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Species diversity and habitat association of butterflies around 30 km radius of Kudankulam Nuclear Power Plant area of Tamil Nadu, India

P. Kumar and A. G. Murugesan*

Sri Paramakalyani Centre of Excellence in Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi- 627 412, Tamil, India.

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A detailed study on the butterfly species diversity was carried around 30 km radius of Kudankulam Nuclear Power Plant area, Tirunelveli, India during 2011-2013. The survey yielded 6347 individuals of 64 species, belonging to the families Nymphalidae, Pieridae, Lycaenidae, Papilionidae and Hesperiidae. A total of 64 species of butterflies belonging to 47 genera were recorded. The relative abundance was high for Nymphalidae (27 species) (41.93%) followed by Pieridae 15 (24.19%), Lycaenidae 11 (16.12%), Papilionidae 7 (11.29%) and Hesperiidae 4 (6.45%). The Nymphalidae were found to be the dominant family in terms species, general and individual relative abundance. Eight species of butterflies are listed as endangered in Wildlife (Protection) Act, 1972. Such studies on monitoring the species diversity and abundance of butterflies offer valuable information on their population dynamics. A detailed study on ecologically important local butterfly fauna in various habitats is in progress to construct a various habitat survey around 30 km radius of Kudankulam Nuclear Power Plant area.

Key words: Kudankulam, butterfly diversity, relative abundance, wildlife protection.

INTRODUCTION

Butterflies are taxonomically well studied group of insects, which have received a reasonable amount of attention throughout the world (Ghazoul, 2002; Robbins and Opler, 1997). The impact of human society on the global environment has triggered mass extinction of significant species and is causing widespread changes in the global distribution of existing species (Chapin et al., 2000; Thomas et al., 2004). Insects are the earth's most diverse organisms, accounting for half of described species of living things and three-quarters of all known animals and it is estimated that more species of insects than known at present remain to be discovered (Wijesekara and Wijesinghe, 2003) among insects, butterflies occupy a vital position in ecosystems and their occurrence and diversity are considered as good indicators of the health of terrestrial biota (Kunte, 2000b). Butterflies are one of the best insect studied groups and are highly sensitive to habitat disturbances; they are

*Corresponding author. E-mail: agmspkce@gmail.com.

commonly used as an indicator of environmental quality (Varshney, 1993; Kremen, 1994; Kocher and Williams, 2000; Koh and Sodhi, 2004). Since the 18th century, about 19,238 species of butterflies have been studied worldwide systematically (Heppner, 1998). In Indian sub-continent, 1504 species of butterflies are recorded (Tiple, 2011) and 285 species found in southern India (Thomas, 1966) of which peninsular India and Western Ghats have 351 and 334 species, respectively. Southern parts of the Indian Peninsular are rich and diverse in butterflies as compared to other parts of Peninsular due to diverse habitats, microclimatic conditions and altitudinal ranges (Chakravarthy et al., 1997). One fifth of the world's total butterflies are available in India (Haribal, 1992). Many researchers have significantly contributed to our understanding of butterfly and abundance in Tamilnadu (Asaithambi, 1994; Baskaran and Eswaran, 2003; Ambrose and Raj, 2005; Eswaran and Promod, 2005; Rajagopal et al., 2011). Human dominated landscape form a substantial and ever increasing amount of the earth's land surface. These modified habitats often negatively influence butterfly species and their dynamics (Gascon et al., 1999) made a detailed study of butterflies of atomic energy campus and recorded a total of 1908 individuals representing 55 species (Ramesh et al., 2010) and seasonal dynamic of butterfly survey yielded 2177 individuals of 56 species (Jahir Hussain et al., 2011). However, comprehensive long-term ecological study to monitor the butterfly diversity of the nuclear power plant area remains serious lacuna. Such studies are imperative to improve the ecological utility of butterflies as indicator taxa. There is a unique relationship between butterflies and plants (Feltwell, 1986). Jha et al (2000) reported that butterflies diversity indirectly reflects overall plant diversity, especially herbs and shrubs in the area. Butterfly species varies in different habitats (Kunte, 1997). Natural vegetation is important for the survival of species and relatively minor perturbation in the habitat that are highly sensitive to change the environment (David et al., 1986). Biotic and abiotic factors influence the butterfly population (Pollard, 1988).

Among the lower invertebrates, butterflies are probably the best studied group in the Western Ghats (Ambrose and Raj, 2005; Baskaran and Solaiappa 2002; Arun, 2003; Gunathilagaraj et al., 1998) in national park and wild life sanctuary (Borkar and Komarpant, 2004; Baslstha et al., 1999; Guptha et al., 2012; Shamsudeen and Mathew, 2010). Study on butterfly diversity was done in university campus and tiger reserves (Chandra et al., 2002, 2007; Arun and Azeez, 2003). Similar studies are done in parks and dams (Perveen and Ahmed, 2012; Kumar et al., 2014).

