

Butterfly diversity of Jayantikunj, Rewa (M.P.)

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Abstract

The investigation was conducted at the Jayantikunj, Rewa (M.P.). It is situated at the western site of Govt. Science College Hostel, Rewa (M.P.). Butterfly watching and recording was done in such a way that there should be least one visit in each line transect during a week with the aid of binocular and digital cameras. Total 138 species of butterflies were recorded belonging to 117 genera and 11 families. Lycaenidae family is consisting of maximum number of genera and species. During unfavourable seasons, that in spring and summer, a low population found. Grass yellow (*Eurema* spp; family pieridae) had high population in all seasons in spring or summer depending on the site.

Keywords: Butterfly; Lepidoptera; biodiversity; Jayantikunj

1. Introduction

There are 1.4 million species on earth; over 53% are insects while about 15,000-16,000 species of butterflies are known worldwide (Hossan, 1994) [1]. Butterflies have been regarded as the symbol of beauty and grace (Rafi *et al.*, 2000) [2]. They are the best known insects due to their diurnal habitats and readily recognized by their bright colours, marvelous shapes and graceful flight give pleasure to everyone (Javid, 1978) [3]. Insects may have coloured wings, but only in Lepidoptera is the colour due to minute scales laid healthy in rows. The scales may be pigmented to give bright patterns, or they may be colorless, but striated with lines so close together that they give even brighter diffraction colors, e.g., the brilliant blue-green of *Papilio paris*, the Paris Peacock.

Butterflies are providing the best rapid indicators of habit quality and they are the sensitive indicators of climatic change (Venkata Ramana, 2010) [4]. In the world, about 19,238 species were documented by Heppner (1998) [5]. There were about 1,504 species of butterflies in Indian subcontinent (Gaonkar, 1996; Smetacek, 1992) [6, 7]. In central India, about 177 species of butterflies were reported in the Central Provinces (Vidarbha, Madhya Pradesh and Chattisgarh) by D'Abreau (1931) [8]. In Vidarbha region, Tiple (2011) [9] was compiled and records of 167 species of butterflies belonging to 90 genera representing 5 families.

Rewa District of Madhya Pradesh the site of present research work is a unique hilly place and very rich in its flora and fauna of the country. Different species of butterflies of the order Lepidoptera were collected from different localities of Jayantikunj, Rewa during the present investigation since March 2015 to February 2016.

Rewa city is important on account of its location in the midst of the district area, where rich mineral deposits are found. There are thick forest in the vicinity of Rewa Distt. The city is located on the plateau surrounded by plane land and villages; the average elevation above mean sea level is 1430 ft.

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College Hostel, Rewa (M.P.). It is about 0.023 hectares. In Jayantikunj rare, vulnerable, medicinal and Threatened species of plants were planted in the nursery for selling. Besides planted trees, a variety of annual wild plants and perennial shrubs grow naturally in this area. The minimum temperature in winter 0-9°C and the maximum temperature in summer is 38°C to 43°C. The climate of the area is subtropical with not summer and tropical with cold winters. Since, the main objective of this study has been conduct preliminary observation of butterflies and carried out the checklist, occurrence and richness inhibiting the Jayantikunj, Rewa (M.P.).

2. Material and Methods

The present study has been carried out for a period of two year from March 2015 to February 2016. Butterfly watching and recording has been done during Sunday and holidays in such a way that there should be least one visit in each line transect during a week. The observations were made with the aid of binocular and digital cameras.

Butterflies of different species were caught at different sites. They also found in common habitats of butterflies, like flowers, jungle, setting in garden and wild flowers.

Many butterflies suck up the moisture from the ground and also found on animal dung, bird droppings, rotting fruits and some of them basking in the sunlight.

Butterfly collection was done with the help of insect nets of medium to large size and some were collected by hand picking with the help of a soft forcep. For killing the insects carbon tetrachloride was injected with the help of fine needle in metathorax. Cyanide bottle for killing of insects was avoided. After killing the insects were pinned with insect pins and stretched on the insect stretching board for measuring their wing span.

Every effort was made to avoid any break of the body parts of the insect. The insects were dried either directly in sunlight or by keeping them at 40 to 45 watt electric bulb. Some time oven was also used. The dried insects were arranged in the

wooden box. Naphthalene balls were kept for the protection from pests.

