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RESEARCH ARTICLE

ANALYSIS OF RICHNESS, DIVERSITYAND EVENESS (SHE-ANALYSIS) OF INSECT FAUNAL POPULATION IN TEAK-SAL ECOTONE, OF PACHMARI BIOSPHERE RESERVE (PBR), MADHYA PARESH, INDIA

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ABSTRACT

Present paper deals about most abundant insect faunal species of PBR, and variation in diversity pattern of insect species in teak –Sal forest ecosystem with seasonal variations. Insect species like *Camopnotous*, *Aciagrion* sp*, Metochus uniguttattus* (Thunberg)*, Creatonotus gangis* (Linn)*, Ypthima* sp, *Myrimica* sp, *Gryllus assimilis* (Fabricius)**, Ypthima* sp*, Clania crameri* (Westwood)*, Scudderia furcata* (Braner)*, and Lasius niger* (Linn.**)** are most abundant and adaptive insect species of Teak- Sal ecotone in PBR, on the basis of richness count. SHE analysis is made to analyze diversity pattern in both ways yearly and seasonally of insect species of PBR

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INTRODUCTION

Pachmarhi area was designated as Biosphere Reserve by Government of India vide notification no J-220116/17/94-BR 3rdMarch 1999 (Anonymous 2001).PBR has varied spectrum variations of the latitude, altitude, rainfall, topography, soil. The altitude varies from 320 to 1352 m above MSL at different locations in the PBR area (Anonymous, 2001). The area has a typical monsoon climate with three distinct seasons of summer (March to June), rainy season (July to October) with heavy rains and cloudy climate and winter (November to February). The meeting zone of two major timber speciessal and teak, formed ecotone zone (Shadangi and Nath, 2008) the Sal-teak mixture, is rare phenomenon in PBR forests. Such ecotone occursonly in some areas of central India in Umariya, Pachmarhi Biosphere Reserve in Madhya Pradesh; Bastar, Raipur and Bilaspur in Chhattisgarh and Khariyar forests in Orissa. These junctions of teak and salforests formed are known asecotones ortransition zones (Shadangi and Nath, 2008). Sal forest zoneslocalized at top hill (Pathak, 2001). This area is dominated by sal trees. However some other plat species are associated like *Mallotus phillippenis, Mangifera indicia, Acbisia procera, Terminalia billerica, Grewia asilatical, Falcourita Indica, Gmelina arbourea, Syzgium cumini, some timber species like Buchinia vahlili, Dioscrea sp Celatrsus penicutala, Phyllanthus emblica*, *Cassiafistula*, *Jasmine*, *Anogeissus pendula*, *Butea monosperma*, *Garcinia indica*, *Terminalia elliptica*, *Holoptelea integrifolia*,*Zizyphus jujuba*, are also associated with it.

The teak (*Tectona grandis*) forest zonesoccur in mixed deciduous forest community. This patch is located at lower region of PBR and associated with, *Albizzialebizzia, Chloroxyln swietenia*, *Pterocarpus marsupium*, *Terminalia tometosa*.ZSI, in its recent publication "Fauna of Panchmarhi Biosphere Reserve" documentated 217 insect fauna of different order.

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MATERIALS AND METHODS

Identification Tool and Agencies

(a) Online Pictorial Key: An attempt to develop as implepictorial key was made for identification of specimens during field investigations.

(b) Identification: Insects collected during a forede scribed surveys using various methods in PBR, insect were made identified by following authorized institutes:

- Zoological Survey of India (ZSI), Jabalpur.
- Forest Entomology Division, Tropical Forest Research Institute, Jabalpur

Field Survey and observation

Faunastic survey was made for analyzing, richness, abundance, density, evenness and diversity during year 2011-2013. Random sampling method was used for analysis of insect fauna of two different selected ecosystem communities with the help of standardized plots of 10m X 10m (Nair and Jaynarayan, 2005). Structure data were generated for all insect faunal species represented in sample plot which included insect faunal species of order Lepidoptera, Odonata, Hymenoptera, Hemiptera, Coleoptera. In order to study identification of insects, host status richness, abundance, density and diversity index work plan was divided in two parts i.e. identification of insects and calculation of population dynamics.

