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Full Length Research Paper

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

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The diversity of butterflies inhabiting the department of atomic energy campus at Kalpakkam was recorded through a modified line transect methodology by setting a permanent line transect of 300m and recoding all species of butterflies observed within a five meter distance around the observer. Five habitats within the campus viz., Garden, Scrub jungle, Riparian woods, Sandy area and *Casuarina* plantation (Monoculture) were evaluated for analysis of the association of the butterfly species with the habitat. A total of 1908 individuals representing 55 species were observed across the five habitat types. Out of these, members belonging to the family Nymphalidae was the most common with 20 species being recorded accounting for 36.3% of total species and 53.6% of total number of individuals collected. The maximum diversity and abundance was observed in the scrub jungle and garden area; these two habitats sharing 29 species among themselves. The species accumulation curve and rarefaction curves computed indicated the likelihood of encountering more number of species in the campus had inventory been more rigorous and extended. The butterfly species viz., *Danaus chrysippus*, *Castalius rosimon*, *Tirumala septentrionis*, *Ariadne merione*, *Appears libythea* and *Cepora nerissa* preferred scrub jungle and garden habitats than the other habitats. The species profile of butterfly communities associated with different habitat and the importance of avian predation in the campus were also discussed in detail.

Key words: Butterfly, species composition, habitat association, DAE campus.

INTRODUCTION

Butterflies are taxonomically well studies group, which have received a reasonable amount of attention throughout the world (Ghazoul, 2002). Many of butterfly species are strictly seasonal and prefer only a particular set of habitats (Kunte, 1997) and they are good indicators in terms of anthropogenic disturbance and habitat quality (Kocher and Williams, 2000). Butterfly community assembly and the factors which influence it, have long been a topic of interest to ecologists and conservationists. 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; Rickets et al., 2001).

Among insects, butterflies are the most studied group. In southern India, butterfly species have been documented since the turn of the 19th century (Bingham 1905, 1907, Williams, 1927). Later, Larsen (1987) made a detailed survey of butterflies of Nilgiri Mountains and recorded nearly 300 species including endemics. Many researchers have been significantly contributed to our understanding of butterfly diversity and abundance (Kunte et al., 1999; Arun and Azeez, 2003; Eswaran and Pramod, 2005; Xavier; 2006; Pramod kumar et al., 2007; Krishnakumar et al., 2008) on aspects such as habitat association, effect of disturbance and area clearance

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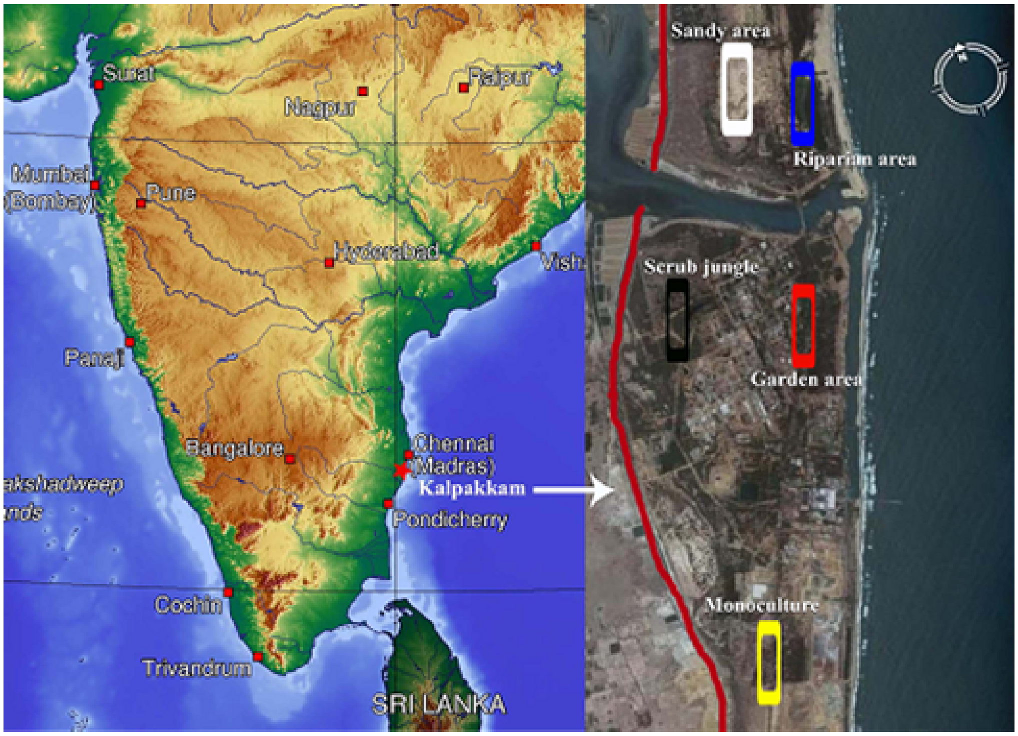

