

A Report on Butterfly Diversity of Reclaimed OBDs of Kathara Coalmine Area, Jharkhand



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Abstract : Butterflies are one of the largest groups of insects and are most noticeable due to their conspicuous nature in a landscape. A study was carried out of four different aged reclaimed over burden dumps (ROBDs) of Kathara coalmine area of Jharkhand from 2007 to early 2009 and the present paper is a report on the diversity of the recorded butterflies. About 327 specimens of butterflies were collected from 10 randomized quadrates of 10 m × 10 m along transect. Out of total observed butterflies twenty seven species belonged to four families: Pieridae, Lycaenidae Nymphalidae and Papilionidae of the super family Papilionoidea. The family Pieridae dominated the ROBDs with their highest occurrence (44 per cent). It was observed that the newly ROBDs are having higher diversity index than the older ROBDs.

Keywords : Butterfly, Reclaimed over burden dumps (ROBDs), Diversity index, Habitat fragmentation

Introduction

Butterflies are economically important winged hexapods (Mani, 1973; Campbell and O'Toole, 1987; Zahradnik and Chvala, 1989). They are beautiful, attractive and have lured zoologists, especially entomologists throughout the world since time immemorial. Hence, there are good number of scientific, literary and jungle stories available (Marshall and De Niceville, 1882; Watson, 1984; Hall, 2005; Tej Kumar, 2009; Mathew and Kumar, http://wiienvic.nic.in/ran_forest/chapter6.htm). The caterpillars of many butterflies are phytophagous and cause damage to agricultural as well as horticultural products. Hence, are economically dear too. There are number of scientific work on ecology and functions of butterfly (Mathew, 1990; Luis-Martinez *et al.*, 2003; Tangah *et al.*, 2004; Hall, 2005; Winarni, 2007; Chandra *et al.*, 2007; Hamback *et al.* 2007; Pozo, *et al.*, 2008; Verma, 2009) and have been referred as 'flagships' and 'honorary birds'. They are valuable pollinators, important food chain components of the birds, reptiles, spiders and predatory insects; and indicators of environmental quality as they are sensitive to the changes in the environment (Hamback *et al.*, 2007). They are good candidate materials for the study of genetics, insect-plant interactions and co-evolution. Therefore, their diversity becomes an index for status of a habitat and landscape.

There are good number of literature on butterflies of India (Moore, 1881; Marshall and de Niceville, 1883; de Niceville, 1886; 1890; Moore and Swinhoe, 1890-1913; Bingham, 1905; Bell, 1909-1927; Ormiston, 1924; Evans, 1932; Yates, 1935, 1946; Wynter-Blyth, 1957; Laithwaite *et al.*, 1975; Smart, 1975; Larsen,

1987a; Kunte, 1997; Anu, 2006; Anu *et al.*, 2009; Shanti *et al.*, 2009; Tiple and Kuhrad, 2009; Verma, 2009; Rajgopal *et al.*, 2011; Ramesh *et al.*, 2010; Singh, 2010 and Hussain *et al.*, 2010). Most of the studies have been carried out in the southern part of the country and there are a few studies of Jharkhand and Bihar (Verma, 2009; Singh, 2010).

There are between 15,000 and 20,000 species of butterflies worldwide and about 1501 species have been reported from India (Gaonkar, 1996). There are a few serious workers (Verma, 2009 and Singh, 2010) who have reported butterflies diversity from Jharkhand and works on the reclaimed OBDs are equivocal. There are several scientific papers on habitat fragmentation and its impact on the species diversity. Previous studies have shown that the response of species richness to habitat change is not instantaneous, but usually occurs after a time delay (Diamond, 1972, Tilman *et al.*, 1994). Such delays vary from years to centuries depending on the taxon and the severity of fragmentation (Brooks and Balmford 1996, Brooks *et al.*, 1999, Ferraz *et al.*, 2003). But there has been lack of information on ROBDs. The present paper is an effort to report the diversity of the butterflies of ROBDs, and the impact of habitat fragmentation on the diversity of butterflies and its consequences on the ecological process.