Calculation and Analysis

For the sample analysis the data gathered from the sample plot were analyzed using the following formulae (Nair and Jaynarayan 2005) evenness index (Kullu and Behera, 2012), SHE analysis (Bhattarya, 2015).

Richness (R) = Actual count of types of 'R'.
Abundance (A) = Total No of individuals / Total No of quadrate of occurrence
Density (D) = Total No of individual / Total No of quadrate sampled Species
Shannon diversity index (H') - Diversity indices were estimated using Shannon diversity index

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

Where:
H = the Shannon diversity index
P_i = fraction of the entire population madeup of species i
S = numbers of species encountered
$\sum$ = sum from species 1 to species S
Evenness index **(J)** – Eveness intex was estimated as per (Pielous, 1975) J = H/ln S
H= Shannon Diversity Index;
S = Total no. of species

RESULTS

Seasonal variation in richness of insect species in Sal forest ecosystem

During winter season, insal forest ecosystem most abundance species (Fig-1) observed are; *G. assimities,* (386.7), followed by *Ypthima* sp. (296.7), *U. s. signat* (279.7), *Anamala* sp. (270), *C. ceremeri* (266.7), *L. niger* (211.3), *P. flavescens* (209.7), *T. areonosa* (208.3), *P. congener* (207), *O. Sabina* (204.3), *T. b. burmeisteri* (201.7), *Camponotus* sp. (201),

Table 1. List of recorded insect species from Teak and Sal forest ecosystem

S.No.	Insect species from Teak and Sal forest ecosystem
1	*Ceriagrion coromandelianum* (Fabricius)
2	*Aciagrion sp* (Selys).
3	*Orthetrum Sabina* (Dhury).
4	*Potamarcha congener* (Rambur)
5	*Crocothemis servilia servilia* (Dhury)
6	*Diplacodes trivialis* (Rambur)
7	*Neurothemis tullia tullia* (Dhury)
8	*Rhyothemis variegate variegate* (Linnaeus)
9	*Pantata flavescens* (Fabricius)
10	*Tramea basilaris burmeisteri* (Kirby)
11	*Urothemis signata signat* (Rambur)
12	*Oncocephalus schioedtei* (Reuter)
13	*Metochus uniguttattus* (Thunberg)
14	*Dysdercus koenigii* (Fabricius)
15	*Cydnus indicus* (Westwood)
16	*Riptortus linerris* (Fabricius)
17	*Ectrychotes dispar* (Reuter)
18	*Dictyophara Lineate* (Don)
19	*Papilio demoleus* (Linnaeus)
20	*Eurema brigitta* (Cremer)
21	*Eurema hecabae* (Linnaeus)
22	*Catopsilia sp.* (Linnaeus)
23	*Danaus chrysippus* (Linnaeus)
24	*Melatis leda* (Linnaeus)
25	*Junonia almanac* (Linnaeus)
26	*Junonia atlites* (Linnaeus)
27	*Junonia lemonias* (Linnaeus)
28	*Phalanta phalantha* (Dhury)
29	*Spialia galba* (Fabricius)
30	*Ypthima sp* (Moore)
31	*Chrysodeixis eriosoma* (Doubleday)
32	*Dysgonia sp.* (Fabricius)
33	*Mocis undata* (Fabricius)
34	*Othreis fullonica* (Linnaeus)
35	*Spodoptera litura* (Fabricius)
36	*Spirama retorta* (Clerck)
37	*Trigonodes hyppasia* (Cramer)
38	*Amata sp.* (Linnaeus)
39	*Creatonotus gangis* (Linnaeus)
40	*Macrobrochis gigas* (Walker)
41	*Agrius convolvuli* (Linnaeus)
42	*Theretra oldenlandiae* (Fabricius)
43	*Parotis sp.* (Hurber)
44	*Clania crameri* (Westwood)
45	*Eutectona machalis*(Walker)
46	*Scudderia furcata* (Braner)
47	*Gryllus assimities* (Fabricius)
48	*Gryllotalpa hexadectyla* (Petery)
49	*Herioglypus banian* (Fabricius)
50	*Tetxix areonosa* (Hancock)
51	*Hyblaea puera* (Cram.)
52	*Apis sp*
53	*Thethredo sp*
54	*Myrimica sp*
55	*Polistis* sp
56	*Lasius niger*(Linnaeus)
57	*Camopnotous* sp
58	*Alissonotum sp.*
59	*Onthophagus dama* (Fabricius)
60	*Onitis philemon* (Fabricius)
61	*Anamala sp* (Fabricius)
62	*Adoretus sp.*
63	*Holotrichia sculpticollis (Blanchard)*
64	*Holotrichia sp*
65	*Onthophagus sp.*
66	*Hoplocerambyx spinicornis* (Newman)