Figure 1. Study area.

(Soubadra Devy and Priya, 2001; Sreekumar and Balakrishnan, 2001; Dolia et al., 2008); seasonal abundance and migration patterns (Kunte, 1997; Arun, 2002; Kunte, 2005; Padhye et al., 2006) and on conservation (Mathew and Binoy, 2002; Mathew and Anto, 2007; Kunte, 2008) from Western Ghats. However, very little attention has been given to eastern plain areas of southern India. The purpose of present investigation is to understand the effects of habitat characteristic on butterfly diversity, community composition and density.

MATERIALS AND METHODS

Study area

The DAE campus at Kalpakkam (12° 33' N and 80° 11' E) encompasses seashore and a vast plain area (2500 acres) of the Bay of Bengal. The coastal system forms the complex natural site where intense interactions occur among land, sea and atmosphere. The unique interaction throws biological consortia peculiar to this ecosystem. It spreads through the biologically diverse and productive habitat of native flora and fauna and aesthetically blended with introduced vegetation. All the study areas are located in DAE campus, Kalpakkam, Tamil Nadu (Figure 1).

Inventory

Prior to butterfly census, two observers spent one year in the field (between April, 2007 to April, 2008) constructing a pictorial monograph (Jahir et al., 2008) for field identification and familiarizing themselves with the local butterfly fauna.

Monitoring (Line transect)

Butterfly species density was assessed quantitatively across different habitats. The entire campus was divided into five different habitats, which were divided on the basis of vegetation and soil type. Sampling was carried out at different habitats during (June, 2008 to February, 2009). Modifications of the line transect count as per. Kunte; (1997) was used to determine butterfly richness and abundance. In this method permanent 300m line transect was setup in each habitat. The transect in each habitat was slowly traversed at a uniform pace for 30min at each habitats from 8.30 to 11.30 h during good weather period (no heavy rain or strong winds). Butterfly species were recorded around a radius of five meter from the observer covering his either sides, above and front. This is a suitable method for surveying butterflies in a wide range of habitats including tropical forest (Walpole and Sheldon, 1999; Caldas and Robbins, 2003; Koh and Sodhi, 2004). All individuals were identified in the field using standard guides (Gunathilagaraj et al., 1998; Kunte, 2000; Jahir et al., 2008).

Habitat characterization

The main type of vegetation in DAE campus is dry evergreen and scrub comprising of members predominantly belonging to the families: *Poaceae, Fabaceae, Cyperaceae, Asteraceae, Euphorbiaceae, Verbenaceae, Solanaceae, Rubiaceae, Convolvulaceae and Amaranthaceae (*Gajendiran and Ragupathy, 2002*).*

Scrub jungle

The dry areas of the DAE premises shelter scattered patches of *Prosophis juliflora* (Sw.) DC. plants. Some of the dominant tree species are: *Acacia polyacantha* ((Willd.), Samanea saman (Jake.) Merr. and *Albanian lebbeck* (L.) Benth. Predominant herbs and shrubs are: *Lantana camera* (L.), *Canthium dicoccum* (Gaertn.), *Euphorbia antiquorum* (L.), *Martynia annua* (L.), *Calotropis gigantean* (L.), *Capparis Sp., Toddalia asiatica* (L.), *Tragia involucrate* (L.), *Crotalaria verucosa* (L.), *Heliotropium indicum* (L.), *Urena lobata* (L.), *Solanum Sp., Tephrosia purpurea* (L.), *Anisomelous Sp., Zizyphus oenoplia* (L.), *Ocimum basilicum* (L.), *Achyranthes aspera* (L.), *Croton bonplandianum* (Baill), *Solanum trilobatum* (L.), *Leucas aspera* (Willd.) Link., *Mimosa pudica* (L.), *Gomphrena serrata* (L.), *Vernonia cinerea* (L.), *Clitoria ternatea* (L.), *Tinospora cordifolia* (L.) and Common twiners.