Butterflies were identified by using various field guides, by internet, by already preserved specimen and available literature (Kunte, 1997; Talbot (1939); Wynter-Blyth (1957); Sabir *et al.*, 2000) [10-13].

Observations were made through walking transects (Pollard, 1993; Caldas and Robbins, 2003) [14, 16] of 0.5 km to 0.7 km length with 2 m to 5 m on either side. The present study is based on 4 line transects to study the butterfly population. The sites were visited in morning and evening hours to note maximum possible species of butterflies and record its activities. The recorded species are identified with the help of photographs by using reference books and publications.

3. Result & Discussion

A checklist of butterflies of Jayantikunj, Rewa has been prepared based on the present study (Tables 1-2; Fig. 1). Total 138 species of butterflies were recorded belonging to 117 genera and 7 families. The family Papilionidae, Pieridae,

Lycaenidae, Libythiidae, Nemebiidae, Hesperidae, Acraidae, Nymphalidae, Amathusiidae, Satyridae and Danaidae were consisted of 6 genera and 13 species; 15 genera and 15 species; 34 genera and 34 species; 1 genera and 1 species, 1 genera and 1 species, 17 genera and 18 species, 2 genera and 2 species, 27 genera and 32 species, 1 genera and 1 species, 8 genera and 13 species and 8 genera and 8 species respectively (Fig. 1). A maximum number of species were belong to family- Lycaenidae (34) followed by Nymphalidae (32), Hesperidae (18), Pieridae (15), Papilionidae (13), Satyridae (13) and minimum number of species were noted in family- Libythiidae, Nemebiidae and Amathusiidae (1). These 11 families were contributed 117 genera. The largest number of genera were reported in family Lycaenidae (34) followed by Nymphalidae (27), Hesperidae (17), Pieridae (15), Satyridae (8), Papilionidae (6) and Danaidae (5) and minimum number of genera (2) were reported in family- Acraidae and one genera Libythiidae, Nemebiidae and Amathusiidae. (Tables 1 and 2).

Table 1: Butterflies fauna of Jayantikunj, Rewa (M.P.) studied during 2015-2016.

S. No.	Family	Sub-Family	Genus	Species	Common Name
1.	Papilionidae	Parnassinae	<i>Parnassius</i>	<i>hardwickei</i>	Snow Appolos
	" "	Papilionae	<i>Teinopalpus</i>	<i>imperealis</i>	Kaiser-I- Hind
	" "	Papilionae	<i>Graphium</i>	<i>sarpedon</i>	Kite swallowtails Common Blue Bottle
	" "	Papilionae	<i>Graphium</i>	<i>eurous</i>	Brown Gorgon
	" "	Parnassinae	<i>Graphium</i>	<i>agamemnon</i>	Tailed Joy
	" "	Papilionae	<i>Papilio</i>	<i>machaon</i>	Black-bodied Sword Tails
	" "	Papilionae	<i>Papilio</i>	<i>machaon</i>	Lime Butterfly
	" "	Papilionae	<i>Papilio</i>	<i>polytes</i>	Common mormon
	" "	Papilionae	<i>Papilio</i>	<i>paris</i>	Common mormon
	" "	Papilionae	<i>Pachliopta</i>	<i>aristolochiae</i>	Common rose (Red bodied Swallow tails)
	" "	Parnassinae	<i>Pachliopta</i>	<i>hector</i>	Crimson Rose
	" "	Papilionae	<i>Pathysa</i>	<i>nomius</i>	Spot Swordtail
	" "	Papilionae	<i>Troides</i>	<i>helena</i> male	Birdwings
2.	Pieridae	Pierinae	<i>Pontia</i>	<i>daplidice</i>	Bath whites
	" "	Pierinae	<i>Pareronia</i>	<i>valeria</i>	Common Wanderer
	" "	Pierinae	<i>Anaphaeis</i>	<i>aurota</i>	Pioneer
	" "	Pierinae	<i>Artogeia</i>	<i>Canidia</i>	Cabbage White
	" "	Pierinae	<i>Cepora</i>	<i>nerissa</i>	Gulls
	" "	Pierinae	<i>Delias</i>	<i>hyparete</i>	Jezebels
	" "	Pierinae	<i>Appias</i>	<i>lyncida</i>	Albatrosses & Puffins
	" "	Pierinae	<i>Leptosia</i>	<i>nina</i>	Psyche
	" "	Pierinae	<i>Hebomoia</i>	<i>glaucippe</i>	Great orange tip
	" "	Pierinae	<i>Valeria</i>	<i>valeria</i> male	Wanderers
	" "	Pierinae	<i>Ixias</i>	<i>pyrene</i> male	Orange tips
	" "	Coliadinae	<i>Catopsilia</i>	<i>crocale</i> female	Emigrants
	" "	Coliadinae	<i>Dercas</i>	<i>verhuelli</i>	Tailed Sulphur
	" "	Pierinae	<i>Eurema</i>	<i>hecabe</i>	Common Grass
	" "	Coliadinae	<i>Colias</i>	<i>fieldii</i> male	Clouded yellows
3.	Lycaenidae	Poritinae	<i>Portia</i>	<i>hewitsoni</i>	Common Gen.
	" "	Miletinae	<i>Miletus</i>	<i>chinensis</i>	Common Brounie
	" "	Miletinae	<i>Spalgis</i>	<i>epics</i>	Apefly
	" "	Miletinae	<i>Spindasis</i>	<i>vulcanus</i>	Common Silverline
	" "	Miletinae	<i>Surendra</i>	<i>quercetorum</i>	Common Acacia Blue
	" "	Miletinae	<i>Syntarucus</i>	<i>plinius</i>	Zebra Blue
	" "	Miletinae	<i>Castalius</i>	<i>rosimon</i>	Common Pierrot
	" "	Curetinae	<i>Curetis</i>	<i>bulis</i> male	Sunbeams
	" "	Theclinae	<i>Euaspa</i>	<i>milonia</i>	Water Hairstreak
	" "	Theclinae	<i>Euchrysops</i>	<i>cnejus</i>	Gram Blue
	" "	Theclinae	<i>Arhopala</i>	<i>eumolphus</i>	Oak blues
	" "	Theclinae	<i>Zesius</i>	Chrysomallus	Redspot
	" "	Theclinae	<i>Zizeeria</i>	<i>maha</i>	Pale Grass Blue