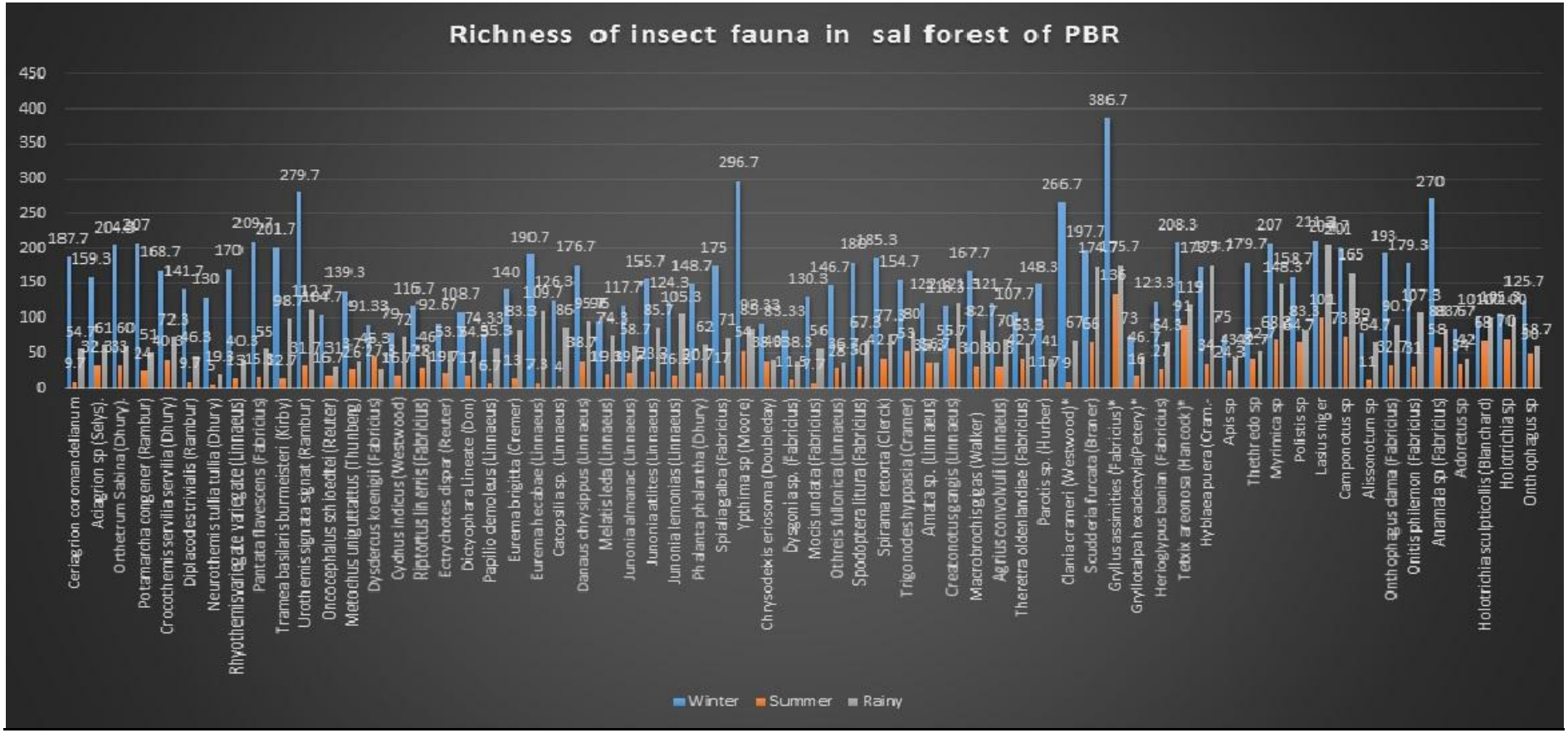

Fig. 1. Richness of insect species in sal forest ecosystem Seasonal variation in richness of insect species in Teak forest ecosystem