Riparian area

The riparian area is relatively dense with *Pandanus fascicularis* (Lam.), Typha *angustata (Bory & Chaubard), Acacia auriculiformis Cunn. ex Benth., Cassia siamea Lamk., Ficus benghalensis* angustata (Bogy & Chaubard), *Prosophis juliflora* (Sw.) DC., *Casuarina equisetifolia (L.), Terminalia arjuna* (L.) along with some nectar fetching plants like *Catharanthus roseus* (L.) G.Don, *Anacardium occidentale* (L.) and *Tephrosia purpurea* (L.). Grasses are also abundant in this location

Garden area

Even though this area witness comparatively high anthropogenic pressure, it is a unique habitat with natural vegetation blended with introduced ornamental flora. Major part of this area comprises *Tridax procumbens* (L.), *Gomphrena serrata* (L.), *Cosmos sulphureus* Cav., *Ricinus communis* (L.), along with common garden species like *Ixora coccinea* (L.), *Ixora pavetta* Andr. and some moist deciduous tree species.

Sandy area

This habitat is a typical costal sand stretch with meager vegetation which consist of *Calotropis gigantean* (L.), *Catharanthus roseus* (L.) G. Don, *Tribulus terrestris* (L.) along with *Acacia auriculiformis* Cunn. ex Benth., and *Casuarina equisetifolia* (L.).

Monoculture

The southern area of campus is dense with *Casuarina equisetifolia* (L.) monoculture plantation. Canopy cover in plantation surveyed was high (60-80%), even though some weedy plants *Catharanthus roseus* (L.) was observed. This area had high anthropogenic disturbance.

Data analysis

Two components, namely α-diversity and β-diversity were calculated. The alpha statistic of Fisher et al; (1943) is often considered the best diversity index for many communities of species, including *Lepidoptera* (Robinson and Tuck, 1993; Wolda et al., 1994, Chey et al., 1997). The Shannon diversity index is also widely used for comparing diversity between various habitats (Clarke and Warwick, 2001). Apart from above indices Simpson indices was also calculated as measure of α-diversity. Beta diversity (between the habitats) captures a fundamental aspect of species diversity and spatial replacement in species identity between any two or more areas. We calculated some classical indices viz., Morista-Hor n similarity index, Sorenson classic and Jaccard classic indices to measure beta diversity based on habitat raw data. The Michaelis-Menten estimate was based on the mean species accumulation curve after 50 randomization of samples order and several diversity estimators were also calculated using the software Estimates (Colwell; 1997). Sample based on rarefaction was calculated using Biodiversity Pro software version 2 (Neil Mcaleece et al., 1997).

RESULTS AND DISCUSSION

A total of 55 species belonging to 5 families of order *Lepidoptera* were recorded (Appendix 1). Out of these, *Nymphalidae* were the most common with 20 species, followed by the *Pieridae* (15 species), *Lycaenidae* (11 species), and the least number of species was observed in *Hesperiidae* by only 4 species and *Papilionidae* by only 5 species. *Nymphalidae* was the dominant family accounting for 36.3% of species and 53.6% of individuals recorded (Table 1). A similar pattern of predominance of *Nymphalidae* was also reported by different researchers (Kunte; 1997; Kunte, et al., 1999; Eswaran and Pramod, 2005; Dolia, et al., 2008; Krishna kumar, et al., 2008; Soubadra devy and Priya, 2001; Pramod kumar et al., 2007; Padhye, et al., 2008) from Western Ghats. However, with respect to Eastern plains of Southern India the information on butterfly diversity and bioecology is sketchy and sporadic. India has more than 1,400 species of butterflies, 330 of them in the Western Ghats alone, and of which 37 are endemic (Kunte, 2008). In the present investigation *Pachliopta hector,* a scheduled species which is protected by Wildlife protection act was also documented.