Materials and Methods

Present study was carried out in the Kathara Coalfield area (Bokaro district) in the State of Jharkhand (Map 1). It is situated at 23° 47' N latitude and 85° 57' E longitudes, above 210 meter above sea level. The experimental area experiences average annual rainfall between 157 cm - 195 cm and the temperature oscillates between 2°C in winter to 45°C in summer. The average



Map 1 : Location map of Kathara coalmine area (study area), Jharkhand, India

pH of the soil ranges from 4.8 to 7. Four sites were selected with different age of plantation as+ a reclamation process. Site I was having five years old plantation, site II had 15 years old plantation, site III had 30 years old plantation and the site IV had more than fifty years plus (approximately) of plantation.

The methods for collection of data was observation, sighting, photography, ground net sweeping and aerial net sweeping of the butterflies from all the four sites. Butterflies were sampled by recording them from randomized quadrates of 10 m X 10 m on the either side of the laid transect (Manakadan and Rahmani, 1977; Anon 2000).

In the present paper authors have followed Mani (1973); different relevant websites, appended after the reference, and Zahradnik and Chvala (1989) for the purpose of field identification and classification.

Results and Discussion

A list of collected and observed butterflies of the ROBDs has been presented in the Table 1. There were 327 butterflies collected during the study period and were identified and classified to four different families. It was noticed that the percentage of the four butterfly families observed /sighted varied greatly: Pieridae family was represented by 44 per cent, Nymphalidae family was represented by 34 per cent, Lycaenidae was represented by 15 per cent, and Papilionidae had 7 per cent representation only (Fig. 1). The Shannon-Weaver (1949) diversity index for these families was calculated and has been presented in table 2. It was observed that the family Lycaenidae had highest diversity index (1.9596) and the family Papilionidae had lowest (1.3261). There is no obvious reason why there are differences in diversity index of these four families. Further, it can be noticed from the table that there is formation of two groups among these four observed

Table: 1. A list of specimen of butterflies collected/observed from all the four mine spoils.

SN	Family	Sp. Name	C Name	Collection Method	Wing Colour
1	Pieridae	<i>Catopsilia Sp.</i>	Mottled Emigrant	Sighting/ Observation, Sweeping, Hand picking, and Photography	Light Green
2	Pieridae	<i>Catopsilia Sp.</i>	Common Emigrant	Sighting/ Observation, Sweeping, Hand picking, and Photography	Light Yellow
3	Pieridae	<i>Catopsilia Sp.</i>	Common Emigrant	Sighting/Observation and Photography	Off white
4	Pieridae	<i>Catopsilia Sp.</i>	Common Grass Yellow	Sighting/Observation and Photography	Yellow
5	Pieridae	?	Common Orange Butterfly	Sighting/Observation	Orange
6	Pieridae	?	Common Blue Butterfly	Sighting/Observation	Blue
7	Lycaenidae	<i>Freyeria sps</i>	Grass Jewel	Sighting/ Observation, Sweeping, Hand picking, and Photography	light Brown
8	Lycaenidae	<i>Rapala Sp.</i>	Indigo Flash	Sighting/Observation and Photography	Steel Grey
9	Lycaenidae	<i>Castalius rosimon</i>	Common Pierrot	Sighting/Observation and Photography	White background with black spots
10	Lycaenidae	?	?	Sighting/Observation and Photography	Yellowish at thorax, white wings with grey at the end
11	Lycaenidae	<i>Catochrysops Sp.</i>	Silver Forget-me-not I	Sighting/Observation and Photography	Whitish Brown
12	Lycaenidae	<i>Catochrysops Sp.</i>	Silver Forget-me-not II	Sighting/Observation and Photography	
13	Lycaenidae	<i>Actytolepis Sp.</i>	Common Hedge Blue I	Sighting/Observation and Photography	Light Brown with black spots
14	Lycaenidae	<i>Actytolepis Sp.</i>	Common Hedge Blue II	Sighting/Observation and Photography	Bluish white
15	Lycaenidae	<i>Tajuria Sp.</i>	Peacock Royal	Sighting/Observation and Photography	Ashy Brown
16	Lycaenidae	<i>Curetis Sp.</i>	Indian Sunbean	Sighting/Observation and Photography	Ashy White
17	Nymphalidae	<i>Precis almana</i>	Peacock Pansy	Sighting/Observation and Photography	Orange-Yellow
18	Nymphalidae	<i>Precis orithya</i>	Blue Pansy	Sighting/Observation and Photography	Black, followed by Peacock blue and grey on the margin

