ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Butterfly diversity in Dry Deciduous Teak forests of Gir Protected Area, Gujarat, India

Anchal Sharma and Dr. S. I. Ahmed

Forest Protection Division, Arid Forest Research Institute, Jodhpur, P. O. Krishi Upaj Mandi, Basni, New Pali Road, Jodhpur-342005 (Rajasthan) INDIA.

Manuscript Info

Manuscript History:

Received: 14 August 2013
Final Accepted: 22 August 2013
Published Online: September 2013

Key words:
Alpha diversity, Gir Protected Area, Indian Wildlife (Protection) Act 1972, Sorensen index, species diversity.

Abstract

Butterflies were sampled during 2011 and 2012 using pollard walk method to assess the species diversity in the Dry Deciduous Teak forest habitats of Sasan Gir protected Area in Junagadh District of Gujarat State, India. The study revealed high alpha diversity of butterflies in these forest tracts, with 67 species recorded. Of these, 23 species are new records for Gir Protected Area wherein 9 species are listed in the Indian Wildlife (Protection) Act 1972. This study provides the revised and annotated checklist of species of butterflies of Sasan Gir Protected Area.

Introduction

The forests of the Gir Protected Area are Dry Deciduous Teak forest, interspersed with semi-evergreen and evergreen flora, acacia, scrub jungle, grasslands and rocky hills. Fed by perennial and seasonal rivers and streams, the sanctuary has large water bodies like the Kamleshwar, Ravale *etc* that are good for flora and fauna. As such these forest tracts are rich in biodiversity. A study was carried out in the Dry Deciduous Teak forest of Gir Protected Area in order to assess the status of butterfly fauna. The aim of the present study was to evaluate species diversity of butterflies and to identify species of conservation priority, if any, as there was a very preliminary study on the invertebrate fauna of GPA.

Perusal of literature reveals that no consolidated account is available on the Lepidoptera fauna of Gir Protected Area, Though, a preliminary work has been done by Ahir and Parikh (2005) and recorded 44 speies (4 families) of butterflies from GPA , Junagadh District, Gujarat. Several earlier workers viz., Bell and Scott (1937), Swinhoe (1905-1912), Bingham (1905, 1907), Evans (1932), Talbot (1939, 1947) and Wynter-Blyth (1957) , Kunte *et al*., (1999) , Kunte (2001, 2005) provided information on butterflies fauna of different states of India including Gujarat.

Most of these studies have proposed that butterflies are important taxa for biodiversity monitoring because they imitated changes in land use patterns (Kunte, 1997, 2000; Kunte *et al*., 1999; Kocker and Williams, 2000; Padhye *et al*., 2006). Butterflies are extensively known as potentially valuable ecological indicators (Erhardt 1855; Brown 1991; Kremen 1992) as they are sensitive to and highly pretentious by any modification to their territories, atmosphere, environment, local weather and climate (Watt *et al*., 1968; Heath, 1981; Rosenberg *et al*., 1986; Dennis, 1993). They are highly delicate towards fluctuations in temperature, humidity, and light levels that are naturally affected by surroundings disturbance (Ehrlich *et al*., 1972; Blau, 1980; Spitzer, 1997; Brunzel and Elligsen, 1999; Balmer and Erhardt, 2000). In addition, butterfly diversity may aid as a substitute for plant diversity because butterflies are directly reliant on on plants, often in highly co-evolved situations (Ehrlich and Raven, 1964).

Material and Methods

Study area:

Gir Protected area (Fig: 1) of Junagadh District, Gujarat comprises 1412 sq km area and lies between between latitude 20°40'N to 21°50‘N and longitude 70°50'E to 71°15' E and is one of the oldest sanctuaries in the country, harbouring the Asiatic LionsThe Gir is fed by perennial and seasonal rivers and streams, the sanctuary has large water bodies like Dams. The soil is generally black with varying proportions of loam. The other types found are red,

yellowish, white clay, and sandy loam soils. The Climatic condition of Gir PAs is generally hot with erratic monsoon. There is incident of frequent draught in this area that results scarcity of resources.