In total, 1908 individuals from 45 transects were observed and identified. A large number was observed at the scrub jungle habitat (649 individuals, 34% of total) while equal numbers were recorded at garden area (632, 33%) and very less numbers were recorded in the sandy area (173, 9%) and monoculture habitat (157, 8.2%). Generally, simple comparison of absolute species number between samples is used most of the time as diversity measure. We also calculated Fisher's alpha diversity and Shannon diversity indices as a measure of diversity within a habitat since these indices incorporate both species richness and abundance into a single value. The Fisher alpha diversity indicated the following habitats in a decreasing order of diversity; scrub jungle (9.12) riparian woods (8.72), garden area (8.29), sandy area (6.26) and monoculture (4.46). The Shannon's diversity index showed the same pattern with minor variations. The Simpson and Shannon J (evenness) indices revealed that in scrub jungle the individuals among species were not evenly distributed during the survey period indicating that some species were more abundant than the others. This reflects on the difference in the efficiency of different butterfly species to efficiently use the habitat. The abundance of individuals of a species at any given point on a temporal scale is again dependent on various biotic and abiotic environmental factors. Hills richness

Table 1. Family wise composition of number, percentage of species and individuals observed.

Family	Number of species (%)	Number of individual (%)
Hesperiidae	4 (7.2)	12 (0.6)
Papilionidae	5 (9)	143 (7.4)
Lycaeniidae	11 (20)	199 (10.4)
Pieridae	15 (27.2)	530 (27.7)
Nymphalidae	20 (36.3)	1024 (53.6)
Total	55	1908

Table 2. Diversity index and abundance scores for butterfly communities along habitats.

Habitat	Fisher alpha	Shannon H'	Shannon J'	Simpson's (D)	Hill's H0	Individuals
Garden area	8.29	1.30	0.84	0.06	36	632
Scrub jungle	9.12	1.20	0.75	0.12	39	649
Riparian woods	8.72	1.23	0.82	0.08	31	297
Sandy area	6.26	1.05	0.79	0.13	21	173
Monoculture	4.46	0.90	0.74	0.19	16	157

indices indicated that scrub jungle was the richest (39 species) followed by garden area (36 species), riparian woods (31 species), sandy area (21 species), and monoculture (16 species) as shown in Table 2.

The structural complexity of habitat and diversity of vegetation forms have been shown to be correlated with animal and insect species diversity (Gardner et al., 1995). Southwood (1975) suggest that the herbivores are more influenced by the food quality. Host plants are utilized only when sufficient adult resources (nectar) are also available (Grossmueller and Lederhouse, 1987). Successful butterfly habitat must therefore include sufficient larval and adult food resources. In the present study, the maximum number of species and individuals were observed in scrub jungle and garden area, where availability of diverse plants and access to host plants viz., *Tragia involucrate, Crotalaria verucosa, Heliotropium indicum, Tridax procumbens, Ricinus communis, Leucas aspera, Mimosa pudica, Gomphrena serrata, Vernonia cinerea, Chromolaena odorata, Anisomelous sp., Lantana camara* and ornamental flowering plants promoted the butterfly richness and density. Most of these plants provide rich nectar sources to adult butterflies. Comparatively the other habitats especially, monoculture and sandy area have lesser density of vegetation. These habitats being highly disturbed due to anthropogenic activities could also account for lower butterfly colonization.