	" "	Theclinae	<i>Irota</i>	<i>timoleon</i>	Silverstreak blue
	" "	Theclinae	<i>Jamides</i>	<i>celeno</i>	Common Cerulean
	" "	Theclinae	<i>Catapoecilma</i>	<i>major</i>	Common Tinsel
	" "	Theclinae	<i>Chilades</i>	<i>laius</i>	Lime Blue
	" "	Theclinae	<i>Loxura</i>	<i>atymmus</i>	Yarafly
	" "	Theclinae	<i>Horaga</i>	<i>onyx</i>	Anyxes
	" "	Theclinae	<i>Cheritrella</i>	<i>truncipe-nnis</i>	Truncate Imperial
	" "	Theclinae	<i>Spindasis</i>	<i>syama</i>	Silverlines
	" "	Theclinae	<i>Ancema</i>	<i>ctesia</i>	Royals
	" "	Theclinae	<i>Chliaria</i>	<i>othena</i>	Tits
	" "	Theclinae	<i>Deudorix</i>	<i>epijarbus</i>	Cornelian
	" "	Lyacaeninae	<i>Lycaena</i>	<i>pavana</i>	Coppers
	" "	Polyommatainae	<i>Abisara</i>	<i>echeirus</i>	Plum Judy
	" "	Polyommatainae	<i>Amblypodia</i>	<i>anita</i>	Leaf Blue
	" "	Polyommatainae	<i>Anthene</i>	<i>emelus</i>	Ciliate blues
	" "	Theclinae	<i>Arhopala</i>	<i>amantes</i>	Largeoak Blue
	" "	Polyommatainae	<i>Niphanda</i>	<i>cymbia</i>	Pointed Pierott
	" "	Polyommatainae	<i>Lampides</i>	<i>boeticus</i>	Pea blue
	" "	Polyommatainae	<i>Rapala</i>	<i>iarbus</i>	Indian Red Flash
	" "	Polyommatainae	<i>Talicada</i>	<i>nyseus</i>	Red pierrot
	" "	Polyommatainae	<i>Polyommatus</i>	<i>nepalensis</i>	Meadow blues
4.	Libythiidae	-	<i>Libythea</i>	<i>lepita</i>	Beaks
5.	Nemebiidae	-	<i>Zemeros</i>	<i>fiogyas</i>	Punchinello
6.	Hesperiidae	Coeliadinae	<i>Bibasis</i>	<i>vasutana</i>	Awlets
	" "	Pyrginae	<i>Lobocla</i>	<i>liliana</i>	Marbled Feat
			<i>Daimio</i>	<i>phisara</i>	Common Crow
	" "	Pyrginae	<i>Spialia</i>	<i>galba</i>	Indian Skipper
	" "	Hesperinae	<i>Carterocephalus</i>	<i>avanti</i>	Orange & silver Mountain Hopper
	" "	Hesperinae	<i>Arnetta</i>	<i>atkinsoni</i>	Atkinson's Bob
	" "	Hesperinae	<i>Badamia</i>	<i>exclamationis</i>	Brown Awl
	" "	Hesperinae	<i>Hasora</i>	<i>chromus</i>	Common banded awe
	" "	Hesperinae	<i>Pithauria</i>	<i>stramineipennis</i>	Light-Strawv Ace
	" "	Hesperinae	<i>Notocrypta</i>	<i>feithamelii</i>	Spotted
	" "	Hesperinae	<i>Zographetus</i>	<i>atwa</i>	Purple & gold flitter
	" "	Hesperinae	<i>Matapa</i>	<i>cresta</i>	Fringed red eye
	" "	Hesperinae	<i>Ochlodes</i>	<i>brahma</i>	Himalyan Darter
	" "	Hesperinae	<i>Taractrocera</i>	<i>maevius</i>	Common grass Dart
	" "	Hesperinae	<i>Telicota</i>	<i>ancilla</i>	Dark polm dart
	" "	Hesperinae	<i>Pelopidas</i>	<i>assamensis</i>	Conjoined Swift
	" "	Hesperinae	<i>Pelopidas</i>	<i>conjuncta</i>	Conjoined Swift
	" "	Hesperinae	<i>Udaspes</i>	<i>folus</i>	Grass Demon
7.	Acraidae	-	<i>Acraea</i>	<i>violae</i>	Tawny costor
	" "	-	<i>Pareba</i>	<i>issoria</i>	Yellow costor
8.	Nymphalidae	Pseudergolinae	<i>Dichorragia</i>	<i>nesimachus</i>	Constable
	" "	Apaturinae	<i>Diagora</i>	<i>nicevillei</i>	Sirens
	" "	Apaturinae	<i>Charaxes</i>	<i>marmax</i>	Rajahs
	" "	Apaturinae	<i>Ariadne</i>	<i>ariadne</i>	Angled Castor
	" "	Apaturinae	<i>Phalanta</i>	<i>phalantha</i>	Leopard
	" "	Apaturinae	<i>Junonia</i>	<i>orithya</i>	Blue Pansy
	" "	Apaturinae	<i>Junonia</i>	<i>hierta</i>	Lemon Pansy
	" "	Apaturinae	<i>Junonia</i>	<i>almana</i>	Peacock Pansy
	" "	Apaturinae	<i>Junonia</i>	<i>atlites</i>	Grey Pansy
	" "	Apaturinae	<i>Precis</i>	<i>iphita</i>	Chocolate Pansy
	" "	Apaturinae	<i>Vanessa</i>	<i>cardui</i>	Painted Lady
	" "	Apaturinae	<i>Hypolimnas</i>	<i>missippus</i>	Danaid Eggfly
	" "	Apaturinae	<i>Hypolimnas</i>	<i>bolina</i>	Greateggfly
	" "	Apaturinae	<i>Kallima</i>	<i>horsfieldi</i>	Blueoakleaf
	" "	Apaturinae	<i>Neptis</i>	<i>jumbah</i>	Chestnut Streaked Sailor
	" "	Apaturinae	<i>Neptis</i>	<i>hylas</i>	Common Sailor
	" "	Apaturinae	<i>Athyma</i>	<i>perius</i>	Common Sergeant
	" "	Apaturinae	<i>Moduza</i>	<i>procris</i>	Commander
	" "	Apaturinae	<i>Euthalia</i>	<i>aconthea</i>	Common Baron
	" "	Apaturinae	<i>Symphaedra</i>	<i>nais</i>	Baronet
	" "	Apaturinae	<i>Charaxers</i>	<i>bernardus</i>	Tawny Rajah
	" "	Apaturinae	<i>Acraea</i>	<i>terpsicore</i>	Tawny Coster