According to WPA, the taxa listed under schedule I have the highest legal protection, Schedule II and IV, second and third highest level of protection (Kunte, 2000b). Eight species of endemic butterflies were listed under the Wildlife (Protection) Act 1972 scheduled under I, II, I and II and IV (Rufus and Sabarinathan, 2007). Studies on butterflies would help to explore their biodiversity and to understand the status of ecosystem and human pressure on natural resource which requires a reliable account of biodiversity (Kremen, 1992). The most important objec-tive of such applied biology is preserving biological diversity for future generation. The aim is to ensure long term conservation of entire flora and fauna of a region (Kerr, 1997; Araujo et al, 2004). The importance of biological diversity is now increasing and is recognized as a vital parameter to assess the global local environmental changes and sustainability. It is impractical to monitor each and every species; some of the key indicator taxa play a vital role in biodiversity monitoring studies. Butterflies are an excellent choice for monitoring the habitat quality (Kunte et al., 1999). Several studies have analysed how radiative substances affect uptake of food chains and ecosystems (Beresford et al., 2012), but ecological impact assessment studies are limited (Moller and Mousseau, 2006). Therefore, the present study, which aimed to contribute to our understanding of the species diversity in different habitats and explore the knowledge of conservation efforts in existing environ-ment, is to be collect and characterized baseline surveys of butterfly fauna in relation to flora in 30 Km radius of Kudankulam Nuclear Power Plant area.

MATERIALS AND METHODS

Study area

Field survey of butterflies was conducted from June 2011 to June 2013, following modified Pollard walking methods (Pollard, 1975) in six distinct habitats: pond area, scrub jungle area, cultivated area, plain area or barren land, sandy area and monoculture or cashew nut plantation around 30 km radius of Kudankulam Nuclear Power Plant area which is approximately 1350 km^2, which lies between latitudes 8° 5′ and 8° 28′ of north and longitudes 77° 28′and 77° 57′ of east (Image 1).

Butterfly species density and relative abundance were assessed quantitatively across the different habitats based on the vegetation. The entire study area was divided on the basis of habitats. In this method, permanent approximately 900 m long and 5 m wide line transect was set up in each habitat and marked in the field along with GPS data and landmark for repeated observations.

The transect in each habitat was slowly traversed at a uniform pace for 40 min at each habitat from 7.30 to 16.30 h during the good weather period without heavy rain. Butterfly species were recorded around the radius of five meters from the observer covering his either side, above and front. This was repeated in each season, maintaining the same spatial scale in each of the five habitats.

Collected butterfly individuals were identified either in the field and/or after reaching the laboratory also following the standard field guides (Gunathilagaraj et al., 1998; Kunte, 2000a). All the scientific names followed Varshney (1983) and family classification (Ackery, 1984). The vouchers of collected specimens were photographed and maintained at Manonmaniam Sundaranar University, Sri Paramakalyani Centre of Excellence in Environmental Science, Alwarkurichi.

The main vegetation types of 30 km radius include dry evergreen, scrub jungle, plain area, sandy area and pond area. The

