S) = -\sum_{i=1}^{S} pi \log pi$$

Where,

H'(S) = symbol for the diversity in a sample of S species or kinds

S = the number of species in the sample

Pi = relative abundance of i^{th} species or kinds measures = ni/N and

qj = ni / N; N = total number of individuals of all kinds

ni = number of individuals of i^{th} species, ln= log to base 2

Evenness (Buzas and Gibson's evenness) E2:

$$E2 = e^{H/S}$$

Where,

S is the number of taxa and H is the Shannon Index

Results

Species richness

A total of 467 individuals belonging to 38 species of 8 families were collected (Table 1). Family Nymphalidae was dominant both in terms of number of species 944.8%) and individuals (42.7%) collected (Table 2).

Monthly variation in the species content is presented in Table 3. Maximum numbers of species (17) were recorded in the month of April while Lepidopterans were completed absent during winters in the months of (January and February).

Species richness was positively correlated with maximum temperature ($r=0.84$; $P\leq0.01$; $df=12$) (Fig.1a), minimum temperature ($r=0.84$; $P\leq0.01$; $df=12$) (Fig. 1b), and rainfall ($r=0.84$; $P\leq0.01$; $df=12$) (Fig. 1c).

Abundance and biomass

Inter-annual variations in abundance were recorded: abundance ranged from 0 ind. ha^{-1} (30 December, 2013) to 39 ind. ha^{-1} (30 April, 2014) during August 2013 to July 2014; and from 0 ind. ha^{-1} (31 January, 2014) to 46 ind. ha^{-1} (31 May, 2015) during August 2014 to July 2015.

Abundance of Lepidoptera was positively correlated with maximum temperature ($r=0.753$; $p\leq0.01$; $df=12$), (Fig. 2a), minimum temperature ($r=0.708$; $p\leq0.01$; $df=12$) (Fig. 2b), and rainfall ($r=0.213$; $p<<0.05$; $df=12$) (Fig. 2c).

Biomass values ranged from 0 mg ha^{-1} (30 December, 2013) to 4015 mg ha^{-1} (30 April, 2014) during August 2013 to July 2014; and from 0 mg ha^{-1} (31 January, 2014) to 4958 mg ha^{-1} (31 May, 2015) during August 2014 to July 2015.

Biomass of Lepidoptera was positively correlated with maximum temperature ($r=0.76$; $p\leq0.01$; $df=12$), (Fig. 3a), with minimum temperature ($r=0.723$; $p\leq0.01$; $df=12$) (Fig. 3b), and with rainfall ($r=0.242$; $p<<0.05$; $df=12$) (Fig. 3c).

Abundance and biomass of lepidopterans were also positively correlated with maximum temperature ($r=0.998$; $p\leq0.01$; $df=12$), (Fig. 4).

Species diversity and Evenness

Shannon index of diversity is considered to be the most complete measures of diversity because it takes into account both number of species and the abundance of each species (Pepper, 1990 ; Pande, 2013). The Shannon Wiener Diversity Index (H') and Evenness (E) calculated for each month is presented in Table 3.

Species diversity varied from 0 to 0.32.Maximum species diversity (0.32) in the month of May and minimum (Zero) during the months of January and February.

Buzas's Evenness which takes into account the distribution of species and their numbers across gradients has returned low values between 0 to 0.035. Monthly fluctuations recorded were due to changes in the numerical importance of some of the species. Diversity was zero during the months of January and February when insects were not recorded due to extreme cold conditions.