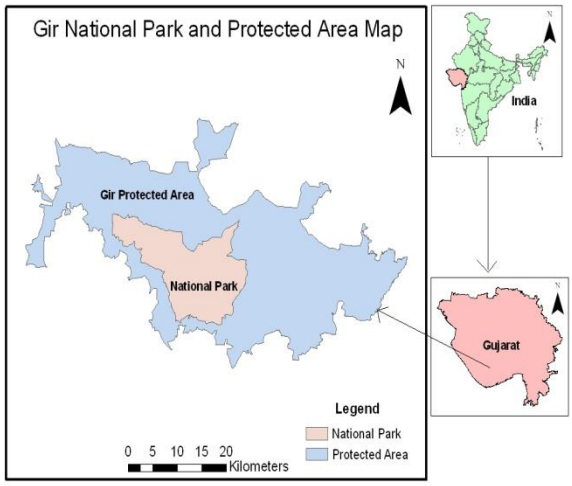

Fig: 1. Map showing Gir Protected Area

According to the Champion and Seth's revised classification of Forest types (Champion & Seth, 1968) (Fig: 2.), the forests of the Gir Protected Area, Junagadh district of Gujarat 5A/Cla, i.e.,very dry teak forests. The sub- types are as under Sub- type: 5/DS1- Dry deciduous scrub forests and Sub-type: 5/DS2- Dry Savannah forests. Important tree species associated with Teak in these forests are *Tectona grandis, Acacia catechu, Terminalia crenulata, Diospyros melanoxylon, Acacia nilotica ssp., Phyllanthus emblica, Lannea coromandelica, Commiphora wrightii, Anogeissus latifolia, Streculia urens, Terminalia bellirica, Zizyphus mauritiana, Butea monosperma, Bauhinia racemosa, Wrightia tinctoria, Aegle marmelos, Cassia fistula, Pueraria tuberosa, Zizyphus ovalifolium, Cuscuta reflexa, Combretum decandrum, Abrus precatorius, Caesalpiniase piaria, Asparagus recemosus, Aristida adscensionis, Andropogoncymbaria, Sorghum halepense, Apludamutica spp. Cymbopogon jwarancusa, Heteropogon contortus, Bothriochloa ischoemum, Sehima sulcatum, Cymbopogon martinii.*