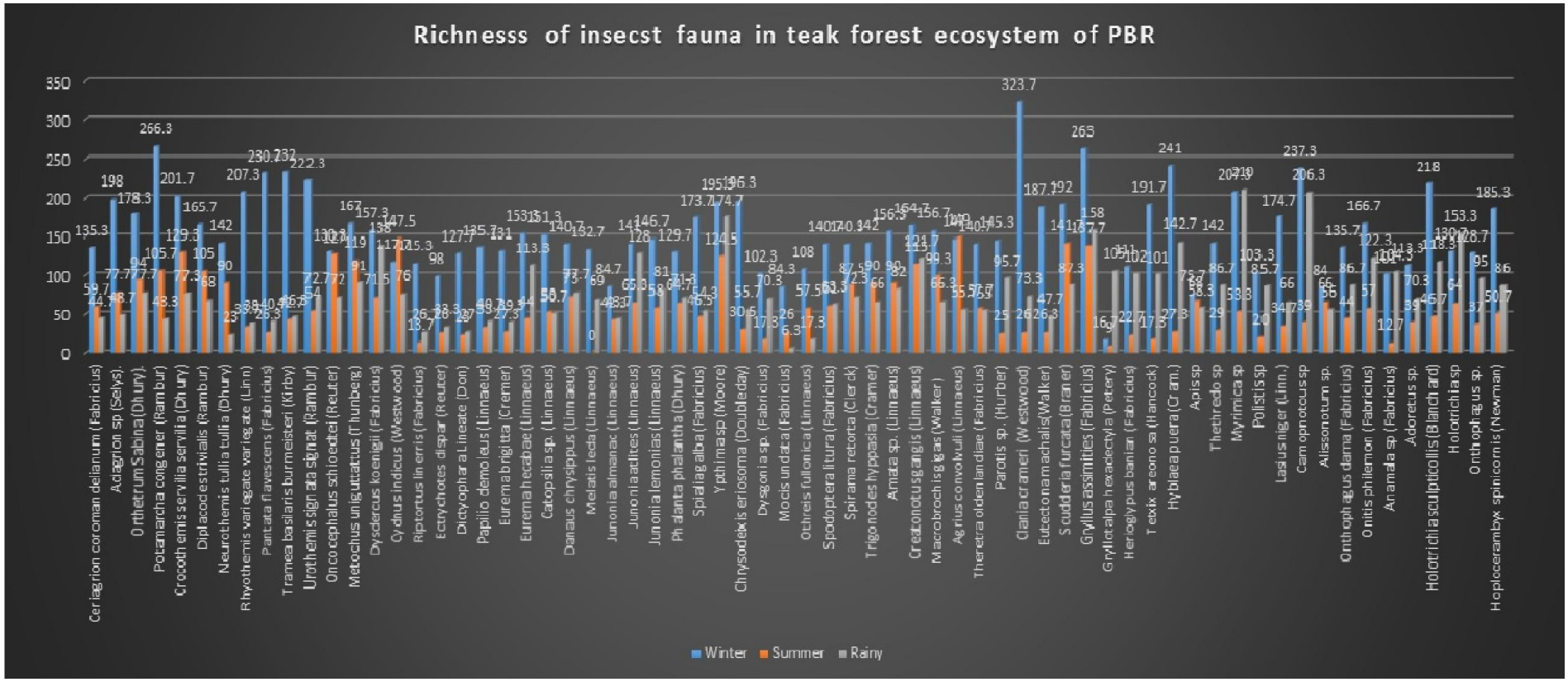

Fig. 2. Richness of insect species in teak forest ecosystem

S. furcata, (197.7), *O. dama* (193), *E. hecabae* (190.7), *C. coromandelianum* (187.7), *S. retorta* (185.3), *S. litura* (180), *Thethredo* sp.(179.7), *O. philemon* (179.3),*O. philemon* (179.3), *D. chrysippus* (176.7), *S. galba* (175) and during summer season; *G. assimities* (136), followed by *L. niger* (101), *T. areonosa* (91),*Camponotus* sp. (73.3), *Holotrichia* sp. (70), *Myrimica* sp.(68.3) *H. sculpticollis* (68) *S. furcata* (66)*Polistis* sp (64.7). In summer 15 insects species found frequently occoured ;are *Anamala* sp. (58), *C. gangis* (55.7), *Ypthima* sp.(54), *T.hyppasia* (53), *Onthophagus* sp.(50), *D.koenigii* (45.3), *S. retorta* (42.7), *T. oldenlandiae* (42.7), *Thethredo* sp.(42.7), *C. s. servilia* (40.3), *D. chrysippus* (38.7), *C. eriosoma* (38.3), *Amata* sp. (35.3), *S. viteripennis* (34), *Adoretus* sp.(34). During rainy season most abundant insect species observed are; *Dysgonia* sp (204.7), followed by *O. schioedtei* (175.7), *P.flavescens* (175.7), *S. galba* (174.7), *Alissonotum* sp. (165), *T.b.burmeisteri* (148.3), *J. atlites* (121.3), *G. hexadectyla* (119), *C. gangis* (112.7), *C. eriosoma* (109.7), *C.Ceremeri* (107.3), *Aciagrion* sp. (105.3).