19	Nymphalidae	<i>Pantoporia Sp.</i>	Common Lascer	Sighting/Observation and Photography	Yellow with black tiger motif
20	Nymphalidae	<i>Euploea core</i>	Common Indian Crow	Sighting/Observation and Photography	Chocolate Brown white spots along the outer margin
21	Nymphalidae	<i>Tirumala sps</i>	Blue Tiger	Sighting/Observation and Photography	Black to Brown with bluish-white semi hyaline spots and streaks
22	Nymphalidae	<i>Danaus Sp</i>	Monarch Butterfly	Sighting/Observation and Photography	Orange wing with dark brown and white markings
23	Nymphalidae	<i>Limenitis Sp</i>	Viceroy Butterfly	Sighting/Observation and Photography	
24	Papilionidae	<i>Papillio Sp.</i>	Lime Butterfly	Observation	Black with white patches
25	Papilionidae	<i>Papillio Sp.</i>	Common Mormon I	Sighting/Observation	Dark Chocolate Brown
26	Papilionidae	<i>Papillio Sp.</i>	Common Mormon II	Sighting/Observation	Black with small whitish patches on the edge of the wing
27	Papilionidae	<i>Graphium Sp.</i>	Common Jay	Sighting/Observation	Black with Whitish patches

Fig. 1. Percentage occurrence of four butterfly families observed/sighted in mine spoils of Kathara coalfield area

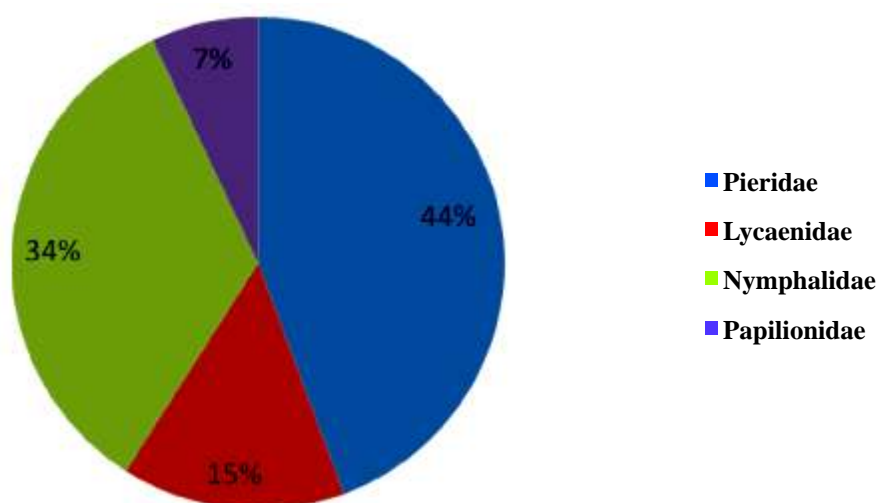


Table 2 : Shannon diversity index of the four families in four sites

SN	Family	Total Observation	Diversity Index
1	Pieridae	145	1.6781
2	Lycaenidae	48	1.9596
3	Nymphalidae	102	1.3291
4	Papilionidae	23	1.3261

families of the butterfly. Pieridae and Nymphalidae are the dominant group, where as the Lycaenidae and Papilionidae forms the other group.

According to Benedic *et al.* (2007) populations within habitat fragments are expected to have lower genetic diversity than those in continuous habitats, due to restricted gene flow, genetic drift and increased inbreeding (Frankham *et al.*, 2002). Further, Hanski's (1999) metapopulation model designed for butterflies': extinction rate depends on patch area and colonisation rate depends on size of and distance to neighbouring patches. In the present study, we observed fewer families of butterflies. The study area is in patches and is distant from the neighboring forest. Hence, the butterflies show a different pattern of distribution and there is lower variety at the family level. In the opinion of the authors it may be due to the habitat fragmentation and anthropogenic activities going in the experimental area.