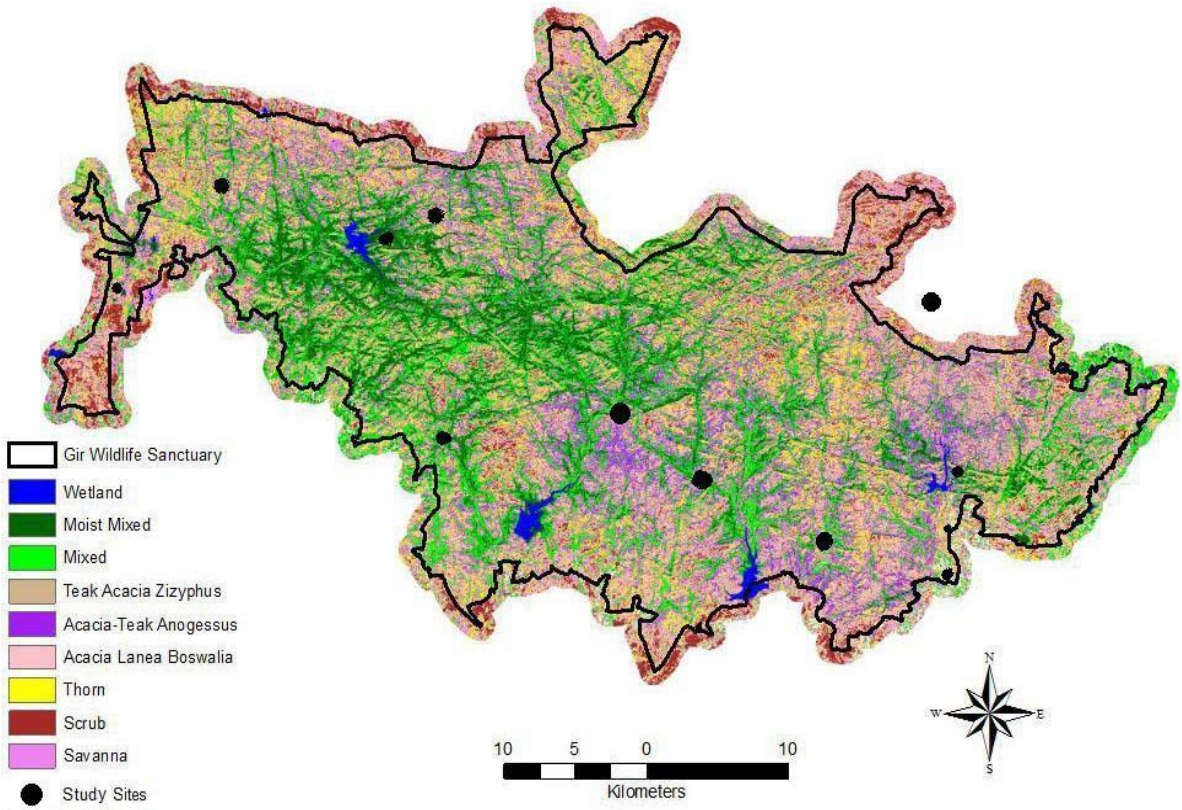

Fig: 2. Vegetation of GPA

Sampling

Ten sites were selected in the proposed forest area (1412 km sq), between latitude 20°40' to 21°50'N and longitude 70°50' to 71°15' E.

Study- sites along with the Forest Range, Forest Type and GPS location has been given in the Table-1 below.

S.No.	Study site	Forest Range	Forest type	Latitude	Longitude
1.	Dudhala	Bedakabi (Gir West Division)	Dry Grassland	21^o 13'	70^o 35'
2.	Devalia	Devaliya (Gir West Division)	Southern Thorn Forest	21^o 09'	70^o 30'
3.	Kamleshwar	Sasan Range (Gir West Division)	Dry Deciduous Teak Forest	21^o 11'	70^o 39'
4.	Barwania	Sasan Range (Gir West Division)	Dry Tropical Revrine Forest	21^o 13'	70^o 42'
5.	Janwadala	Ankolwadi (Gir West Division)	Dry Deciduous Acacia Forest	21^o 04'	70^o 44'
6.	Chhodavadi	Chhodavadi (Gir West Division)	Desert Thorn Forest	21^o 05'	70^o 54'
7.	Banej	Babaria (Gir West Division)	Desert Thorn Forest and Dry Acacia Forest	21^o 02'	71^o 00'
8.	Ghodavadi	Jasadhar (Gir East Division)	Dry Savannah Forest	20^o 59'	70^o 35'
9.	Raval Dam	Hadala (Gir East Division)	Tropical Euphorbia Scrub Forest	21^o 02'	71^o 03'
10.	Jasadhar	Jasadhar (Gir East Division)	Dry Savannah Forest	20^o 59'	71^o 04'

Table:1. List of Study sites (GPA).

Several 15- 20 days surveys were carried out quarterly during 2010-2011 & 2011- 2012 at the ten study sites. The year was divided into four seasons for the interpretation of the Data. The survey has made in the morning hours from 9 am to 4 pm on a linear transect of 200 m on each of the study sites. Each transect was walked to sample butterflies using the standard 'Pollard Walk' methodology. All the species encountered and their relative abundance was recorded daily while walking along the fixed transects. Specimens were collected of the species that could not be identified in the field and were photographed in the field. Specimens of some species were caught for identification and later released. Data on the abiotic factors has been collected from the Metrological Department of Wildlife Division, Sasan Gir, Gujarat.

Statistical Analysis:

Species diversity was calculated using the Shannon Index, which pools the number of species within a site with the relative abundance of each species (Shannon 1948; Magurran 1988, Odum 1997; Krebs 1989).

$H' = - \Sigma \, pi \ln pi$

Here, pi is the proportion of the ith species in the total sample. The number of species (species richness) in the community and their evenness in abundance (or equitability) are the two parameters that define H'.

B. Pielou's Evenness index (Equitability) or J': The species evenness is the relative abundance or proportion of individuals among the species. Evenness of species reveals how their relative

abundance is distributed in a particular sample or site (Pielou 1969; Magurran 1988).

J' =H'/ ln S

Here, S is the number of species present in the site. The value of J' ranges from 0 to 1. The less variation in communities between the species, the higher the value of J'.

C. Sorensen's Similarity Index:

C = 2c / (S1 + S2)

where, S1= the total number of species recorded in the first community, S2= the total number of species recorded in the second community, and c = the number of species common to both communities. The Sorensen's index (Sorensen 1948) is a very simple measure of beta diversity, ranging from a value of 0 where there is no species overlap between the communities, to a value of 1 when exactly the same species are found in both communities.

Identification of butterflies was done using the following literature: Evans (1932), Talbot (1939, 1947), Wynter-Blyth (1957), D'Abrera (1982, 1985, 1986), Haribal (1992) and Kunte (2000). The classification of butterflies followed here is based on Ackery (1984).