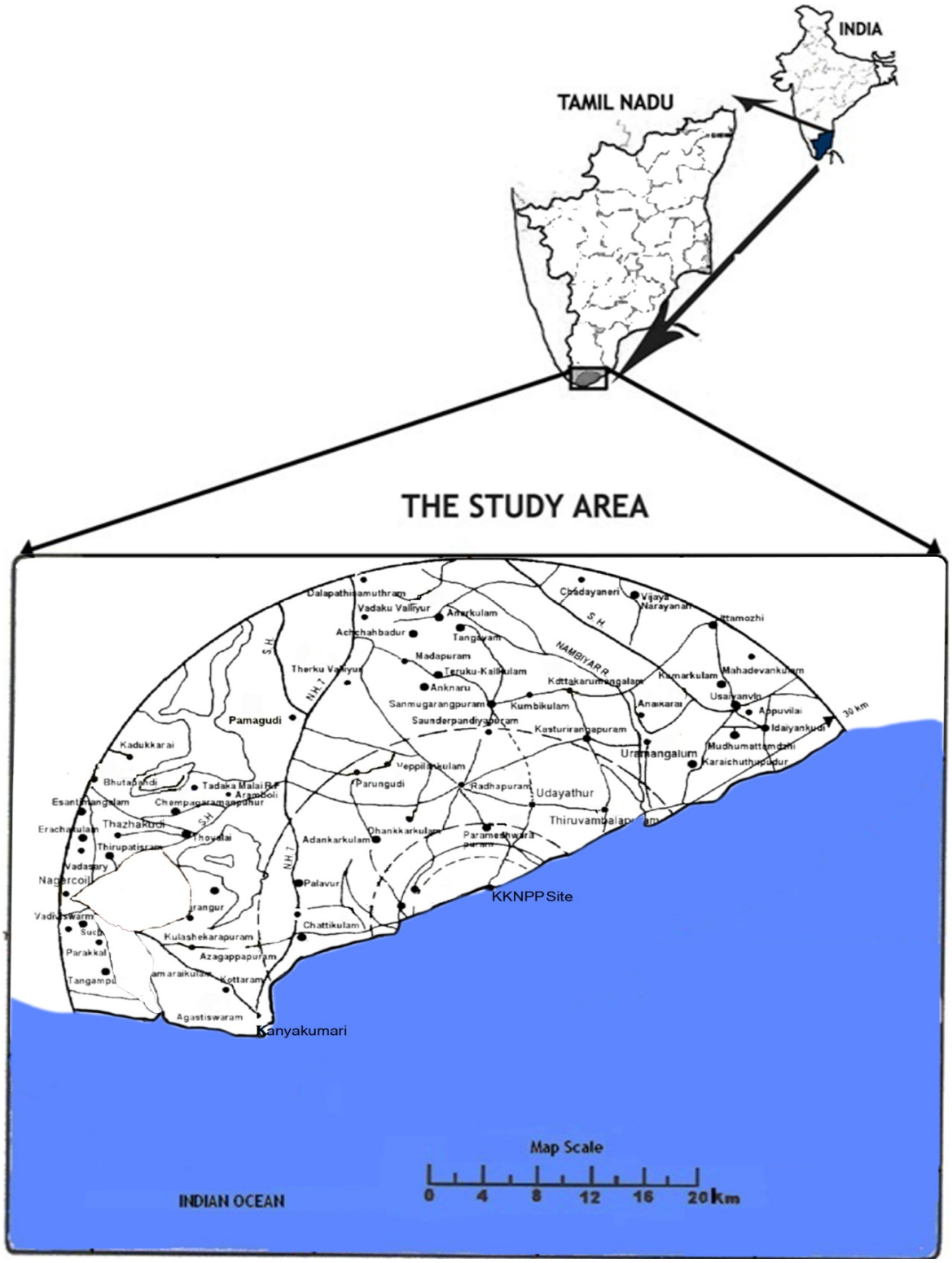

Image 1. Map of 30 km radius of Kudankulam Nuclear Power Project area.

dominant species of scrub jungle are *Acacia nilotica* (Fabaceae), *Prosobis juliflora* (Fabaceae), *Cassia auriculata* (Fabaceae) and *Lantana camera* (Verbenaceae). The plain area has mostly grasses and *Euphorbia antiquorum* (Euphorbiaceae). The sandy area has *Prosobis juliflora* and *Acacia nilotica*. The pond area has *Azima tetracantha* (Salvadoraceae). The trees, shrubs and herbs comprising members of predominant family belong to Anacardiaceae, Apocyanaceae, Laminaceae, Solanaceae, Rubiaceae, Euphorbiaceae, Cyperaceae, Fabaceae, Amaranthaceae and Convolvulaceae, Verbenaceae.

RESULTS AND DISCUSSION

The study revealed the occurrence of 64 species of butterflies around 30 Km radius of Kudankulam Nuclear Power Project area (Table 1). Occurrence of maximum number of species in the family Nymphalidae, Pieridae and Lycaenidae could be due to high availability of food plants in the study area.

Nymphalidae is the dominant family in terms of species composition and abundance, with 27 species and 41.93%, Pieridae (15 species, 24.19%), Lycaenidae (11 species, 16.12%), Papilionidae (7 species, 11.29%) and Hesperiidae (4 species, 6. 45%). In total, 6347 individuals from 14 transects in winter, summer, southwest monsoon and northeast monsoon were observed and identified. A large number of individuals was observed in Pieridae 2287 individuals followed by Lycaenidae 2089 individuals, Nymphalidae 1688 individuals, Papilionidae 207 individuals and very less individuals was observed in 76 individuals. Totally, 47 genera were observed in study area. Nymphalidae is the dominant genera (16 genera, 34.78%) followed by Pieridae (12 genera, 26.08%), Lycaenidae (10 genera, 21.74%), Papilionidae (4 genera, 8.70%) and Hesperiidae (4 genera, 8.70%) as presented in Table 2.

A similar pattern of predominance of Nymphalidae was also reported by different researchers. These results are similar to that found by Tiple (2012) and Murugesan et al. (2013) at the biosphere reserve of Seshachelam hills which were a total 50 species of butterflies in five families (Guptha et al., 2012). Ramesh et al. (2010) reported 55 species of butterflies inhabiting the Department of Atomic Energy, at Kalpakkam campus. The family Nymphalidae was the dominant one, followed by Lycaenidae, Pieridae, Papilionidae and Hesperiidae (Guptha et al., 2012). A total of 66 species of butterflies belonging to 47 genera and five families were recorded in Tropical Forest Research Institute, Madhya Pradesh (Tiple, 2012). Murugesan et al. (2013) observed total of 63 butterfly species belonging to 47 genera under the five families in Oussudu bird sanctuary, Puducherry. Shamsudeen and Mathew (2010) found 73 butterfly species in Shenduruny Wildlife Sanctuary. Chandra et al. (2007) observed 174 species, subspecies of 100 genera under 8 families in Madhya Pradesh and Chhattisgarh state. Wijesekara and Wijesinghe (2003) revealed 2158 species of lepidopterans, 234 species of butterflies in ten families recorded in Sri Lanka. Gunathilagaraj et al. (1998) observed that high percentage of Nymphalids may be due to the presence of flowers belonging to families Euphorbiaceae, Compositae, Rubiaceae and Verbinaceae. The great variety of butterflies, moths and skippers are recorded and supported by their food and host plants (Borkar and Komarpant, 2004). Availability of larval and adult food plants, habitat quality appeared to be one of the most important parameters to determine butterfly community (Barlow et al., 2007). Abundance of butterfly species is due to favourable tropical climate conditions, availability of host plants, food and vegetation (Ravindra et al., 1996); topographic features (Amala et al., 2011); predators, parasitoids and prevalence of disease (Mathew and Rahamathulla, 1993). Chandra et al. (2002) observed 38 species in 8 families in Pench Tiger Reserve, Madhya Pradesh. Around Nagpur, 145 species of butterflies, of which 62 species are new records seen. Nymphalidae showed the highest number of butterflies (Tiple and Khurad, 2009). Nymphalids butterfly feed on fourteen species of angiosperms whereas papilionids feed on eight species. Pieridae have six species of plants as feed, Lycaenidae feed on two species of plants but Hesperiidae prefer only one plant species (Raut and Pendharkar, 2010). The higher species richness of butterflies associated with gardens indicates availability and access to food plants. The exotic species, *L. camera* is an important nectar source for several species of butterflies in degraded and urbanized habitat (Raju and Reddy, 1995). Nymphalidae was the dominant species and the relative abundance recorded was 36.3% (Ramesh et al., 2010). The least number of butterfly species were recorded in the family Papilionidae (14%) and Hesperiidae (14%) with nine species each (Murugesan et al., 2013).