Table 1: Lepidopteran species and number of individuals collected in the oak forest during August, 2013 to July, 2015

S.N.	Taxonomic composition	Number of individuals	(%)
	Family-Danaidae		
1.	*Euploea core core* Cramer	6	1.2
2.	*Danaus chrysippus* Linnaeus	4	0.9
	Family-Nymphalidae		
3.	*Lasimmata schakra* Kollar	29	6.2
4.	*Vanessa cashmirensis* Kollar	42	9.0
5.	*Vanessa indica* Herbrt	6	1.2
6.	*Junonia lemonias* Linneaus	3	0.6
7.	*Neptis yerburyi yerburyi* But	4	0.9
8.	*Neptis m. mahendra* Moore	10	2.1
9.	*Callerebia nirmala* Moore	32	7.8
10.	*Vanessa cardui* Linnaeus	3	0.6
11.	*Aulocera swaha* Kollar	19	4.0
12.	*Ariadne m.cramer* Cramer	4	0.9
13.	*Lethe verma sintica* Kollar	4	0.9
14.	*Lethe rohria* Fabricius	4	0.9
15.	*Junonia orithya* Linnaeus	3	0.6
16.	*Junonia hierta* Hubner	3	0.6
17.	*Euthalia patala* Kollar	14	3.0
18.	*Phalanta phalantha* Drury	3	0.6
19.	*Euthalia lubentina* Cramer	6	1.2
	Family-Papilionidae		
20.	*Papilio protenor romulus* Cramer	5	1.0
21.	*Atrophaneura polyeuctes* Doubleday	6	1.2
22.	*Papilio memnon agenor*	3	0.6
	Family-Pieridae		
23.	*Pieris canidia* Evans	124	26.5
24.	*Catopsilia pyranthe* Linnaeus	10	2.1
25.	*Aporia aganthon.caphusa* Moore	5	1.0
26.	*Colias electo fieldi* Menestries	9	2.0
27.	*Pontia daplidice* Linnaeus	4	0.9
28.	*Eurema herla laeta* Boisduval	12	2.6
29.	*Eurema hecabe* Linnaeus	5	1.0
30.	*Gonepteryx r.nepalensis* Linnaeus	2	0.4
31.	*Cepora nerissa* Fabricius	9	2.0
	Family-Lycanidae		
32.	*Heliophorous sena* Kollar	29	6.2
33.	*Heliophorous oda* Hewitson	18	3.8
34.	*Lycaena phlaeas* Linnaeus	5	1.0
35.	*Zizeeria sp.*	7	1.4
	Family-Geometridae		
36.	*Rhodostrophia sp.* Moore	2	0.4
	Family-Riodinidae		
37.	*Dodona durga* Kollar	11	2.3
	Family-Acraeidae		
38.	*Acraea vesta* Fabricius	2	0.4
	Total	467	100.0

Table 2: Percent contribution of species and individuals of different families of Lepidoptera

Family	Species		Individuals	
	Number	(%)	Number	(%)
Nymphalidae	17	44.8	199	42.7
Pieridae	9	23.8	170	36.4
Lycanidae	4	10.5	59	12.6
Papilionidae	3	7.9	14	3.0
Danaidae	2	5.2	10	2.1
Riodinidae	1	2.6	11	2.4
Geometridae	1	2.6	2	0.4
Acraeidae	1	2.6	2	0.4
Total	38	100.0	467	100.0

Table 3: Shannon-Wiener diversity index (H') and Evenness of lepidopterans in the oak forest during August, 2013 to July, 2015

Months	S (Richness)	N (Abundance)	H' (Shannon index)	E (Evenness)
August	12	18	0.22	0.018
September	10	14	0.18	0.018
October	10	16	0.20	0.02
November	4	9	0.14	0.035
December	2	8	0.13	0.06
January	0	0	0	0
February	0	0	0	0
March	8	16	0.20	0.03
April	17	38	0.32	0.02
May	15	34	0.30	0.02
June	13	26	0.26	0.02
July	11	20	0.23	0.02