Results

The study revealed the presence of 67 species of butterflies belonging to four families and 41 genera from all 10 sites during the sampling surveys (2011-2012) (Table: 2 & 3).

Maximum number of individuals was observed in the Autumn season (4693) with 64 species. The most common species sampled during the study was the Common Grass Yellow *Eurema hecabe*, *Eurema laeta*, *Catopsilia crocale*, *Catopsilia Pomona*, *Catopsilia pyranthe*, *Junonia almana*, *Junonia iphita*, *Castalius rosimon*, *Zizeeria lysimon*, *Colotis danae*, *Colitis eucharis*,.

S.No.	Family	Common Names	Genera	Species
1.	Pailionidae	Swallowtail butterflies	3	6
2.	Pieridae	White and yellow butterflies	10	22
3.	Nymphalidae	Brush-footed butterflies	15	23
4.	Lycaenidae	Blues, hairstreaks & gossamer-winged butterflies	13	16
		Total	**41**	**67**

Table: 2. Family and species-wise distribution of butterflies of Gir Protected Area (GPA) after revision and updation as on May, 2013

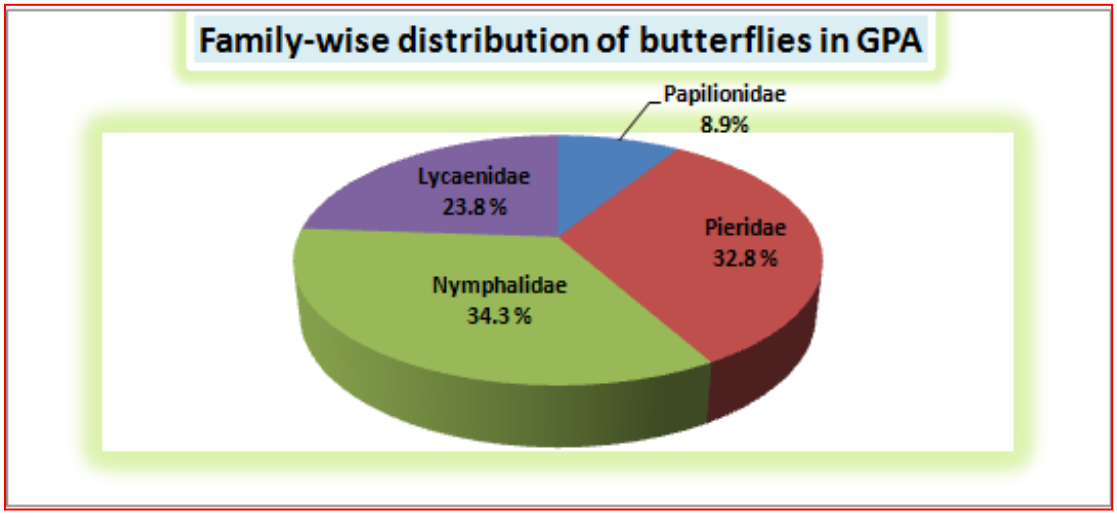

Fig: 3. Family wise distribution of butterflies in GPA

Table: 3. Seasonal abundance of butterfly species in different seasons in GPA.

S. No.	Butterfly species	Average number of individuals observed/ collected during 2011-12			
		Autumn	Winter	Spring	Summer
1.	*Papilio polytes*	25	10	9	11
2.	*Papilio demolus*	49	13	11	13
3.	*Pachiliopta aristolochiae*	15	5	5	5
4.	*Pachiliopta hector*	1	1	1	1
5.	*Graphium agamennon*	11	8	9	7
6.	*Graphium nomius*	0	2	0	0
7.	*Danaus chrysippus*	130	57	47	40
8.	*Danaus genutia*	54	19	25	17
9.	*Euploea core*	46	23	15	19
10.	*Hypolimnas missipus*	54	20	9	15
11.	*Hypolimnas bolinia*	17	8	3	10
12.	*Junonia orithiya*	35	21	13	14
13.	*Junonia lemonias*	56	28	19	19
14.	*Junonia hierta*	94	34	21	21
15.	*Junonia iphita*	138	69	36	56
16.	*Junonia almana*	186	91	55	58
17.	*Acraea violae*	7	4	3	4
18.	*Ariadne ariadne*	4	0	1	0
19.	*Ariadne merione*	2	2	0	2
20.	*Phalanta phalanta*	78	6	5	8
21.	*Trirumala limniace*	8	6	6	6
22.	*Cynthia cardui*	37	18	14	14
23.	*Melanitis leda*	19	5	5	4
24.	*Melantis phedima*	1	1	1	1
25.	*Byblia ilithiya*	1	1	1	1
26.	*Ypthima asterope*	8	6	5	8
27.	*Mycalesis spp.*	1	1	0	1
28.	*Euthalia nais*	19	13	11	7
29.	*Charaxes fabius*	1	1	0	1
30.	*Delias eucharis*	58	22	13	17
31.	*Ixias pyrene*	131	33	17	21
32.	*Ixias marianne*	144	72	39	37
33.	*Anaphaeis aurota*	83	41	22	23
34.	*Eurema brigitta*	198	106	68	66
35.	*Eurema hecabe*	260	142	90	83
36.	*Eurema laeta*	149	77	41	44