Eight species of butterflies are listed as endangered in Wildlife (Protection) Act, 1972. Among the eight, three species of butterflies are listed under the schedule I (Crimson rose, *Atrophaneura hector*; Southern Bird Wing, *Troides minos*; Common Pierrot, *Castalius rosimon*) and two species are in schedule II (Gram Blue, *Euchrysops cnejus*; Common Albatross *Appias albino* and Common Gull, *Cepora nerissa*) Schedule I, II and IV has only one species each are (Danaid Eggfly, *Hypolimnas misippus*) and Common Indian Crow, *Euploea core*. Totally, 64 species of butterflies were recorded and Nymphalidae are most dominant (36%) followed by Lycaenidae (27%), Pieridae (17%), Hesperiidae (11%) and Papilionidae (9%). Among the 64 species of butterflies, about 34% (22) were occurring very common, 27% of species (27) were common, 23% (15) were uncommon and 16% were rare (10) as shown in Figure 1. Guptha et al. (2012) reported that butterflies of Eastern Ghats of Seshachalam biosphere reserves were categorized as very common (VC) 40% (20 species), common (C) 36% (18 species), uncommon (UC) 10% (5 species), occasional (O) 8% (4 species) and rare (R) 6% (3 species). Five species of protected and seven rare species are distributed in Shendurny Wildlife Sanctuary, Kerala (Shamsudeen and Mathew, 2010). Among the 64 species 15 were found very common, 27 species common, 17 species not rare and five species were found rare. None of the species were observed in very rare category from the study area. Six species are under protection of the Indian Wildlife (Protection) Act 1972 (Nimbalkar et al., 2011).

Five endemic species were listed from encountered butterflies in the study area in different habitats. The

Table 1. List of butterflies present around 25 km radius of KKNPP Project area.