During winter season, in Teak forest ecosystem most abundance species (Fig.2) observed are; *C.Ceremeri* (323.7) followed by *P. congener* (266.3) *G.*assimities (263.0) *S.*viteripennis (241.0) *Camopnotous* sp (237.3) *T. b.burmeisteri* (232.0) *P.* flavescens (230.7) *U. s. signat* (222.3) *H. sculpticollis* (218.0) *R.v.variegate* (207.3) *Myrimica* sp (207.3) *C.s. servilia* (201.7) *Aciagrion* sp (198.0) *C.* eriosoma(196.3) *Ypthima* sp (195.3) *S.*furcata (192.0) *T.areonosa* (191.7) *E.* machalis (187.7) *H.* sprinicro (185.3) *O.*sabina (178.3) *L. niger* (174.7) *S.*galba (173.7), *M.* uniguttattus (167.0) *O. philemon* (166.7) *D.*trivialis (165.7) *C.* gangis (164.7).During summer most abundant; *A.*convolvuli (149.0) followed by *C. indicus* (147.5) *S. furcata* (141.7) *G. assimities* (137.7) *C. s. servilia* (129.3) *O.schioedtei* (127.0) *Ypthima* sp(124.5) *M.uniguttattus* (119.0) *C.gangis* (115.0) *P. congener* (105.7) *D. trivialis* (105.0) *M. gigas* (99.3) *O.sabina* (94.0) *N.t. tullia* (90.0) *T.hyppasia* (90.0) *Amata* sp (90.0) *S. retorta* (87.5) *Aciagrion* sp(77.7). During winter most abundant; *Myrimica* sp (210) followed by *Camopnotous* sp (206.3) *Ypthima* sp (174.7) *G.*assimities (158.0) *Holotrichia* sp (153.3), *S. viteripennis* (142.7) *D.koenigii* (138.0) *J.*atlites (128.0) *O.philemon* (122.3).