37.	*Eurema blanda* *	-			
38.	*Cepora nerissa*	159	80	45	57
39.	*Appias libythea*	177	97	62	63
40.	*Parenonia valeria*	74	27	18	18
41.	*Catopsilia pomona*	248	127	90	72
42.	*Catopsilia pyranthe*	219	127	80	82
43.	*Catopsilia florella*	77	19	21	14
44.	*Catopsilia crocale*	244	142	78	103
45.	*Catopsilia duvivieri*	44	20	11	15
46.	*Colitis etrida*	174	93	53	69
47.	*Colitis danae*	138	75	46	46
48.	*Colitis eucharis*	150	75	40	56
49.	*Colitis fausta*	101	58	45	48
50.	*Colias fieldii*	128	64	66	55
51.	*Colitis amata*	37	19	16	12
52.	*Tarucus nara*	17	13	14	10
53.	*Euchrysops cnejus*	69	16	11	7
54.	*Zizera lysimon*	108	28	17	19
55.	*Curetis thetis*	23	17	15	12
56.	*Rapala airbus*	22	14	10	14
57.	*Catlius rosimon*	117	22	13	15
58.	*Spindasis vulcanus*	70	37	22	18
59.	*Catochysops strabo*	32	17	10	11
60.	*Leptotes plinius*	33	20	15	18
61.	*Lampides boeticus*	24	14	10	12
62.	*Spindasis ictis*	16	10	7	9
63.	*Tarucus therophrastus*	10	4	0	2
64.	*Azanus ubaldus*	52	4	2	6
65.	*Faegana sp. indt*	0	2	3	0
66.	*Dendoryx epijarbas*	9	5	7	4
67.	*Azanus jeasons*	1	1	1	1
	Total species	**4693**	**2213**	**1448**	**1522**

**Not encountered during present study in GPA but reported earlier by Ahir and Parikh (2005)*

The list of 9 species of butterflies of GPA, pertaining to their status, as protected under Indian Wildlife (Protection) Act. 1972, has been given (Table: 4). Of them, four species of butterflies *viz.,Pachiliopta hector, Hypolimnas missipus, Castalius rosimon* and *Dendoryx epijarbas* are included in Schedule-I and another four species namely, *Charaxes fabius*, *Cepora nerissa, Euchrysops cnejus* and *Lampides boeticus* are included under Schedule-II, while remaining only one species *Euploea core* has been included under Schedule-IV.

Table: 4. List of species butterflies of GPA with their status under Wild Life Protection Act- 1972 (WPA)

S.No	Family	Species	Status as WPA (1972)
1.	Papilionidae	*Pachiliopta hector*	Schedule – 1 (WPA- 1972)
2.	Nymphalidae	*Hypolimnas missipus*	Schedule – I (WPA- 1972)
3.	Nymphalidae	*Charaxes fabius*	Schedule – II (WPA- 1972)
4.	Nymphalidae	*Cepora nerissa*	Schedule – II (WPA- 1972)
5.	Nymphalidae	*Euploea core*	Schedule – IV (WPA- 1972)
6.	Lycaenidae	*Euchrysops cnejus*	Schedule – II (WPA- 1972)
7.	Lycaenidae	*Castalius rosimon*	Schedule – I (WPA- 1972)
8.	Lycaenidae	*Lampides boeticus*	Schedule – II (WPA- 1972)
9.	Lycaenidae	*Dendoryx epijarbas*	Schedule – I (WPA- 1972)

Abundance profile for butterflies observed in different Season in Gir PAs: The abundance in population has significantly been recorded during all the season of both the years in Gir Protected Areas (Fig: 3.). Among overall family abundance, the family Pieridae was the only family which has been preponderant during all seasons in both the years during 2011 and 2012 in GPA.