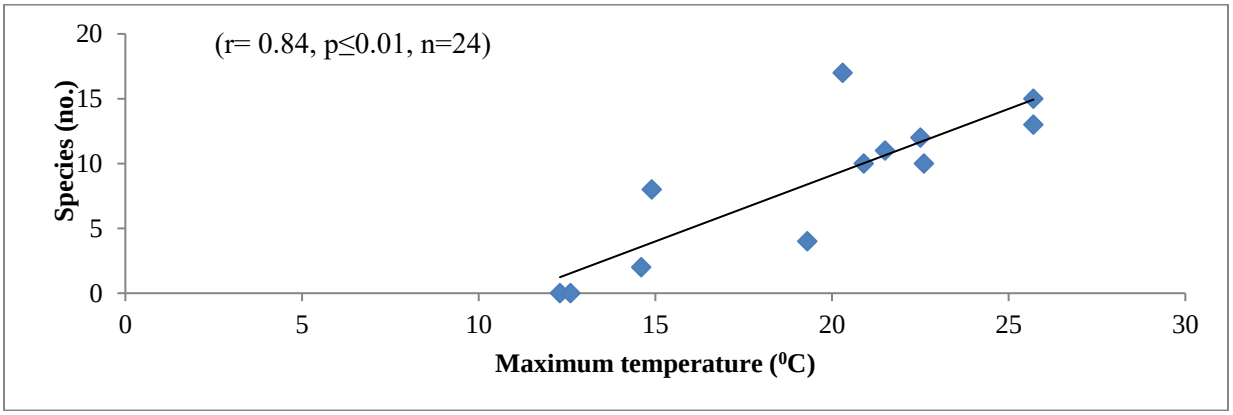

Fig. 1a

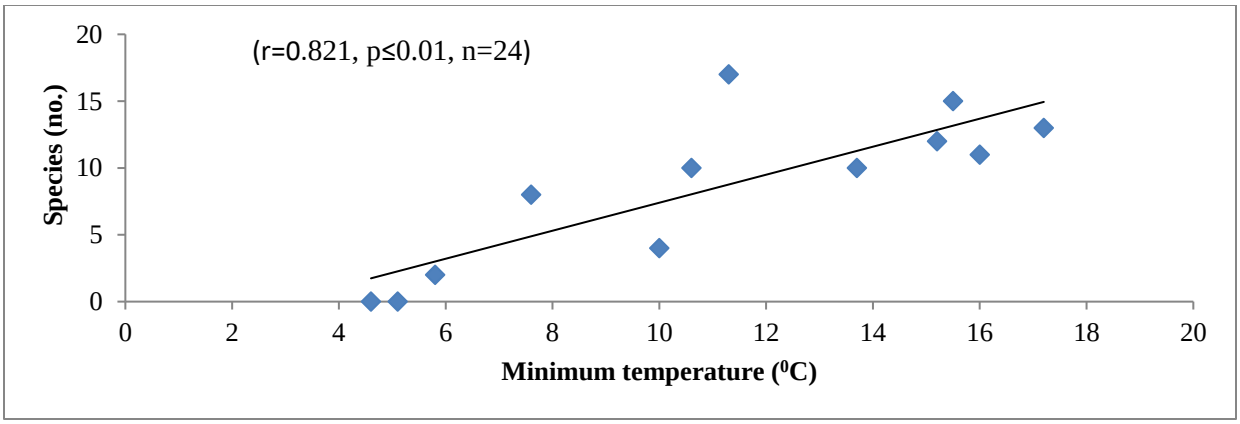

Fig. 1b

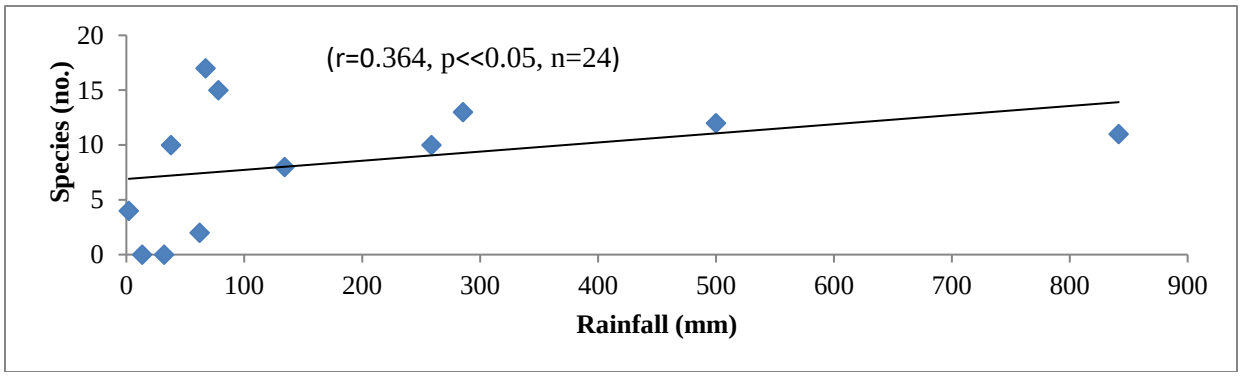

Fig. 1c

Fig.1a-c. Correlation between maximum temperature and species richness (1a), minimum temperature and species richness (1b) and rainfall and species richness (1c) collected in the oak forest during August 2013 to July 2015