Family	Zoological name	Common name	Status
Nymphalidae	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger	VC
,,	*Danaus genutia* (Cramer,1779)	Striped Tiger	C
,,	*Ariadne merione* (Cramer,1777)	Common Caster	UC
,,	*Ariadne ariadne* (Linnaeus 1763)	Angled Castor	UC
,,	*Acraea terpsicore* (Linnaeus, 1758)	Tawny Caster	VC
,,	*Neptis hylas* (Linnaeus, 1758)	Common Sailor	R
,,	*Phalanta phalantha* (Drury,1773)	Common Leopard	UC
,,	*Hypolimnas bolina* (Linnaeus, 1758)	Great Egg Fly*&**	C
,,	*Hypolimnas misippus* (Linnaeus,1764)	Danaid Egg Fly	C
,,	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy	VC
,,	*Junonia iphita* (Cramer,1779)	Chocolate Pansy	C
,,	*Junonia hierta* (Fabricius, 1798)	Yellow Pansy	VC
,,	*Junonia almana* (Linnaeus, 1758)	Peacock pansy	UC
,,	*Junonia oithya* (Linnaeus,1758)	Blue Pansy	UC
,,	*Junonia atlites* (Linnaeus,1763)	Grey Pansy	R
,,	*Cirrochora thais* (Fabricius,1787)	Tamil Yeoman	R
,,	*Euploea core* (Cramer,1780)	Common Indian Crow	C
,,	*Tirumala septentrionis* (Butler, 1874)	Dark Blue Tiger	R
,,	*Tirumala limniace* (Cramer,1775)	Blue Tiger	VC
,,	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	UC
,,	*Mycalesis perseus* (Fabricius, 1775)	Common Bush Brown	UC
,,	*Mycalesis mineus* (Linnaeus, 1758)	Dark Brand Bush Brown	UC
,,	*Ypthima ceylonica* (Hewitson, 1865)	White Four Ring	R
,,	*Ypthima asterope* (Klug, 1832)	Common Three Ring	R
,,	*Euthala nais* (Forrstar,1771)	Baronet	UC
,,	*Argynnis hyperbius* (1763)	Indian Fritillary	R
,,	*Byblia ilithya* (Drury, 1773)	Joker	R
Pieridae	*Colotis danae* (Fabricius,1775)	Crimson Tip	C
,,	*Colotis etrida* (Boistuval, 1836)	Small Orange Tip	C
,,	*Ixias marianne* (Cramer, 1779)	White Orange Tip	VC
,,	*Ixias pyrene* (Linnaeus, 1764)	Yellow Orange Tip	R
,,	*Hebomoia glacippe* (Linnaeus, 1758)	Great Orange Tip	R
,,	*Belenosis aurota* (Fabricius,1793)	Pioneer	UC
,,	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow	VC
,,	*Catopsillia pomona* (Fabricius,1775)	Common Emigrant	VC
,,	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant	VC
,,	*Delias eucharis* (Drury,1773)	Common Jezebel**&***	UC
,,	*Cepora nerissa* (Fabricius, 1775)	Common Gull	C
,,	*Leptosia nina* (Fabricius,1793)	Psyche	UC
,,	*Colisa croceus* (Geoffroy, 1785)	Dark Clouded Yellow	UC
,,	*Colitis amata* (Fabricius, 1775)	Small Salmon Arab	VC
,,	*Appias albino* (Boisduval, 1836)	Common Albatross	UC
Lycaenidae	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot	C
,,	*Arhopala centaurus* (Fabricius,1775)	Large Obakblue	R
	Discolampa centaurus (Fabricius, 1775)	Banded Blue Pierrot	R
,,	*Spindasis vulcanus* (Fabricius, 1775)	Common Silver Line ***	UC
,,	*Euchrysops cnejus* (Fabricius,1798)	Gram Blue	VC
,,	*Jamides celeno* (Grammer, 1775)	Common Cerulin	VC
,,	*Freyeria trochylus* (Freyer, 1845)	Grass Jewel	VC

VC- Very Common; C- Common; UC- UnCommon and R- Rare *Endemic species found in Peninsular India; **Sri Lanka; ***Southern India and WG- Western Ghats.

Table 1. Contd.

Family	Zoological name	Common name	Status
,,	*Tarucus plinius* (Fabricius, 1793)	Zebra Blue	C
,,	*Zizina otis* (Fabricius, 1787)	Lesser Grass Blue	VC
,,	*Zizeeria knysna* (Trimen, 1862)	Tiny Grass Blue	VC
,,	*Chilades parrhasius* (Fabricius, 1793)	Indian Cupid	VC
Papilionidae	*Troides minos* (Cramer, 1779)	Southern Bird Wing***WG	R
,,	*Papilio polymnastor* (Cramer,1775)	Blue Mormon *&**	R
,,	*Papilio polytes* (Linnaeus, 1758)	Common Mormon	R
,,	*Papilio demoleus* (Linnaeus, 1758)	Lime Butterflies	UC
,,	*Graphium agamemnon* (Linnaeus 1758)	Tailed Jay	R
,,	*Atrophaneura aristolochiae* (Linnaeus, 1758)	Common Rose	C
,,	*Atrophaneura hector* (Linnaeus, 1758)	Crimson Rose ** &***	VC
Hesperiidae	*Borbo cinnara* (Wallace, 1866)	Rice Swift	UC
,,	*Sarangesa purendra* (Moore, 1882)	Spotted Small Flat	R
,,	*Spialia galba* (Fabricius, 1793)	Indian Skipper	UC
,,	*Suaatus gremius* (Fabricius, 1798)	Indian Palm Bob	R

Table 2. Species, general relative abundance (%) of butterflies in the study area.

S/N	Family	No. of Genera (%)	No. of Species (%)	No. of Individuals (%)
1	Nymphalidae	17 (34.78%)	27 (41.93%)	1688 (26.59%)
2	Pieridae	12 (26.08%)	15 (24.19%)	2287 (36.03%)
3	Lycaenidae	10 (21.74%)	11 (16.12%)	2089 (32.91%)
4	Papilionidae	4 (8.70%)	7 (11.29%)	207 (3.26%)
5	Hesperiidae	4 (8.70%)	4 (6.45%)	76 (1.19%)
Total	5	47 (100%)	64 (100%)	6347 (100 %)