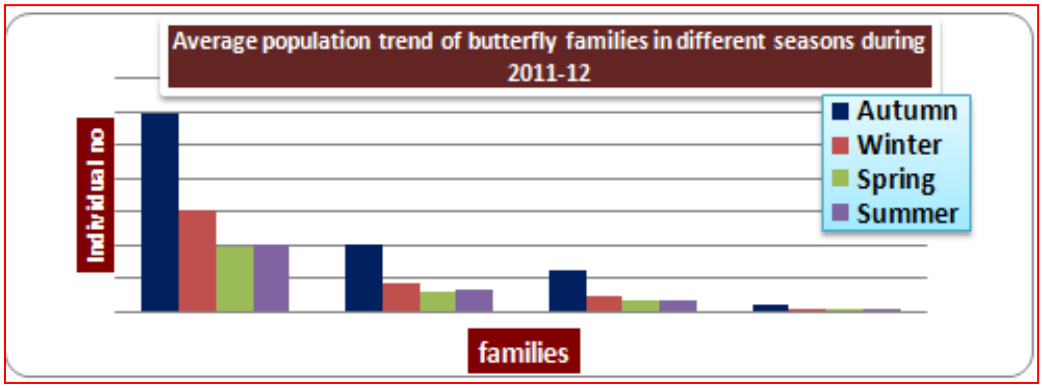

Fig: 3. Average population trend of butterfly families in different seasons.

Species Diversity and Evenness at the Ten Study Sites:

Species richness i.e. the total number of species encountered, diversity index, and evenness index did not vary much amongst the sites (Fig. 4). However, Site 4 had the highest value for all three of these parameters. The high value of the Shannon diversity index was mainly attributed to 'edge effect'.

Similarity of sites for butterfly species by Sorensen's Similarity index

In the community similarity study based on the Soresson Index. It is observed that there were very much likeness in the communities present at the 10 study sites of GPA as the values obtained ranges from 0.71 to 0.85 which shows that more the communities have in common as it is very close to 1.

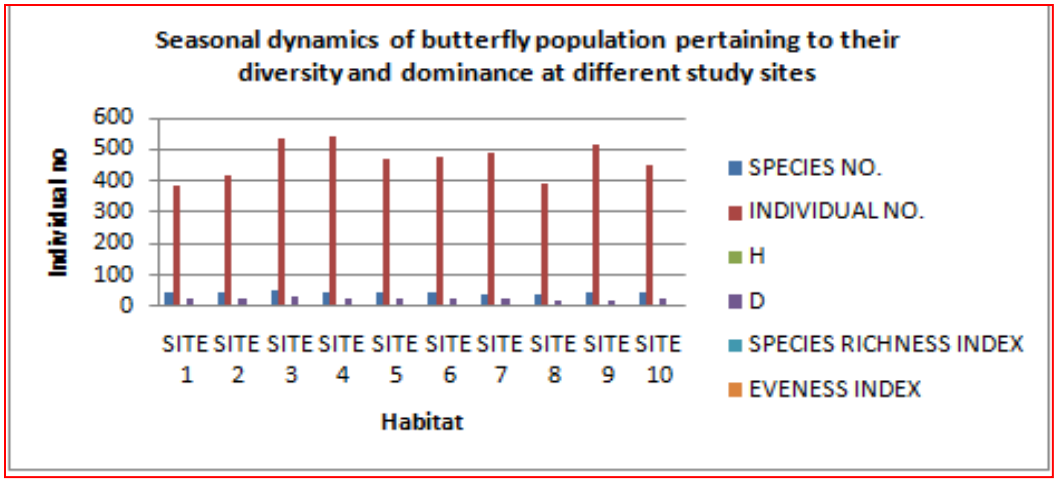

Fig: 4. Seasonal dynamics of butterfly population pertaining to Diversity, Dominance , Evenness and Richness.