Family Pieridae :

Out of the total collection of 327 specimens from all the four experimental sites 145 individuals were classified to family Pieridae. Shannon-Weaver diversity index for this family (community) was 1.6781 (Table 2). Butterflies from this family are predominantly white or yellow in colour along with black markings. Their flight was rapid and they move erratically from plant to plant (Benedick *et al.*, 2007)

Mottled Emigrant: Collected from all the four sites in different months. Wing span varied from 50-65 mm. The mottled emigrants are greenish white butterfly with a black apical border on the upper side of the wings (Mani, 1973; Zahrdnik and Chvala 1989)

Common Emigrant I & II: Collected from all four sites in different months. Colour of the butterfly is pale yellow. Wing span varied from 50-65 mm.

Common grass yellow: Collected from all the four sites (site I, II, III and IV). These are very common butterflies and are found in all seasons. Wing colour is yellow and wing span is of 35-45 mm.

Common grass orange: Collected from Site I, II and IV. Wing span is 30-40 mm.

Common grass blue: Collected from site IV only. Wing span varied from 30-35 mm.

Family Lycaenidae :

Butterflies of this family are small, mostly under 5 cm. Their flight is rapid and erratic and very close to the ground. Subfamilies include the Blues, Coppers, Hairstreaks and Harverstes. We were able to collect only forty eight individuals for this family. They were identified and classified into seven species and we were not able to identify one species up to the genus level. Shannon-Weaver diversity index for the family was recorded to 1.9596.

Grass Jewel: Collected from site IV only. Wing span varied from 40-50 mm.

Indigo Flash: Collected from site I. Wing span of 30-35 mm.

Common Pierrot : Collected from site IV in the month of September 2008. The Common Pierrot is a small pied butterfly, flies close to the ground and settles down often. Body colour is white with black patch. It has a distinct unmarked gap in the centre of its hind wing. Wing span is about 35 mm.

Lycaenidae, Genus: Collected from site I. Colour of wing is pale gray to pale white. Wing span is of 60-70 mm.

Forget-me-not I: Collected from site III. **Forget-me-not II:** Collected from site III and IV. **Common Hedge Blue:** Collected from site II. **Common Hedge Blue:** Collected from site III. **Peacock Royal:** Collected from site I, II and III. **Indian Sunbean:** Collected from site II.

Family Nymphalidae :

The Brush-footed family is the largest butterfly family in the world, consisting of several thousand species. The butterflies are medium to large sized and can be extremely diverse in nature. In India there are about 480 species from this family. This family includes

the subfamily Danainae, the milkweed butterflies. Total number of collection/observation was 102 recorded for this family, in which seven species were identified and it had the Shannon diversity index of 1.3291.

Peacock Pansy: Collected from site II in the month of Jan. 2009. Butterflies are orange to yellow in colour. Wing span varied from 70-75 mm. It has a very plain underside and looks like a dry leaf when its wings are closed. This butterfly gets its name from the prominent eye spots on its wings. These 'eyes' can be suddenly displayed by opening its wings to startle predators.

Blue Pansy: Collected from site IV in the month of Aug 2008. One of the prettiest butterflies, it has a very plain underside and looks like a dry leaf when its wings are closed. Blue Pansy (*Precis species*), is a sexually dimorphic butterfly. They have unique color combination of blue, black and brown. Wing span varied from 40-60 mm.

Upper side of the male fore wings basal with two thirds black and apex has pale brown with white transverse bands. Hind wing predominantly bright blue (hence the common name). Both wings are with 2 orange-ringed ocelli on each. Female is larger, pale almost light brown. Blue marking in the hind wing is slight and orange-ringed spots bigger than in male. Underside is grayish brown with white markings and there are wavy lines. Ocelli are visible in forewing only. Wing span was about 40-60mm.

Common Lascer : Collected from site II in the month of July 2009. Upper side of the wing was yellow to orange with black bands. Wing span varied from 24-32 mm.

Common Indian Crow : Collected from site II in month of Aug. 2008. The Common Crow (*Euploea core*) is a glossy black butterfly or glossy chocolate brown butterfly with white marks along the outer margins of the wing. The body also has prominent white spots along its wing margins. Wing span varied from 8-9 cm.

Blue Tiger : Collected from site I, II and III in the month of September 2009. Most are large brightly coloured butterflies usually brownish with black and white markings and white spotted body segments. Upper side was black, with bluish-white semi hyaline spots and streaks. Wing spans about 75 mm.