	" "	Marpesiinae	<i>Cyrestis</i>	<i>thyodamas</i>	Common map
	" "	Marpesiinae	<i>Cethosia</i>	<i>biblis</i>	Red Lacewing
	" "	Marpesiinae	<i>Childrena</i>	<i>childreni</i>	Large Silverstripe
	" "	Marpesiinae	<i>Melitaea</i>	<i>arcesia</i>	Blackvein Fritillary
	" "	Marpesiinae	<i>Aglais</i>	<i>ladakensis</i>	Ladak Tortoise shell
	" "	Marpesiinae	<i>Hypelminas</i>	<i>bolina</i>	Great Egg Ely
	" "	Marpesiinae	<i>Ariadne</i>	<i>merione</i>	Common Castor
	" "	Marpesiinae	<i>Limenitis</i>	<i>procris</i>	Comander
	" "	Marpesiinae	<i>Phaedyma</i>	<i>aspasia</i>	Great Hockystick Sailer
	" "	Marpesiinae	<i>Euthalia</i>	<i>patala</i>	Grand Duchess
9.	Amathusiidae	-	<i>Discophora</i>	<i>sondaica</i>	Common
10.	Satyridae	Satyrinae	<i>Melanitis</i>	<i>leda</i>	Evening Browns
	" "	Satyrinae	<i>Elymnias</i>	<i>malelas</i>	Palmflies
	" "	Satyrinae	<i>Lathe</i>	<i>europa</i>	Bamboo Treebrown
	" "	Satyrinae	<i>Lethe</i>	<i>rohria</i>	Common Trebrown
	" "	Satyrinae	<i>Orinoma</i>	<i>damaris</i>	Tiger brown
	" "	Satyrinae	<i>Mycalesis</i>	<i>suavolens</i>	Bush browns
	" "	Satyrinae	<i>Mycalesis</i>	<i>perseus</i>	Common Bushbrown
	" "	Satyrinae	<i>Mycalesis</i>	<i>mineus</i>	Dark-brand Bush-brown
	" "	Satyrinae	<i>Ypthima</i>	<i>sakra</i>	Rings
	" "	Satyrinae	<i>Ypthima</i>	<i>asterope maharatta</i>	Common Threering
	" "	Satyrinae	<i>Ypthima</i>	<i>huebneri</i>	Common Fourring
	" "	Satyrinae	Coenonympha	<i>amaryllis</i>	Mustang Heath
	" "	Satyrinae	<i>Aulocera</i>	<i>padma</i>	Satyrs
11.	Danaidae	Danainae	<i>Danaus</i>	<i>chrysipus</i>	Tawny Tigers
	" "	Danainae	<i>Danus</i>	<i>genutia</i>	Striped Tiger
	" "	Danainae	<i>Parantica</i>	<i>sita</i>	Glassy Tigers
	" "	Danainae	<i>Parantica</i>	<i>aglea</i>	Glassy Tiger
	" "	Danainae	<i>Tirmala</i>	<i>septentrionis</i>	Blue Tigers
	" "	Danainae	<i>Tirumala</i>	<i>limniace</i>	Blue Tiger
	" "	Euploeinae	<i>Euploea</i>	<i>mulciber</i> female	Crows
	" "	Danainae	<i>Euploea</i>	Core	Common Crow