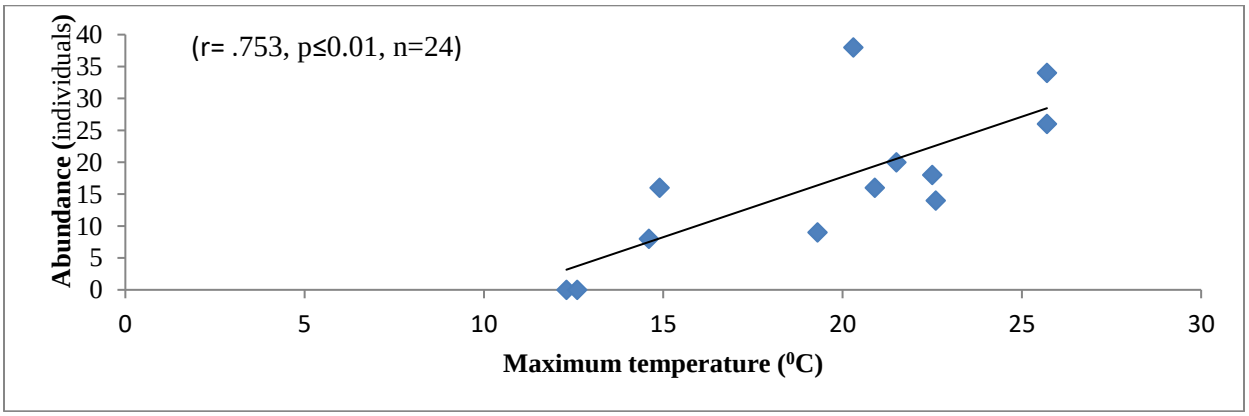

Fig. 2a

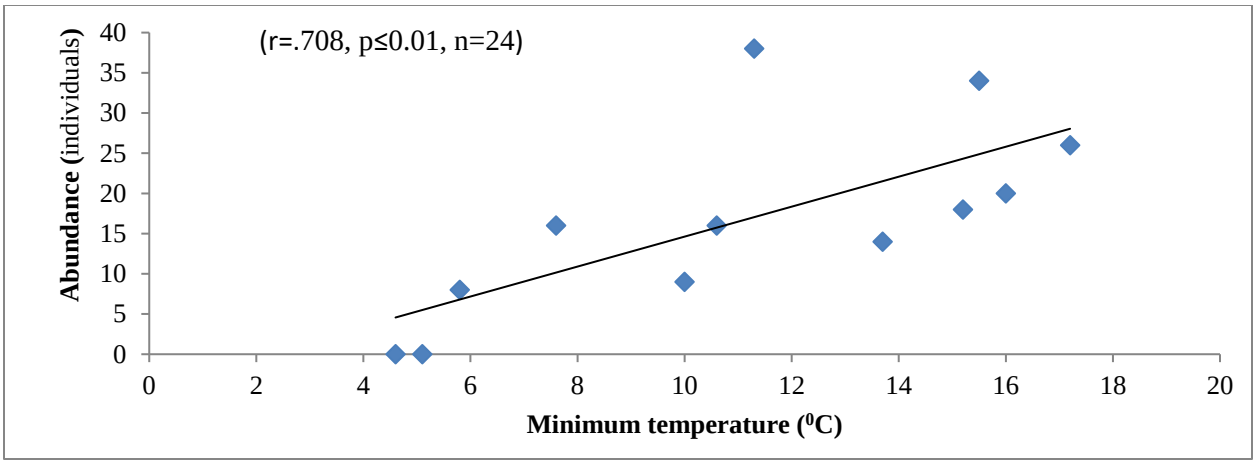

Fig. 2b

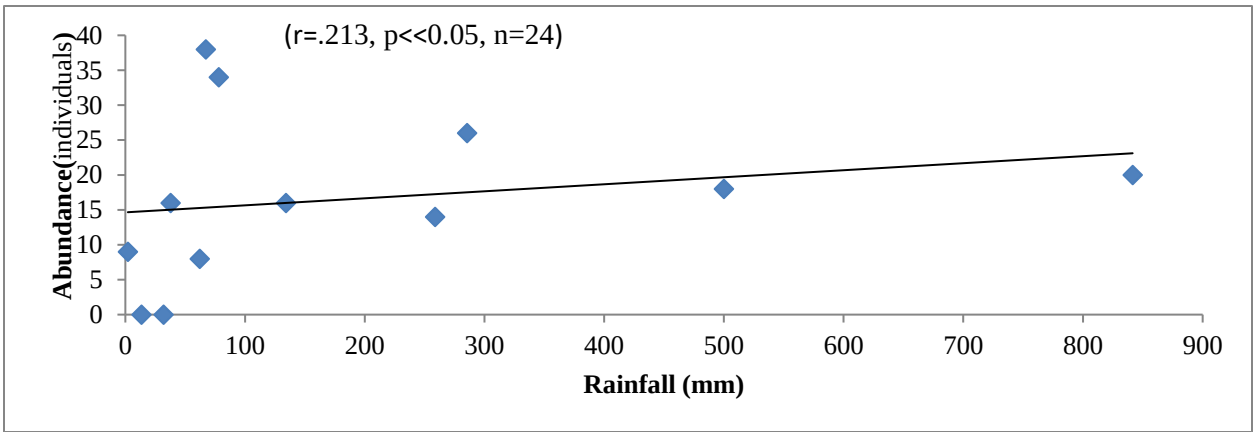

Fig. 2c

Fig.2a-c. Correlation between maximum temperature and abundance (2a), minimum temperature and abundance (2b) and rainfall and abundance (2c) collected in the oak forest during August 2013 to July 2015