The butterfly distribution are expected to cover with the distribution of their host plants even at small scales and type of vegetation may reflect difference in the composition of butterfly communities among habitats at the generic and family level (Beccaloni; 1997). Our results also conformed the above finding; at the scrub jungle *Danaus chrysippus*, *Danaus genutia*, *Tirumala septentrionis* and *Euploea core* of subfamily Danainae contributed 38% of total density of that particular habitat. This is due to the fact that the two abundant host plants of that habitat namely *Heliotropium indicum* and *Crotalaria verucosa* are major source of Pyrollizine alkaloids, which is a precursor of Danaids pheromone cum defense chemical called Danaidone (Boppre et al.,1978). Interestingly, Danaidone is not available from the plants that the larvae feed on and must be obtained by the adults after emergence. And this task is accomplished by feeding on plants that do contain these substances. Studies elsewhere have shown that males that do not accumulate Danaidone are consistently refused by the females. So it seems that the females not only seek chemicals for their own survival and their progeny, but also indirectly select genes that are correlated well with good foraging ability is an excellent strategy for survival of the species. It is principally from these plant species that the male Danaids obtain most of the chemicals required to synthesize their pheromones. All *Danaid*s are irresistibly attracted to these plants. Hence, the adult Danaid density was more at scrub jungle where these plants are abundant. This dominance of particular taxa was clearly reflected in Shannon's J evenness index.

Beta diversity is essentially a measure of how different (or similar) a range of habitats are in terms of the variety and abundance of species found in them. An approach to the measurement of beta diversity is to investigate the degree of association or similarity of habitats or samples using standard ecological technique of ordination and classification (Southwood, 1978). A vast range of similarity indices are available, however, some of the oldest similarity coefficients are also the most useful (Magurran, 1988). Particularly widely used are the Jaccard and Sorenson index. The shared species statistics between pairs of the five habitats are provide in the Table 3. The

Table 3. Shared species statistics and similarity coefficients between pairs of the five habitats.

First sample	Second sample	Shared species	Jaccard classic	Sorensen classic	Morisita-Horn
Garden area	Scrub jungle	29	0.63	0.773	0.607
Garden area	Riparian woods	21	0.457	0.627	0.698
Garden area	Sandy area	16	0.39	0.561	0.433
Garden area	Monoculture	15	0.405	0.577	0.554
Scrub jungle	Riparian woods	24	0.522	0.686	0.707
Scrub jungle	Sandy area	18	0.429	0.6	0.444
Scrub jungle	Monoculture	15	0.375	0.545	0.749
Riparian woods	Sandy area	17	0.486	0.654	0.812
Riparian woods	Monoculture	13	0.382	0.553	0.778
Sandy area	Monoculture	9	0.321	0.486	0.571

number of species observed in each habitat and the number of species encountered in both the habitats were compared. The garden area and scrub jungle showed highest number of shared species (29 species), because these areas had comparatively similar plant composition and provide perennial nectars sources for adult butterflies. Even though the sandy area and monoculture habitats shared nine general species, they comprise of a relatively contrast set of species (multifamily) due to their difference in vegetation type. Seventeen species of butterflies were seen in both the riparian habitat and sandy area and this is reflected in the Jaccard value. From the results of the Sorenson index, it recognized as one of the best indices of shared species measure, it is clear that garden/scrub jungle and scrub jungle/ riparian habitat were represented by relatively same species and abundance profile. Similarly the high value for riparian habitat and sandy area was due to their similarity in species assemblage. The Morisita Horn index is highly sensitive to the species assemblage and abundance of the most abundant species between each pair of habitats. This index reveled that riparian woods and sandy area were similar in their abundant species profile. In these habitats, the most abundant species was mottled emigrant which was not common to other habitats.

Species accumulation curve is a approach by plotting the cumulative number of species collected against the sampling effort (months/sample unit), which describes species richness in a local homogenous assemblages as a function of sampling effort. This technique is very much useful for standardizing the sample size. In the present study the species accumulation curve could not attain asymptote even after nine sampling efforts (especially scrub jungle habitat), which indicated that, with increase in sampling efforts there is more likelihood of adding new records of species (Figure 2), from the study area.

As discussed by Colwell and Coddington (1994), the problem of estimating the true number of species shared by two (or more) habitats or biotops based on sample data presents a difficult but important challenge. Most widely used approach for estimating species richness is based on extrapolation from known species accumulation curve. Michaelis-Menten type model describes well about the accumulation of species records as the number of sampling attempt increases. In rarefaction curve Michaelis-Menten Mean (MMMean) and Coleman curve were used as estimators of species richness. MMMean and Coleman curve were fitted to sampling data after randomizing them 50 times using the procedure of Colwell (1997). In the present study, the curve indicated that more number of species observed in scrub jungle from the early effort. However, after the second effort very less numbers were observed (Figure 3).