Table 2: Distribution of genera and species of Butterflies in respective families.

S. No.	Family	No. of genera	No. of species
1.	Papilionidae	6	13
2.	Pieridae	15	15
3.	Lycaenidae	34	34
4.	Libytheidae	1	1
5.	Nemebiidae	1	1
6.	Hesperiidae	17	18
7.	Acraidae	2	2
8.	Nymphalidae	27	32
9.	Amathusiidae	1	1
10.	Satyridae	8	13
11.	Danaidae	5	8
Total		117	138

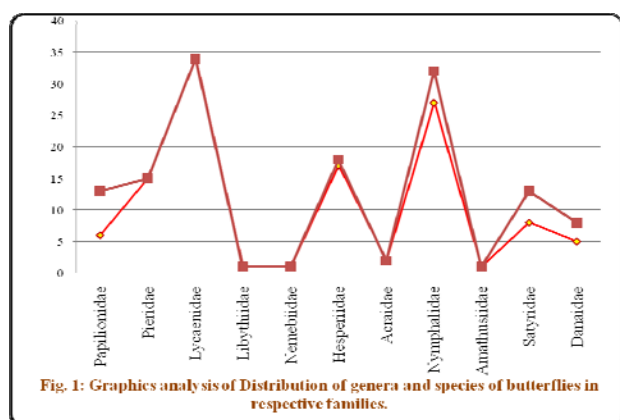


Fig. 1: Graphics analysis of Distribution of genera and species of butterflies in respective families.