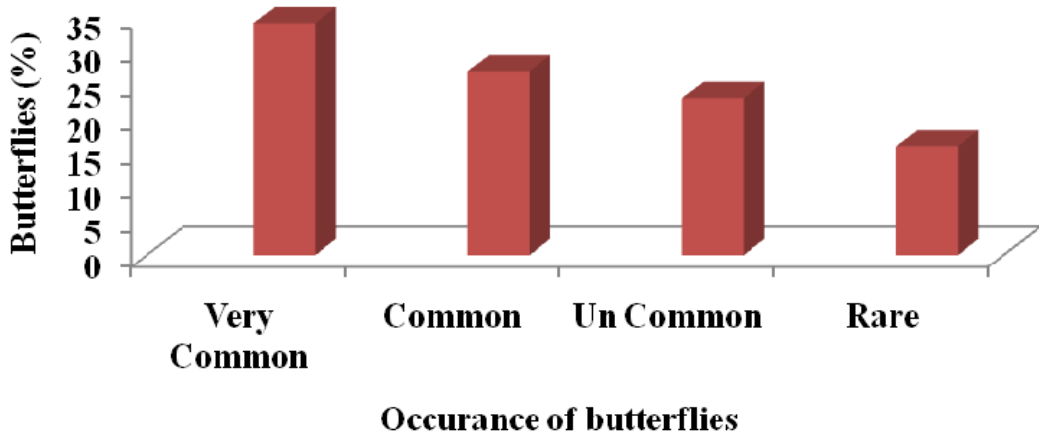

Figure 1. Status of butterflies recorded in the study area.

species like Crimson Rose, *Atrophaneura hector* and Southern Bird Wing, *Trodes minos* are endemic to the Western Ghats, Peninsular India and Sri Lanka, Danaid Eggfly and Common silver line are endemic to peninsular India and Sri Lanka. Blue Mormon, *Papilio polymnestor* are endemic to Peninsular India; Sri Lanka and Indian

Table 3. List of butterflies with status of endemism.

Zoological name	Common name	WPA 1972
Hypolimnas misippus (Linnaeus,1764)	Danaid Egg Fly	Sch I&II
Euploea core (Cramer, 1780)	Common Indian Crow	Sch IV
Cepora nerissa (Fabricius, 1775)	Common Gull	Sch II
Appias albino (Boisduval, 1836)	Common Albatross	Sch II
Castalius rosimon (Fabricius, 1775)	Common Pierrot	Sch I
Euchrysops cnejus (Fabricius,1798)	Gram Blue	Sch II
Trodes minos (Cramer, 1779)	Southern Bird Wing	Sch I
Atrophaneura hector (Linnaeus, 1758)	Crimson Rose	Sch I

Sch- Schedule.

subcontinent. In the study area, significant number of protected and endemic butterflies species need conservation. Minimizing the anthropogenic disturbances can help to improve the status of habitat specialized butterflies of 30 km radius of KKNPP area as given in Table 3.

Conservation of biodiversity covered 99 national parks 513 wildlife sanctuaries, 44 conservation reserves and 4 community reserves (Anonymous, 2008). Borkar and Komarpant (2004) reported that Wildlife Sanctuary of Goa 13 species are scheduled category and 8 are endemic species.

The Southern bird wings are endemic to Indian Subcontinent and Western Ghats and Grass jewel are endemic to Peninsular India. The study is dry evergreen and supports a variety of rare and endemic species, these areas are facing severe anthropogenic disturbances.

Kunte (2008) reported that 33 out of 333 butterflies are endemic to Western Ghats; eight species shared the WG and Sri Lanka biodiversity hot spots. Six species of butterflies are under schedule act and there is an urgent need to adapt conservation polices (Guptha et al., 2012).

Conclusion

The surrounding area of KKNPP site is rich in butterfly species, representing many families. The butterfly fauna of the microhabitats are to be protected as per the Wildlife (Protection) Act, 1972. The situation reflects on the availability of diverse habitats as well as microclimatic zones around the project sites.

Any change in the landscape, land use pattern, loss of vegetation in the habitats that are harmful to the butterfly diversity in terms of species richness leads to a potential loss of endemism and endangerment. Butterfly diversity depends upon the floral diversity (among other factors), so conservation of butterflies may possibly be by enhancement of vegetation composition of habitats around the project area.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Ackery PR (1986). Systematic and faunistic studies on butterflies. The biology of butterflies. Symposium of the Royal Entomological London. 4-9.

Amala S, Rajkumar M, Anuradha V (2011). Species richness of butterflies in the selected areas of Siumalai Hills. Int. J. Pure Appl. Sci. Technol. 6(2):89-92.

Ambrose DP, Raj DS (2005). Butterflies of Kalakad-Mundanthurai Tiger Reserve, Tamil Nadu. Zoos' Print J. 20 (12): 2100-2107.

Anonymous (2008). *Annual Report-2007-2008.* Ministry of Environment and Forests, Government of India, New Delhi. 79.

Araujo MS, Cabeza M, Thuiller, W, Hannah L, Williams PH (2004). Would climate change drives species out of reserve? An assessment of existing reserve selection methods. Glob. Change Biol.10.1618-1626.

Arun PR (2003). Butterflies of Siruvani forests of Western Ghats, with notes on their seasonality. Zoo's Print J. 18: 1003-1006.

Arun PR, Azeez PA (2003). On the butterflies of Puynakutty forests Kerala, India. Zoo's Print J. 18(12): 1276-1279.

Asaithambi P (1994). Butterflies of Mudumalai wildlife sanctuary, TamilNadu, Zoo's Print J. 12(11): 1.

Barlow J, Overal WL, Araujo IS, Gardner TA, Carlos AP (2007). The value of primary, secondary and plantation forest for fruit feeding butterflies in the Brazilian Amazon. J. Appl. Ecol. 44: 1001-1012.