To compare sample-based rarefaction curves, expected expected species of the sample (habitat) are plotted against number of individuals. This plot provides a measure of species diversity, which is robust to sample size effects, permitting comparison between communities. Steeper curves indicate more diverse communities. The steeper curve was observed for scrub jungle and garden area which were equally richer and more abundant when compared to all other habitats. At community level the sandy area and monoculture were less diverse (Figure 4). Richness estimators were highly influenced by rare species. In our study, out of 55 species, eight species were singleton species and three species were represented by two individuals (doubletons). The larger the number of singletons within a sample, for a given number of doubles, the greater would be the difference between observed and the true species richness for the assemblages sampled (Senthilkumar, 2003).

To find out the abundance pattern, the rank abundance curve was plotted using grand mean of the all species. The common species are displayed on the left, and the rare species are on the right. While ranking overall abundance (all habitats pooled together) and ten species were more common followed by few abundant species and large proportion of rare species was observed (Figure 5). Species abundance of DAE butterflies has showed that, only a small proportion (18%) of the assemblage occurred in relatively high number. This is a reflection of a situation where one or a few factors dominate the ecology of a community (Magurran, 1988). Dominance of a species in an ecosystem reveals its

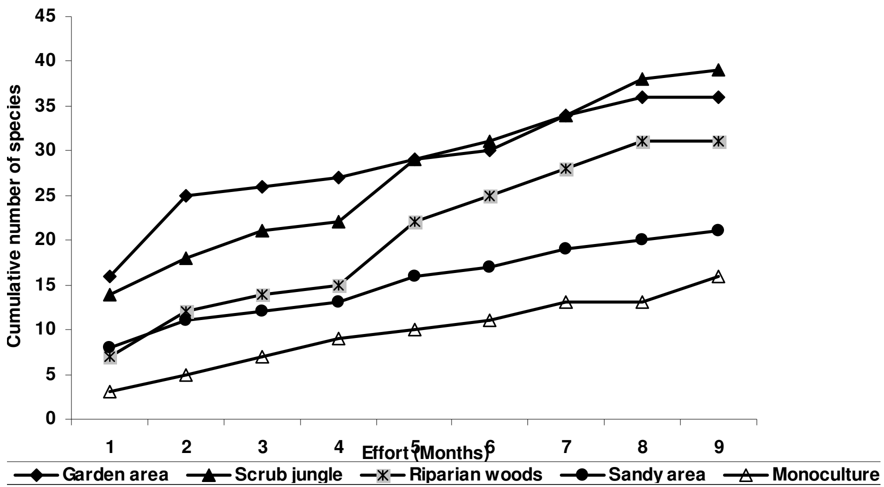

Figure 2. Species accumulation curves for five habitats.

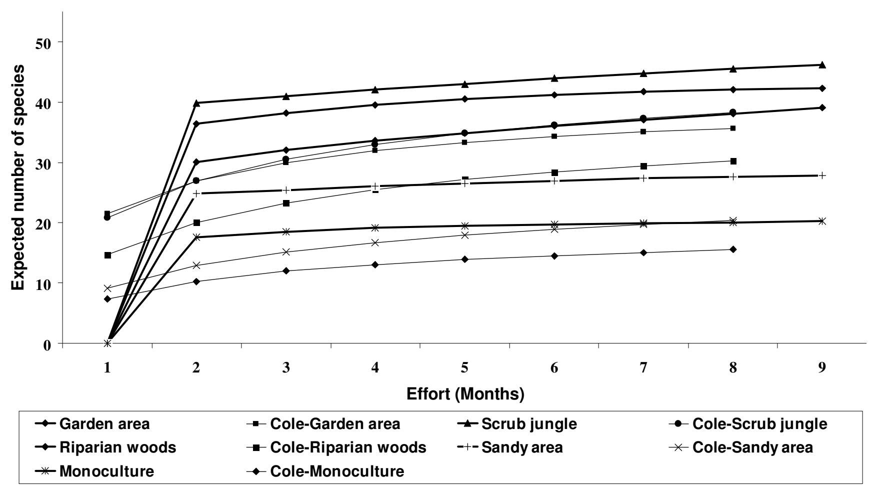

Figure 3. Rarefaction curve for five different habitats.