In the present study, total 138 species of butterflies were recorded belonging to 117 genera and 11 families. Family-Lycaenidae was the largest family comprised of maximum number of genera (34) and species (34).

Tiple and Khurad (2009) [15] were recorded total 145 species of butterflies in and around Nagpur City at the eight study sites (Seminary Hills, Satpuda Botanical Garden, Agricultural Land and Bull Rearing Center, R.T.M. Nagpur University and L.I.T. Campus, Ambazari Garden and Bare Land at Lake Side, Sides of National Highway, Maharaj Bag and Futala Farm Area). The highest number of butterflies was recorded belonging to the Nymphalidae (51 species) followed by Lycaenidae (46 species), Hesperidae (22 species), Pieridae (17 species) and Papilionidae (9 species). The study revealed that Nymphalidae was most dominating family with a highest number of species and most butterfly species were observed from the monsoon to early winter but thereafter declined in early summer (Kunte, 1997) [10].

4. Conclusion

The present research have concludes by systematically studied butterfly biodiversity and prepared a checklists and catalogs in the study area. Family-Nymphalidae carries the maximum number of species than other families. Species representing families Lycaenidae, Nymphalidae and Satyridae are more commonly available the families Hesperidae, Pieridae and Papilionidae are less common.

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6. References

1. Hossan SA. Butterflies of Islamabad and Muree Hills. 1-68, Asian study group, Islamabad, Pakistan, 1994.
2. Rafi MA, Khan MR, Irshad M. Papilionid (Swallowtails) Butterflies of Pakistan, 2000; 1-33.
3. Javid I. Preliminary report of butterflies of district Rawalpindi and Islamabad. *Biologia* 1978; 24(2):238-247.
4. Venkata Ramana SP. Biodiversity and Conservation of Butterflies in the Eastern Ghats. *The Ecoscan* 2010; 4(1):59-67.
5. Heppner J. Classification of Lepidoptera- Part I Introduction. *Holarctic Lepid*, 1998; 5:148.
6. Gaonkar H. Butterflies of Western Ghats with notes on those of Sri Lanka. A Report to the Center of Ecological Sciences. Indian Institute of Science, Bangalore, Zoological Museum, Copenhagen and Natural History Museum, London, UK, 1996.
7. Smetacek P. Record of *Plebejuse versmanni* (Stgr.) from India. *Journal of the Bombay Natural History Society*. 1992; 89:385-386
8. D'Abreau EA. The Central Provinces Butterfly List. Records of the Nagpur Museum Number VII. Government Printing Press, Nagpur. India, 1931.
9. Tiple AD. Butterflies of Vidarbha region, Maharashtra State, central India. *Journal of Threatened Taxa*. 2011; 3(1):1469-1477.
10. Kunte KJ. Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. *Journal of Biosciences*. 1997; 22(5):593-603.
11. Talbot G. The fauna of British India including Ceylon and Burma, Butterflies-2nd Edition Vol. Taylor & Francis Ltd. London, 1939, 600.
12. Wynter-Blyth MA. Butterflies of the Indian Region, Bombay Nat. Hist. Soc. Bombay, 1957; XX:523.
13. Sabir AM, Bhatti Suhail A. Distribution of Nymphalid Butterflies (Brush footed) in districts Rawalpindi & Islamabad, Pakistan. *Journal of Biological Science*. 2000; 3(P):1213-1254.
14. Pollard E, Yates TJ. *Monitoring Butterflies for Ecology and Conservation*. Chapman & Hall, London, UK, 1993.
15. Tiple AD, Khurad AM. Butterfly Species Diversity, Habitats and Seasonal Distribution in and Around Nagpur City, Central India, *World Journal of Zoology*. 2009; 4(3):153-162.
16. Caldas A, Robbins R. Modified Pollard transects for assessing tropical butterfly abundance and diversity. *Biological Conservation* 2003; 110:211-219.