Baskaran S, Eswaran R (2003). Patterns of phenology and voltinism of butterfly species in Sivakasi district (Virudhunagar), TamilNadu, India. Oikoassay. 16(1): 15-16.

Baskaran S, Solaiappan A (2002). Butterflies of Madurai city, TamilNadu. Zoo's Print J. 7(10):913-914.

Baslstha SK, Ahmed F, Deka P (1999). Butterflies of Orang Wildlife Sanctuary Assam. Zoo's Print J. 14: (4)1.

Beresford N, Barnett C, Howard B, Wells C, Tyler A, Bradley S, Copplestone

D (2012). Observations of Fukushima fallout in great Britain. J. Environ. Radioact. 144:48-53.
Borkar MR, Komarpant N (2004). Diversity, abundance, and habitat association of butterfly species in Bondla Wildlife Sanctuary of Goa, India. Zoo's Print J. 19(10):1648-1653.
Chakravarthy AK, Rajagobal D, Jagannatha R (1997). Insects as bioindicators of conservation in the tropics. Zoo's Print J. 12:21-25.
Chandra K, Chaudhary LK, Singh RK, Koshta ML (2002). Butterflies of Pench Tiger reserve Madhya Pradesh. Zoo's Print J. 17(10):908-909.
Chandra K, Sharma RM, Singh A, Singh RK (2007). A checklist of butterflies of Madhya Pradesh and Chhattisgarh states, India. Zoo's Print J. 22(8):2790-2798.
Chapin FS, Zavaleta ES, Eviner VT, Naylor RL, Vitousek PM, Reynolds HL, Hooper DU, Lavorel S, Sala OE, Hobbie SE, Mack MC, Diaz S (2000). Consequences of changing biodiversity. Nature 405:254-242.
David RM, Dunks HN, Dennis L (1986). Importance of Insects in environmental impact assessment. Environ. Manag. 10(6):773-783.
Easwaran R, Pramod P (2005). Structure of butterfly community of Anaikatty hills, Western Ghats. Zoo's Print J. 20(8):1939-1942.
Feltwell J (1986). The National History of Butterflies. Groom Helen Ltd., Provident House, Bureel Row, Beckenham Kent BR3 1AT, 133pp.
Gascon C, Lovjoy TE, Bierregaard RO, Malcolm JR, Stouffer PC, Vasconcelos HL, Laurance WF, Zimmermen D, Tocher M, Borges S (1999). Matrix habitat and species richness in tropical forest remnants. Biol. Conserv. 11:521-541.
Ghazoul J(2002). Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand. Biodivers. Conserv. 11:521-541.
Gunathilagaraj K (1998). Some south Indian butterflies. Tamil Nadu, India: Nilgiri Wildlife and Environment Association, Udhagamandalam, Nilgiris. 274pp.
Gunathilagaraj K, Berumal TNA, Jayaram K, Ganeshkumar M (1998). Butterflies of Coimbatore. Zoos' Print J. 12:26-27.
Guptha MB, Rao PVC, Reddy DS, Maddala SRSCS, Babu PM (2012). A Preliminary observation of butterflies Seshachalam Biosphere Reserve, Eastern Ghats AndraPradesh, India. J. Zool. 7(1):83-89.
Haribal M (1992). The butterflies of Sikkim and their Natural History. Sikkim Nature Conservation Foundation, Gangtok, 217pp.
Heppner J (1998). Classification of Lepidoptera. Part I. Introduction. Holarctic Lepid 5:148.
Hussain KJ, Ramesh T, Satpathy KK, Selvanayagam M (2011), Seasonal dynamic of butterflies population in DAE compus, Kalpakkam, Tamil Nadu India. J. Threat. Taxa. 30(1):1401-1414.
Jha, CS, Dutt CBS, Bawa KS (2000). Deforestration and landuse changes in Western Ghats, India. Curr. Sci. 79:231-238.
Kerr J (1997). Species richness, endemism and choice of areas for conservation. Conserv. Biol.11:1094-1100.
Kocher SD, Williams EH (2000). The diversity and abundance of North American butterflies, vary with habitat disturbance and geography. J. Biogeogr. 27:785-794.
Koh LP, Sodhi NS (2004). Importance of reserves, fragments and parks for butterfly conservation in a tropical urban landscape, Ecol. Appl. 14:1695-1708.
Kremen C (1994). Biological Inventory using target taxa: a case study of butterflies of Madagascar. Value of the countryside for forest birds in central Sulawesi (Indonesia). Biol. Conserv. 122:547-558.
Kremen, C (1992). Assessing the insulator properties of species assemblages for natural area monitoring. Ecol. Appl. 2(2): 203-217.
Kumar P, Ramarajan S, Murugesan AG (2014). Butterflies of Pillavakkal dam of giant grizzled squirrel wildlife sanctuary, Srivilliputtur Tamil Nadu India. World J. Zool. 9(1):46-51.
Kunte K (1977). Seasonal patterns in butterflies abundance and species diversity in four tropical habitats in the North Western Ghats. J. Biosci. 22:593-603.
Kunte K (2000a). Butterflies of Peninsular India. Indian Academy of Science, University of Press (India) Limited, Hyderabad, India, 354.