	Site- 1	Site- 2	Site- 3	Site- 4	Site- 5	Site- 6	Site- 7	Site- 8	Site- 9	Site- 10
Site- 1	-	0.87	0.81	0.74	0.83	0.82	0.76	0.85	0.82	0.80
Site- 2	-	-	0.85	0.75	0.78	0.79	0.78	0.80	0.80	0.73
Site- 3	-	-	-	0.79	0.76	0.73	0.79	0.81	0.80	0.72
Site- 4	-	-	-	-	0.83	0.72	0.74	0.79	0.73	0.76
Site- 5	-	-	-	-	-	0.82	0.71	0.72	0.71	0.78
Site- 6	-	-	-	-	-	-	0.73	0.73	0.72	0.75
Site- 7	-	-	-	-	-	-	-	0.79	0.73	0.71
Site- 8	-	-	-	-	-	-	-	-	0.80	0.72
Site- 9	-	-	-	-	-	-	-	-	-	.75
Site- 10	-	-	-	-	-	-	-	-	-	-

Table: 5. Data showing community similarity

It is established that none of the communities of the study sites result into 1 or 0 which indicates that neither the community is completely overlap nor they are completely dissimilar but are very close to each other.

Discussion

The results indicate high alpha diversity of butterflies in these Gir forest habitats. Sixty seven species of butterflies were sampled in the study area, however these consist of mostly 'common' and 'generalist' species, as Nine of the species is protected by law as they are listed in the Indian Wildlife (Protection) Act 1972 under Schedule I, Schedule II, part II (Anonymous 2006). Apart from these a female form of *Hypolimnas missipus i.e., Hypolimnas missipus inaria* was also observed but are restricted to some of the sited only which come under the category of rare species as per IUCN Red List 2008.

The occurrence of all these species indicates that these forest tracts are having flora rich habitats that hold faunal diversity that is typical of 'undisturbed tropical moist deciduous forest.

Acknowledgement

This study was part of Ph. D programme, AFRI, Jodhpur (FRI - Dehradun). The author is thankful to Director AFRI, CCF and DCF Gir National Park, for providing the necessary facilities to carry out this study and Department of Science and Technology (DST), New Delhi for Funding.

References

Ackery, P.R. (1984). Systematic and faunistic studies on butterflies, pp. 2-91. In: Wright, R.I.V. and P.R. Ackery (eds.). The Biology of Butterflies.Symposium of the Royal Entomological Society of London, Academic Press, No.11.

Anonymous (2006).The Wildlife (Protection) Act 1972.Natraj Publishers, Dehradun, 235pp.

Balmer, O. & A. Erhardt (2000). Consequences of succession on extensively grazed grassland for central European butterfly communities: Rethinking conservation practices. *Conservation Biology*. 14: 746-757.

Blau, W.S. (1980). The effect of environmental disturbance on a tropical butterfly population. *Ecology* .61: 1005-1012.

Brown, K. S. (1991). The conservation of insects and their habitats, pp. 350-403. In: Conservation of Neotropical Environments: Insects as Indicators. 15th Symposium of the Royal Entomological Society.

Brunzel, S. and Elligsen, H., (1999). Changes of species set and abundance along a short gradient: The impact of weather conditions on the conservation of butterflies. *BeitragezurEntomologie* 49: 447-463.

Champion, H.G. & S.K. Seth (1968).A Revised Survey of Forest Types of India.Govt.of India Press, Delhi.

Chandra, K., R.M. Mishra, A. Singh & R.K. Singh (2007). A checklist of butterflies of Madhya Pradesh and Chattisgarh states, *India. Zoo's Print Journal*. 22: 2790-2798.

Choudhury, A., D.K.L. Choudhury, A. Desai, J.W. Duckworth, P.S. Easa, A.J.T. Johnsingh, P. Fernando, S. Hedges, M. Gunawardena, F. Kurt, U. Karanth, A. Lister, V. Menon, H. Riddle, A. Rübel& E. Wikramanayake (2008). Elephasmaximus. In: IUCN 2010. IUCN Red List of Threatened Species.Version 2010.2.

D'Abrera, B. (1982). Butterflies of the Oriental Region - Part I. Papilionidae, Pieridae&Danaidae. Hill House, Victoria, Australia, 244pp.

D'Abrera, B. (1985). Butterflies of the Oriental Region- Part II. Nymphalidae, Satyridae&Amathusiidae. Hill House, Victoria, Australia, 534 pp.

D'Abrera, B. (1986). Butterflies of the Oriental Region - Part III.Lycaenidae&Riodinidae. Hill House, Victoria, Australia, 672pp.

Dennis, R.H.L. (1993). Butterflies and Climate Change.University Press, Manchester, xv+302pp.

DFE (2009). Division Wise Composition of Jharkhand Forest - 6 Saranda Part I. Chapter-II, A - The Forests. Department of Forests & Environment, Government of Jharkhand, 31pp. Available online at http://www.jharkhandforest.com/files/saranda_terrain .pdf

Ehrlich, P.R., D.E. Breedlove, P.F. Brussard& M.A. Sharp (1972).Weather and the regulation of sub-alpine populations. *Ecology* 53: 243-247.