On the basis of mean value (Fig. 1 & 2) it is interpreted that richness in variation is comparable of Take and Sal forestss. In Sal forest ecosystem, during winter 23.4 % insect species are dominant followed by 18% in rain and 5.25% in summer. Simultaneously in Teak forest ecosystem, during winter 40.6 % followed by 27% in summer 19% in rain.

Diversity index and evenness index Sal and Teak forest ecosystem year wise (2011-2014)

Sal and Teak forest ecosystem of Pachmari Biosphere Reserve lies in Tropical climate. Diversity index and evenness index of insect species is 1.7 and 0.9 respectively for both the forest ecosystems (Table 2).

Diversity index value 1.7 shows, highest diversity status of insect species in forest. Evenness index for topical forest is highly significant, evenness index for tropical and sub-tropical forest ranges between 0-3.

Diversity index and evenness index Sal and Teak forest ecosystem Season wise

Diversity index rangers from 0.24 to 1.64 season wise, this variation caused due to variation occurred in species richness (3.3 to 4.0) and evenness index (0.0 to 0.9) (Table 3 to 4). In both the forests highly variation occurred in evenness (Table 3) due to seasonal change. It indicates role of climate factor like temperature humidity in contributing diversity status of Sal and Teak forest ecosystem of Pachmari Biosphere Reserve.

SHE analysis (Year wise, 2011-14)

SHE analysis (Table 2) revealed clear distribution of two ecosystems of insect species richness(S), diversity (H) and evenness (E) in Pachmarhi Biosphere reserve. Analysis indicate (Fig. 3 & 4) that H'_1~ H'_2, S_1~S_2, E_1= E_2 are similar (Buzas, Hayek 1996 and 1998); Wilson *et al*., 2010), (where 1 and 2 in suffix are any two population). (Buzas Hayek, (1996 and 1998) pointed out that of tenth diversity (H') changes because the differences between richness (S) and evenness(E) donot offset each. In Pachmarhi Biosphere reserve S1~S 2, E1= E2 (Similar), therefore diversity of both ecosystem is H'1 ~ H'2 (Similar). SHE analysis in to Sal and Teak forest ecosystem was significantly not comparable. The diversity pattern in both ecosystems is similer. It may be due to plenty of food resource, host plant habitat, suitable niche, and temperature available for insect species species accorded in Teak-Sal ecotones are polyphagous, so they are flourishing in similar extent. It may also that, the junctions of Teak and Salforests (ecotones) (Shadangi and Nath 2008) are nearest of each other. So ecological attributes like migration and natality is more dynamic, which contributes to similar diversity index.

Table 2. Year wise *SHE* analysis of insect species population in two diffent Sal and Teak forest ecosystem of PBR. (Kullu and Behera, 2012; Hayek and Buzas, 1997)

Year	SHE analysis of sal forest ecosystem (E_1)			SHE analysis of teak forest ecosystem (E_2)		
	LnS_1	H'_1	LnE_1	LnS_1	H'_1	LnE_1
2011-12	4.024	1.755	0.977	4.261	1.78345	0.983
2012-13	4.136	1.798	0.988	4.331	1.78843	0.983
2013-14	4.338	1.784	0.983	4.352	1.7759	0.977