Monarch Butterfly : Very common butterfly in the study sites, collected from all the four sites. There are white spots on outer margin and orange patches near the top of the forewings. The hind wings are round, and are lighter in color than the forewing. The body is black with white spots. Wing span is about 70-75 mm.

Viceroy Butterfly : Collected from all the four sites. Its wings feature an orange and black pattern, and over most of its range it is Monarch butterfly. Wingspan is between 53 and 81 mm.

Family Papilionidae :

Swallowtail butterfly family consists of about 550 species of which 84 are found in India. Most swallowtails are medium to large, brilliantly coloured and extremely beautiful. Butterflies from this family are commonly found in both tropical and temperate habitats. They are called swallowtails because some of species have tailed hind wings. However, not all family members have tails. Total number of observation was twenty three; they were identified in two species. Shannon-Weaver diversity index of this family was 1.3261. Five different species were collected of this family. **Lime Butterfly:** Collected from site III. **Common Mormon I:** Collected from site II. **Common Mormon II:** Collected from site III. **Common Jay:** Collected from site I and III.

Conclusions :

The variation in the Shannon-Weaver diversity indices (Table 2) of the butterfly and percentage occurrence (Fig 1), the authors opine, are due to mining – landscape of the area. The change in the land use pattern has consequent impact on habitat and finally the number and density of the butterflies. The fragmentation of habitat has affected the life-cycle of butterflies. Further, it appears that the habitat fragmentation has impact on the distribution pattern as the newer ROBDs have higher DI than the older one. The natural food chain is broken. This can be obvious from the results that the sites, which are having newer plantations (Site I and II) had more Shannon diversity index (1949), implying that the species are more rare, rudrals rather than the sites having more than 30 years of plantation (Site III and IV) had lower species diversity, implicitly presence of K-select species, established to their habitats (Magurran, 1988; Krebs, 1999 and Bitzner *et al.*, 2005).

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References

Anon. (2000): Determination of Carrying Capacity of

Wildlife habitat with or without Mining Operations and Rehabilitation Plan for Flora and Fauna in the Event of Mining. Funded by Ministry of Coal, Govt. of India. Principal Implementing Agency, Singareni Collieries Company Limited, Kothagudem. A publication of Environmental Impact Assessment Cell, Bombay Natural History Society.