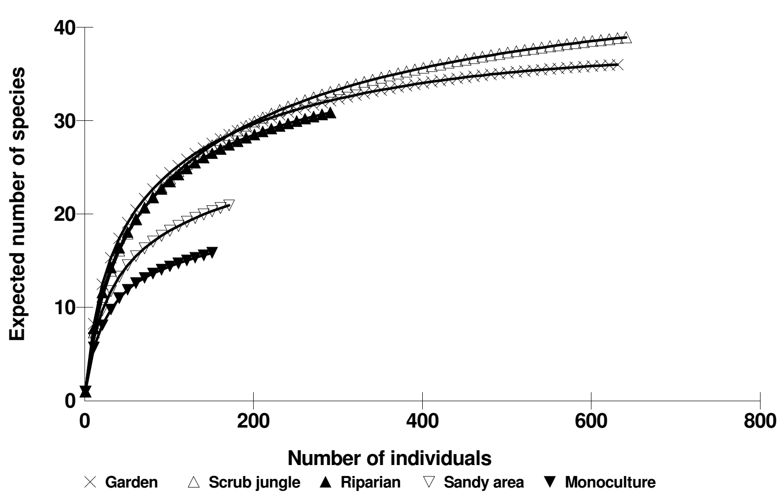

Figure 4. Sample based rarefaction curve for the five different habitats.

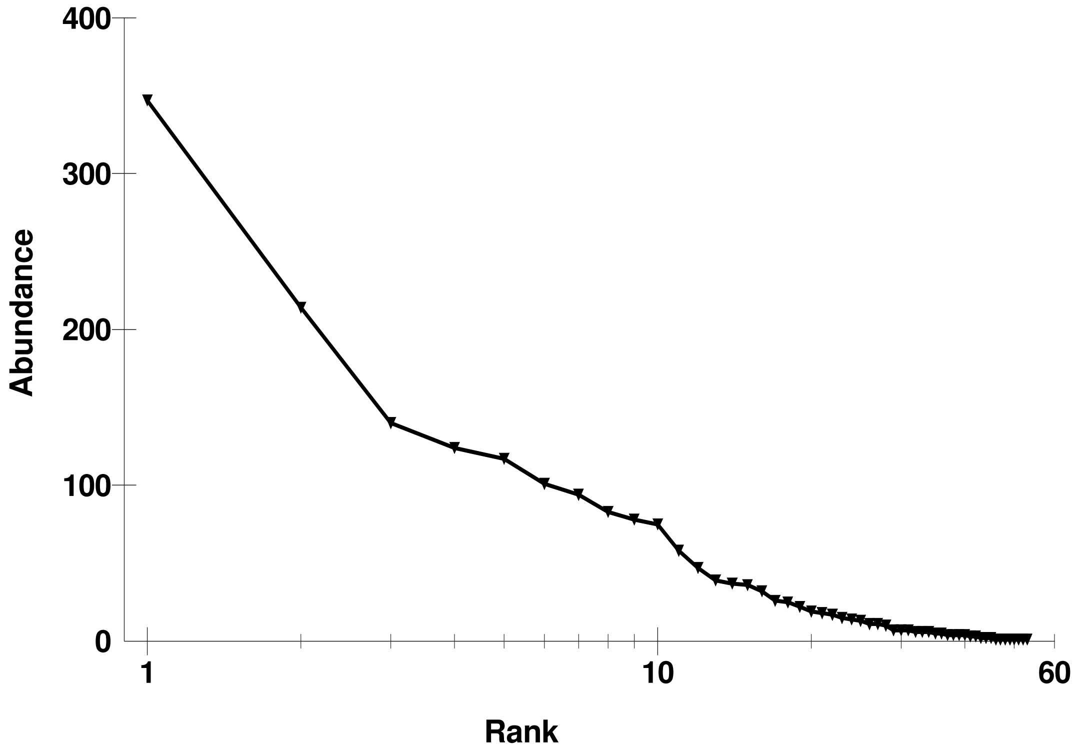

Figure 5. Over all species rank abundance.