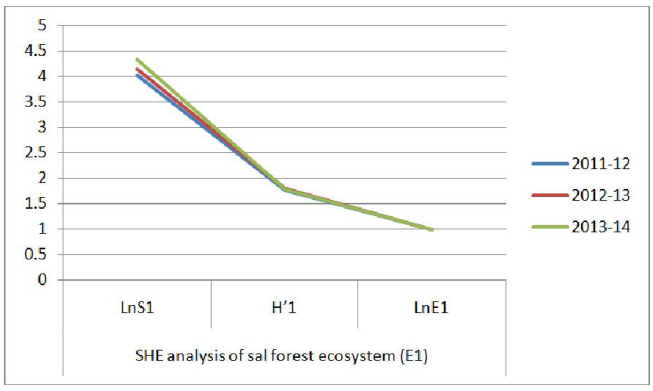

Fig. 3. Year wise *SHE* plotfor insect population Sal forest ecosystem (E_1) of PBR

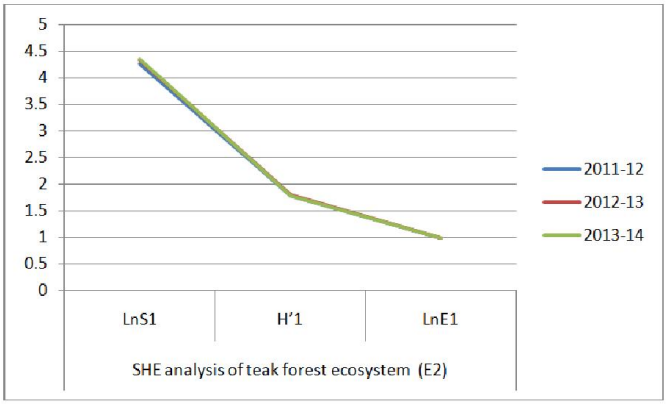

Fig 4. Year wise *SHE* plot forinsect population in Teak forest ecosystem (E_1) of PBR

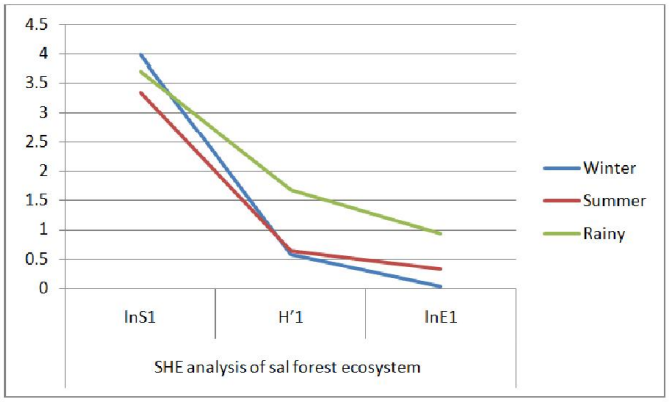

Fig. 5. Seasonal *SHE* plot for insect population Sal forest ecosystem in different seasons

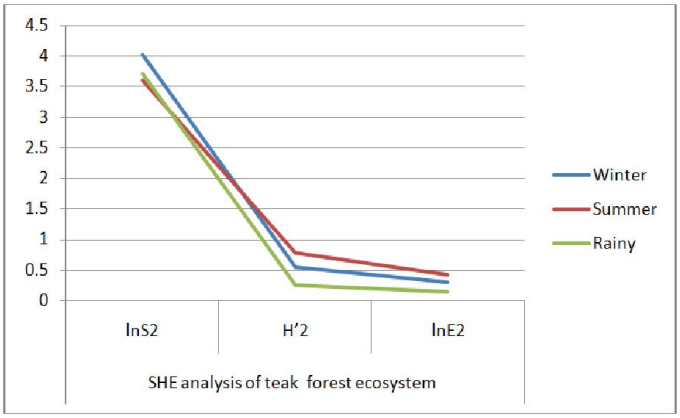

Fig. 5.6 (b) SHE plot for insect population o teak forest ecosystem in different seasons