- Anu A. (2006): Entomofaunal Dynamics and Biochemistry of Litter Decomposition in a Natural Forest with Special Reference to the Systematics of Dung Beetles (Coleoptera: Scarabaeinae). PhD Dissertation. University of Calicut, Kerala, India.
- Anu A., Sabu T.K. and Vineesh P.J. (2009): Seasonality of litter insects and relationship with rainfall in a wet evergreen forest in south Western Ghats. *Journal of Insect Science* **9**: 46. available online: insectscience.org/9.46
- Bell T.R. (1909-1927): The common butterflies of the plains of India. *J. Bombay Nat. Hist. Soc.* **19-31**, 1000 pp.
- Benedick S., White T. A., Searle J. B., Hamer, Keith C., Mustaffa N., Khen, C. V., Mohamed M., Schilthuizen M and Hill J. K. (2007): Impacts of habitat fragmentation on genetic diversity in a tropical forest butterfly on Borneo. *Journal of Tropical Ecology* **23**:623–634.
- Bingham C.T. (1905): Butterflies. Fauna of British India (London). **2**, 1-480.
- Bitzer R.J., Rice M.E., Pilcher C.D., Pilcher C.L. and Lam W.F. (2005): Biodiversity and Community Structure of Epedaphic and Euedaphic Springtails (Collembola) in Transgenic Rootworm Bt Corn. *Environ. Entomol.* **34**(5), 1346-1376.
- Brooks T. M. and Balmford A. (1996): Atlantic forest extinctions. *Nature*. 380:115.
- Brooks T. M., Pimm S. L. and Oyugi J. O. (1999): Time lag between deforestation and bird extinction in tropical forest fragments. *Conservation Biology*. **13**:1140–1150.
- Campbell A. and O’toole C. (1987): Animals of the World Insects and other Invertebrates. The Leisure Circle.
- Chandra K., Sharma R.M. and Singh R. K. (2007): A checklist of Madhya Pradesh and Chhattisgarh States, India. *Zoos Print Journal*. **22**(8), 2790-2798.
- de Niceville L. (1886): Butterflies of India, Burmah and Ceylon. (Repr. 1979), New Delhi. **2**, 1-332.
- de Niceville L. (1890): The butterflies of India, Burmah and Ceylon. (Repr. 1979), New Delhi. **2**, 1-503.
- Diamond J.M. (1972): Biogeographic kinetics: estimation of relaxation times for avifaunas of southwest Pacific islands. *Proceedings of the National Academy of Sciences USA*, **69**:3199–3202.
- Evans, W. H. (1932): *The identification of Indian butterflies*. (Revised 2nd ed), Bombay Natural History Society. 464 pp.
- Ferraz G., Russell G. J., Stouffer P. C., Bierregaard R. O., Pimm S. L. and Lovejoy T. E. (2003): Rates of species loss from Amazonian forest fragments. *Proceedings of the National Academy of Sciences USA*, **100**,14069–14073.
- Frankham R., Ballou J. D. and Briscoe D. A. (2002): Introduction to conservation genetics. (Cambridge University Press, Cambridge). 617 pp.
- Gaonkar H. (1996): Butterflies of the Western Ghats, India, including Sri Lanka: A biodiversity assessment of a threatened mountain system. 51 pp.
- Hall J P W. (2005): Montane speciation patterns in Ithomiola butterflies (Lepidoptera: Riodinidae): are they consistently moving up in the world? *Proc Biol Sci.* **272** (1580), 2457-2466.
- Hamback P A, Summerville K S, Steffan-Dewenter I. Krauss J, Englund G. and Crist T. O. (2007): Habitat specialization, body size, and family identity explain lepidopteran density-area relationships in a cross-continental comparison. *PNAS*. **104** (20), 8368-8373.
- Hanski I. (1999): *Metapopulation ecology*. Oxford University Press
- Hussain K., Jahir Ramesh T., Satpathy K.K. and Selvanayagam M. (2011): Seasonal dynamics of butterfly population in DAE Campus, Kalpakkam, Tamil Nadu, India. *JoTT Communication*. **3**(1), 1401-1414.
- Krebs C.J. (1999): *Ecological methodology*, (Benjamin/Cummings, Menlo Park, CA, 2nd Edition).
- Kunte, K. (1997): Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in the northern Western Ghats. *Journal of Bioscience*. **22**, 593-603.
- Laithwaite E., Watson, A. and Whally, S.P (1975): The dictionary of butterflies and moths in colour. (Michael Joseph, London).
- Larson T.B. (1987a): Butterflies of India. (Oxford University Press, New Delhi).
- Luis-Martinez A., Llorente-Bousquets J., Vargas-Fernandez I. and Warren A. D. (2003): Biodiversity and Biogeography of Mexican Butterflies (Lepidoptera: Papilionoidea and Hesperioidea). *Proc. Entomol. Soc. Wash.* **105**(1), 209-224.
- Magurran A.E. (1988): Ecological diversity and its measurement. (Princeton University Press, Princeton, NJ).
- Manakadan R. and Rahmani A.R. (1997): Rollapadu Wildlife Sanctuary. 124-129 :In Rahmani, A.R. A