Ehrlich, P.R. & P.H. Raven (1964). Butterflies and plants: a study in co-evolution. *Evolution* 18: 586-608.

Erhardt, A. (1985). Diurnal Lepidoptera: Sensitive indicators of cultivated and abandoned grassland. *Journal of Applied Ecology* 22: 849-861.

Garshelis, D.L., S. Ratnayeke & N.P.S. Chauhan (2008).Melursusursinus. In: IUCN 2010. IUCN Red List of Threatened Species.Version 2010.2.

Haribal, M. (1992) The Butterflies of Sikkim Himalaya and their Natural History. Sikkim Nature Conservation Foundation, Sikkim, 217pp.

Heath, J. (1981). Threatened Rhopalacera (Butterflies) of Europe.Council of Europe, Strasbourg, 157pp.

Kocher, S.D. & E.H. Willaims (2000). The diversity and abundance of North American butterflies vary with habitat disturbance and geography. Journal of Biogeography 27: 785-794.

Krebs, C. (1989). Ecological Methodology. HarperCollins, New York, 654pp.

Kremen, C. (1992). Assessing the indicator properties of species assemblages for natural area monitoring. Ecological Applications 2: 203-217.

Kunte, K. (1997). Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. Journal of Biosciences 22: 593-603.

Kunte, K., A. Joglekar, G. Utkarsh& P. Padmanabhan (1999).Patterns of butterfly, bird and tree diversity in the Western Ghats. Current Science 77: 577-586.

Kunte, K. (2000). Butterflies of Peninsular India.University Press, Hyderabad, India, 254pp.

Morrison-Godfrey, P.W. (1950). Butterflies of south Bihar. Journal of Bombay Natural History Society 47: 644-651.

Magurran, A.F. (1988). Ecological Diversity and Its Measurements. University Press, Cambridge, 192pp.

Odum, E.P. (1997). Ecology: A Bridge between Science and Society. Sinauer Associated Inc. Sunderland, Massachusetts, USA, 330pp

Pielou, E.C. (1969). An Introduction to Mathematical Ecology. John Wiley, New York, 286pp.

Rajamani, N., S. Molur& P.O. Nameer (2009).Ratufaindica. In: IUCN 2010. IUCN Red List of Threatened Species.Version 2010.2

Rosenberg, D.M., H.V. Danks. & D.M. Lehmkuhl (1986).Importance of insects in environmental impact assessment. Environmental Management 10: 773-783.

Shannon, C.E. (1948). A mathematical theory of communication.Bell System Technical Journal 27: 379-423 & 623-656.

Sinha, J.N. (1962). Fourth Revised Working Plan for the Reserved and Protected Forests of Saranda Division, Bihar 1956-57 to 1975-76. Superintendent, Secretariat Press, Bihar (Patna), 257pp.

Sorensen, T.A. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. Kongelige Danske Videnskabernes Selskabs Biologiske Skrifter 5: 1-34.

Spitzer, K., J. Jaros, J. Havelka, & J. Laps (1997). Effect of small- scale disturbance on butterfly communities of an Indochina montane rainforest. Biological Conservation 80: 9-15.

Verma, S.K. (2009). Species composition and seasonal variation of butterflies in Dalma Wildlife Sanctuary, Jharkhand, India. Journal of Threatened Taxa 1(5): 295-297.

Talbot, G. (1939). The Fauna of British India including Ceylon and Burma. Butterflies. 2nd edition. Vol.I . Taylor & Francis, London. 600pp.

Talbot, G. (1947) The Fauna of British India including Ceylon and Burma.Butterflies.2nd edition Vol II. Taylor & Francis, London, 506pp.

Ten Kate, K., J. Bishop, & R. Bayon (2004). Biodiversity Offsets: Views, Experience, and the Business Case. IUCN, Gland, Switzerland and Cambridge, UK and Insight Investment, London, UK, 95pp.

Watt W.B., F.S. Chew, L.R.G. Snyder, A.G. Watt & D.E. Rothschild (1968). Population structure of pierid butterflies, I. Numbers and movements of some montane Colias species. *Oecologia, Berl*. 27: 1-2.

Wynter-Blyth, M.A. (1957). Butterflies of the Indian Region. Bombay Natural History Society, Bombay, 523pp.