Kunte K (2000b). Project life scape, Resonance 5:86-97.
Kunte K (2008). The wildlife (Protection) act and conservation prioritization of butterflies of the Western Ghats, South Western India. Curr. Sci. 94(6):25.
Kunte K, Joglekar A, Utkarsh G, Padmanabhan P (1999). Patterns of butterfly, birds and tree diversity in the Western Ghats. Curr. Sci. 77:577-586.
Mathew G, Rahamathulla VK (1993). Studies on the butterflies of silent valley national park, Entomology 18(3&4):185-192.
Moller A, Mousseau T (2006). Biological consequences of Chernobyl: 20 years on. Trends Ecol. Evol. 21 (4): 200-207.
Murugesan M, Arun PR, Prusty BAK (2013). The butterfly community of an urban wetland system- a case study of Oussude Birds Sanctuary, Puducherry, India. J. Threat. Taxa 5(12):4672-4678.
Nimbalkar RK, Chandekar SK, Khunte P (2011). Butterfly diversity in relation to nectar food plants from Bhor Tahsil, Pune District, Maharashtra, India. J. Threat. Taxa 3(3):1601-1609.
Perveen F, Ahmed A (2012). Checklist of butterflies fauna of Kohat Khyber, Pakhtunhwa, Pakistan. Arthropod 1(3):112-117.
Pollard E (1988). Temperature, rainfall and butterfly numbers. J. Appl. Ecol. 25:819-828.
Pollard E, Elias, DO, Skelton, MJ, Thomas AJ (1975). A method of assessing the abundance of butterflies in Monk's Wood National Nature Reserve in 1973. Entomologist's Gazeteer. 26: 79-88.
Rajagopal T, Sekar M, Manimozhi A, Baskar N, Archunan G (2011). Diversity and community structure of butterfly of Arignar Anna zoological park, Chennai, TamilNadu. J. Environ. Biol. 32: 201-207.
Raju AJS, Reddy CS (1995). Flower colour shifts and pollination in Lantana camera L. Verbenaceae. J. Palynol. 31:275-289.
Ramesh T, Jahir Hussain, Selvanayagam M, Satpathy KK, Prasad MVR (2010). Patterns of diversity, abundance and habitat associations of butterflies communities in heterogeneous landscapes of the department of atomic energy (DAE) campus at Kalpakkam, South India. Int. J. Biodivers. Conserv. 2(4):75-85.
Raut NB, Pendharkar A (2010). Butterfly (Rhopalpcera) fauna of Maharashtra Nature Park, Mumbai, Maharashtra, India. Journal of Species List and Distribution 6(1):22-25.
Ravindra M, Viswanathan, S, Ram GM (1996). Checklist of butterfly species of Osmania University Campus, Hyderabad. Zoo's Print J. 11(10): 5.
Robbins RK, Opler PA (1997). Butterfly diversity and preliminary comparision with bird and mammal diversity. In: Biodiversity II, understanding and protecting our biological resources, D.E. Wilson, M.L. Reaka-Kudla and E.O. Wilson (eds). Joseph Henty Press, Washington, DC.
Rufus KC, Sabarinathan SP (2007). A checklist of butterflies of Thengumarahada in the Nilgiris Southern India. Zoo's Print J. 22(9):2837-2838.
Shamsudeen RSM, Mathew G (2010). Diversity of butterflies in Shendurny Wildlife Sanctuary, Kerala (India). World J. Zool. 5(4):324-329.
Thomas CD, Cameron AJ, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, Erasmus BFN, Ferreira de Siquiera M, Grainger A, Hannah L, Hughes L, Huntley B, Van Jaarsveld AS, Midgelet GF, Miles L, Ortega-Huerta MA, Peterson AT, Phillips OL, Williams SE (2004). Extinction risk from climate change. Nature. 427:145-148.
Thomas S (1966). Bulletin of Madras Governmment Museum-descriptive catalog of the butterflies. Natural History Section 7:1.
Tiple AD (2011). Butterflies of Vidarbha region, Maharastra, India; a new review with and implication for conservation. J. Threat. Taxa. 3(1):1469-1477.
Tiple AD (2012). Butterfly species diversity, relative abundance and status in tropical forest research institute, Jabalpur, Madhya Pradesh, central India. J. Threat. Taxa. 4(7):2713-2717.
Tiple AD, Khurad AM (2009). Butterfly species diversity, habitats and seasonal distribution in and around Nagpur city, Central India. World J. Zool. 4 (3):153-162.
Varshney RK (1983). Index *Rhopalocera indica* part II. Common names of butterflies from India and neighbouring countries. Records of Zoological Survey of India. Occasional Paper no. 47:1-49.
Varshney RK (1993). Index *Rhopalocera indica* part II. Common names of butterflies from India and neighbouring countries. Orient. Insects 27:347-372.
Wijesekara A, Wijesinghe DP. (2003). History of insect collection and a review of insect diversity in Sri Lanka. Ceylon J. Sci. Biol. Sci. 31:43-59.