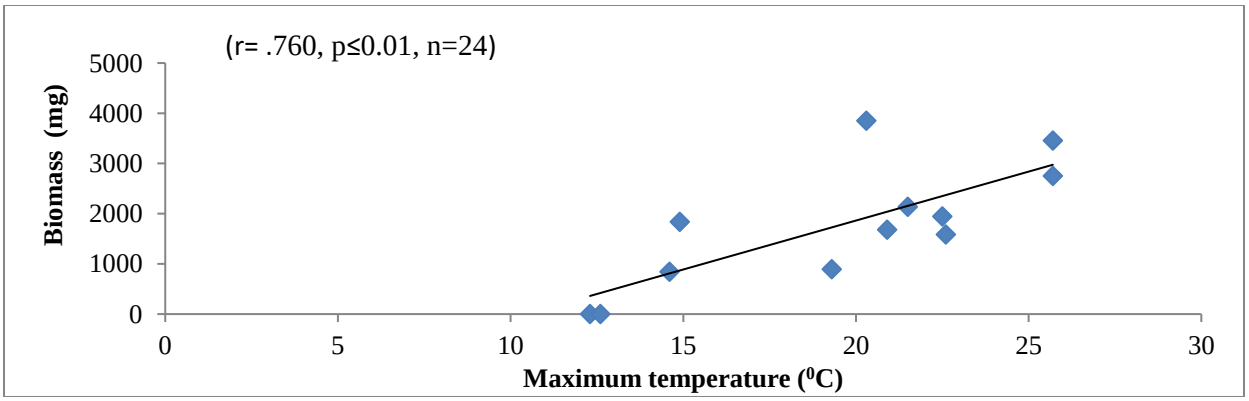

Fig. 3a

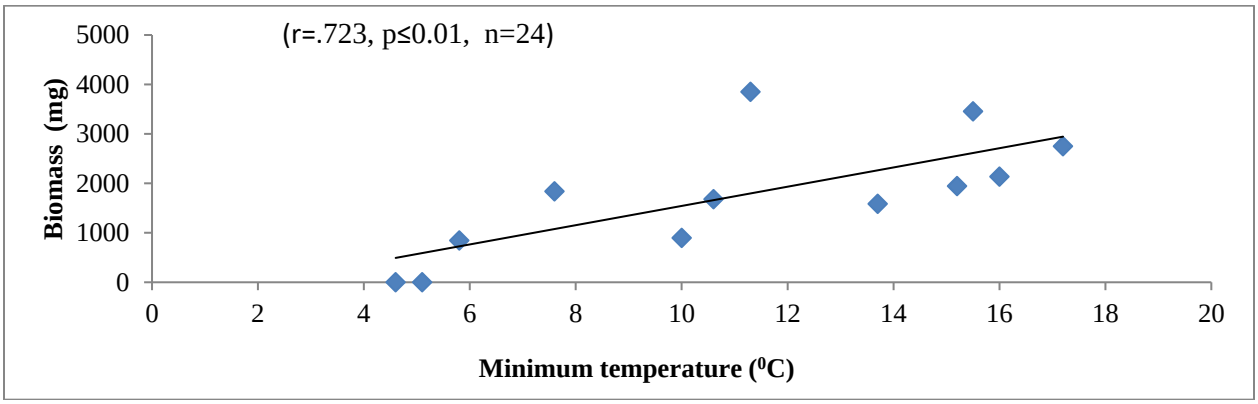

Fig. 3b

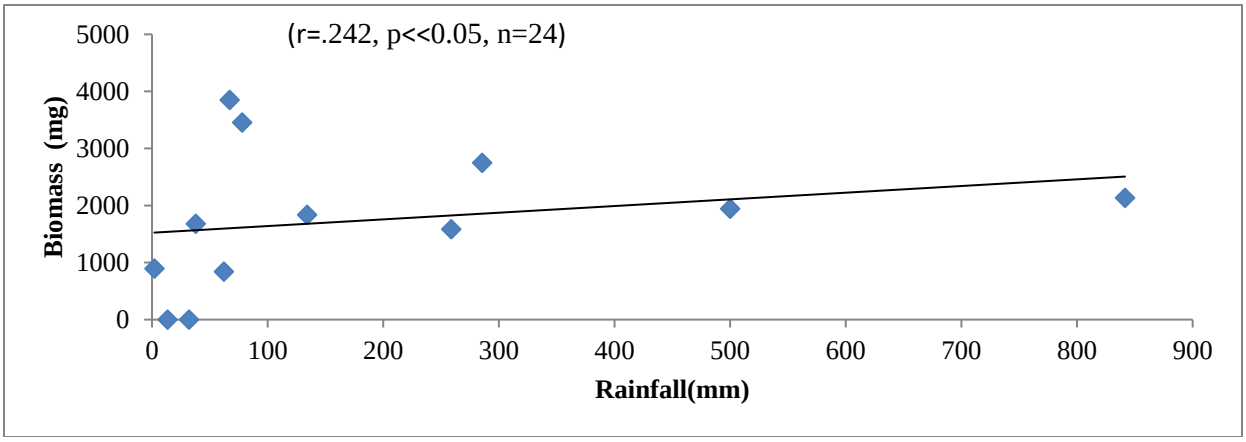

Fig. 3c

Fig.3a-c. Correlation between maximum temperature and biomass (3a), minimum temperature and biomass (3b) and rainfall and biomass (3c) collected in the oak forest during August 2013 to July 2015

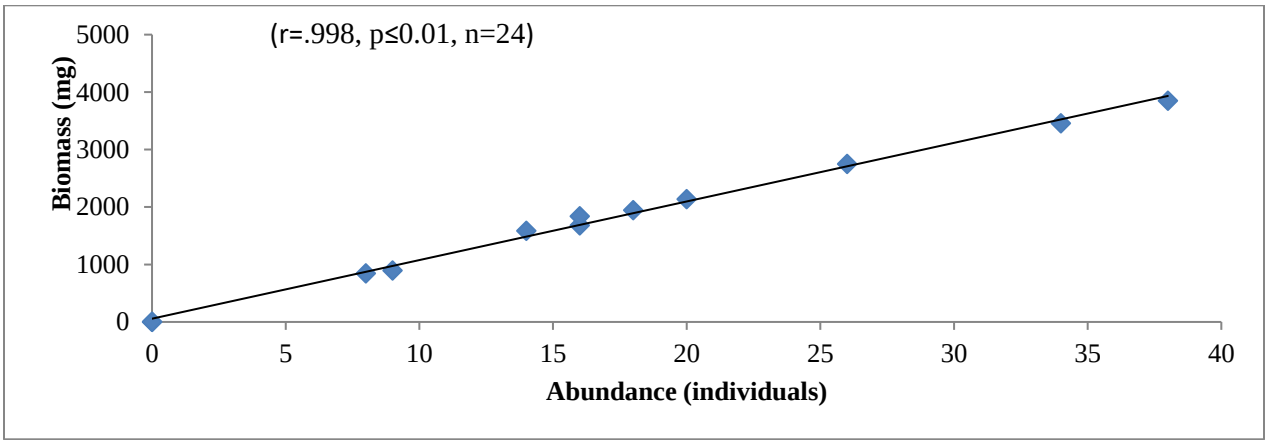

Fig. 4. Correlation between abundance and biomass of total insects collected in the oak forest during August 2013 to July 2015

Discussion

Diversity of order Lepidoptera varies with season, being abundant for only a few months and absent or rare during other months of the year (Pepper, 1990 ; Kunte, 2000 ; Nadia *et al*., 2015). The abundance of butterflies in the present study was maximum during pre and post-monsoon seasons which are very similar to the findings of Tiple *et al*. (2007), Tiple and Khurad (2009) and Tiple (2012).

Lepidopterans were completely absent during winter season due to unfavourable climate conditions and unavailability of host plant and our results are very similar to the findings of Brehm *et al*. (2006) , Regniere *et al*. (2012) and Nadia *et al*. (2015).

Lower values of species diversity and evenness recorded in the present study in comparsion to higher reported values of 1.0-3.57 (Agarwala *et al*., 2010; Tyagi *et al*. , 2011; Arya *et al*., 2014) could be due to lower number of species and abundance of insects recorded.

It is thus concluded from the present study that population of Lepidoptera is influenced by environmental factors and availability of host plants. Natural habitats conservation is very important for the existence of lepidopterans species. Further studies are required for the identification of rare species of butterflies.

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