SHE analysis (Season wise, 2011-14)

SHE analysis (Table 2) revealed a clear distribution of two ecosystems of insect species richness (S), diversity (H) and evenness (E) in the three different season seasons. Analysis indicate s that in winter, summer and rainy seasons $H'_1 \sim H'_2$, $S_1 \neq S_2$, $E_1 \neq E_2$; $H'_1 \neq H'_2$, $S_1 \neq S_2$, $E_1 \neq E_2$ and $H'_1 \sim H'_2$, $S_1 \neq S_2$, $E_1 \neq E_2$respectively (Buzas, Hayek 1996 and 1998); Wilson *et al*., 2010). In winter, in Sal forest ecosystem species were not shown significant evenness (Table 2). It is also observed that yearly, SHE analysis in to Sal and Teak forest ecosystem was significant as comparable to season wise SHE analysis. Diversity pattern changes in ecosystem as per seasonal changes. However in winter season was H1~H2. It may be due to plenty of food resource, host plant habitat, suitable niche, and suitable temperature. It may also that, the junctions of Teak and Salforests (ecotones) (Shadangi and Nath, 2008) are nearest of each other so they migrate to the adjacent ecosystem area. It reveals that in species accorded in Teak-Sal ecotones are polyphagous, so they are flourishing each other. (Buzas Hayek, 1996 and 1998) pointed out that of tenth diversity (H') changes because the differences between richness (S) and evenness (E) donotoffseteach other and such SHE plot is log normal one (Fig. 5 & 6). Difference observed in H'1≠H'2, during summer and rainy seasons, in teak-salecotones, which indicate the change in diversity of the population.

Table 2. SHE analysis of insect species population season wise of in two diffrent sal and teak forest ecosystem, (Kullu and Behera, 2012; Hayek and Buzas, 1996, 1998; Wilson *et al*., 2010)

Seasons	SHE analysis of sal forest ecosystem			SHE analysis of teak forest ecosystem		
	lnS_1	H'_1	lnE_1	lnS_2	H'_2	lnE_2
Winter	3.998	0.57	0.031	4.015	0.54	0.296
Summer	3.334	0.64	0.334	3.598	0.78	0.428
Rainy	3.694	1.68	0.928	3.719	0.24	0.134

(Note -that species evenness s ranges from zero to one, with zero signifying no evenness and one, a complete evenness)

DISCUSSION

Estimation of evenness of insects species stands at 0.9, which is significant for in tropical forest climate.PBR has unique transition of Teak –Sal forests which is said as Teak –Sal ecotones. Though is dominated by trees of teak and sal, still it is a hub for diverse insect fauna. SHE analysis supports that seasonally diversity of insect fauna shows variation. Seasonally diversity index of insect fauna in teak sal ecotone shows high variation. Diversity is controlled by richness and evenness. Highest richness value indicates highest abundance of species in teak sal ecotone.

Present analysis of richness show that most adapted species in this transitional area are; *Camopnotous sp*, *Aciagrion* sp, *M.* uniguttattus, *C.* gangis *Ypthima* sp, *Myrimica* sp, *G. assimities, Ypthima* sp *C. ceremeri, S. furcata, L. niger.*

Conclusion

Entomofaunal survey was made in PBRs teak and sal forest ecosystem .Diversity of insect fauna was recorded and SHE analysis made to determine diversity of insect fauna of PBR. Diversity index of insect faunas is estimated 1.7, is highest.

Among 66recorded insect species 11 were observed most abundant in area with seasonal variation viz *Camopnotous*, *Aciagrion* sp., *M.* uniguttattus, *C.* gangis *Ypthima* sp., *Myrimica* sp., *G. assimities, Ypthima* sp., *C. ceremeri, S. furcata, L. niger,* on the basis of richness count.

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