- study on the ecology of grasslands of the Indian plains with particular reference to their endangered fauna. Final Report. Pp. 549, Bombay Natural History Society, Mumbai.
- Mani M. S. (1973): *General Entomology*. (Oxford & IBH Publishing Co. New Delhi 2nd Edition).
- Marshall G.F.L. and de Niceville L. (1883): *Butterflies of India, Burmah and Ceylon.*, New Delhi, Repr.1979), **1**, 1- 327.
- Marshall Major G.F.L., De Niceville L. (1882): *The Butterflies of India Burmah and Ceylon* (Calcutta Central Press Co Ltd) **1**.
- Mathew G. (1990): Studies on the Lepidopteran fauna. In: Ecological studies and long term monitoring of biological processes in the Silent Valley National Park. Report submitted to the Ministry of Environment, govt. of India, Kerala Forest Research Institute, 239 pp.
- Mathew, G. and Kumar, M. M. (2001): State of art knowledge on the butterflies of Nilgiri Biosphere Reserve, India. In Gupta, A.K., Kumar, A. & Ramakantha, V. (Eds) ENVIS, proceedings of a three day workshop on Research priorities in Tropical Rain forest in India held at Coimbatore. Feb 2001. (http://wiienvis.nic.in/rain_forest/chapter6.html).
- Moore F and Swinhoe C. (1890-1913): *Lepidoptera Indica*. **1**, 1-10.
- Moore F. (1881): *Lepidoptera of Ceylon*. Vol. I, 190 pp, London.
- Ormiston W. (1924): *The Butterflies of Ceylon*. Colombo.
- Pozo C. Luis-Martinez A., LLorente-Bousquets J., Salas-Suarez N., Maya-Martinez A., Vargas-Fernandez I. and Warren A. D. (2008): Seasonality and Phenology of the Butterflies (Lepidoptera: Papilionoidea and Hesperioidea) of Mexico's Calakmul Region. *Florida Entomologist*. **91** (3), 407-422.
- Rajagopal T., Sekar M., Manimozhi, A., Baskar N. and Archunan G. (2011): Diversity and community structure of butterfly of Arignar Anna Zoological Park, Chennai, Tamil Nadu. *J. Environ. Biol.* **32**, 201-207.
- Ramesh T., Hussain K., Jahir Selvanayagam M., Satpathy K. K. and Prasad M. V. R. (2010): Patterns of diversity, abundance and habitat associations of butterfly communities in heterogeneous landscapes of the department of atomic energy (DAE) campus at Kalpakkam, South India. *International Journal of Biodiversity and Conservation*. **2**(4), 75-85
- Shannon C.E and Weaver W. (1949): *The Mathematical Theory of Communication*. (University Press, Urbana, Illinois).
- Shanthi R., Hussain K.J and Sanjayan K.P. (2009): Influence of weather on the incidence of sucking pest complex on summer-irrigated cotton crops of Tamil Nadu. *Hexapoda* **16**(1), 89-92.
- Singh A.P. (2010): Butterfly diversity in tropical moist deciduous sal forests of Ankua Reserve Forest, Koina Range, Saranda Division, West Singhbhum District, Jharkhand, India. *JoTT Communication*. **2** (9), 1130-1139.
- Smart P.F. (1975): *The illustrated encyclopedia of the butterfly world*. (Salamander Book, London).
- Tangah J., Hill, J. K., Hamer K. C., and Dawood M. M. (2004): Vertical distribution of fruit-feeding butterflies in Sabah, Borneo. *Sepilok Bulletin* **1**, 17-27.
- Tej Kumar S. (2009): The need for Butterfly conservation. <http://bcshyd.com/articles/expert-articles/41-butterfly-conservation/...> Accessed on 25/9/2009, 1:18pm
- Tilman D., May, R. M., Lehman C. L. and Nowak M. A. (1994): Habitat destruction and the extinction debt. *Nature*. **371**:65-66.
- Tiple A.D. and Khurad A.M. (2009): Butterfly Species Diversity, Habitats and Seasonal Distribution in and around Nagpur City, Central India. *World Journal of Zoology*. **4**(3), 153-162.
- 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.
- Watson A. (1984): *Butterflies and Moths through the year* (The nature detective Series). (Macdonald & Comp. Ltd, Maxwell House, London).
- Winarni N L. (2007): The important of detectability in butterfly monitoring: Butterfly diversity of Lambusango Forest, Buton, Southeast Sulawesi. Paper presented at National Insect Conference Bogor.
- Wynter-Blyth M.A. (1957): *Butterflies of the Indian Region*, BNHS, Bombay, 523 pp.
- Yates J.A. (1935). *Butterflies of the Nilgiri District*. *J. Bombay nat. Hist. Soc.* **38**, 330-40.
- Yates J.A. (1946): The butterflies of the Nilgiris – a supplementary note. *J. Bombay nat. Hist. Soc.* **46**, 197-198.
- Zahradnik J and Chvala M. (1989): *Insects: A comprehensive illustrated guide to insects of Britain and Europe*. (Ed.) Whally, P. (Published by the Hamlyn Publishing Group Ltd. London).