survival superiority over other species. In the present study the overall dominance by *D. chrysippus* was due to its chemical defence against predations. The larvae of this species often feed on plants containing poisons and unpalatable substances. Instead of eliminating or detoxifying chemicals, they assimilate them in their body fluids and retain them till their adulthoods. The male adult also assimilates a toxin called danaidone from plants. Females prefer to mate with males who exude significant amounts of danaidone from their hair pencils. In addition, the spermatophore (sperm package) that the male passes over to the female during mating also contains danaidone as well as sperm and other nutrients. The danaidone is incorporated into the eggs as well as into the female's tissues. This is not only to increase the chances of survival of the eggs that are laid, but alsomakes the female less palatable to predators. In the study area the most important predators are birds, small mammals, reptiles, predating insects and spiders (Jahir et al., 2008). Birds can be considered the most important predators on adult, mobile butterflies (Bowers et al., 1985). During our intense field survey we observed birds species viz., *Merops orientalis, Merops philippinus, Dicrurus macrocercus, Dicrurus leucophaeus, Dicrurus aeneus, Artamus fuscus, Lanius cristatus, Terpsiphone paradise, Coracias benghalensis* and *Hirundo daurica* are actively preying on palatable butterfly species. Hence the predatory pressure imposed by avian fauna on butterfly community is one of the important governing factors of butterfly population. Being an unpalatable prey species to birds, *D. chrysippus* has greater survival superiority. Similarly *Acraea violae* also possesses plant acquired chemical defense which provided the survival ability than other species in the heterogeneous ecosystem. In the present study, it is evident that apart from vegetation type, predation by birds is also a major factor influencing butterfly community.

Habitat association of butterflies can be directly related to the availability of food plants (Thomas; 1995).The criterion of representative diversity which is based on the recognition of assemblages of species that are typical for specific habitats seems more interesting (Dufrene and Legendre, 1997). A potentially useful tool is the single species approach based on focal or surrogate species, which can indicate ecological change, patterns of richness or habitat type (Caro and Doherty, 1999; Fleishman, et al., 2000). Each habitat has a specific set of micro environment suitable for a species. In the present investigation species such as *Cepora nerissa* were observed only in the garden area and *Appias libythea* were observed only in the scrub jungle habitat, indicating its preference towards particular habitat. Percentage frequencies of selected species are given in (Table 4). Out of 13 species, seven species were predominant at the garden area and four species were very common at the undisturbed scrub jungle. These two habitats were strongly

Table 4. Percentage composition of selected butterfly species associated with five habitats.

Species name	Garden area	Scrub jungle	Riparian woods	Sandy area	Monoculture
Appias libythea	0	100	0	0	0
Cepora nerissa	100	0	0	0	0
Castalius rosimon	49	30	6	10	5
Pachliopta hector	60	16	9	0	15
Euploea core	62	19	17	2	0
Junonia atlites	78	11	0	11	0
Tirumala septentrionis	62	15	14	3	8
Leptosia nina	83	10	7	0	0
Colotis amata	91	0	9	0	0
Ariadne merione	26	72	2	0	0
Phalanta phalantha	11	81	0	0	8
Danaus chrysippus	15	53	13	5	14
Danaus genutia	25	63	6	3	3

strongly supporting the butterfly community. From our observation we conclude that, even in the small study area butterfly communities varied significantly among different habitats. In a heterogeneous ecosystem like DAE campus, vegetation type played a major role in diversity and density patterns of butterfly communities. Moreover the avian predation also has a profound effect on abundance pattern of butterfly communities.

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Appendix 1. Butterflies sighted from the area during the study period.

S. no	Family/Subfamily	Scientific name	Common name
	Hesperiidae		
1	Hesperiinae	Parnara bada (Moore, 1878)	Common straight swift
2	Hesperiinae	*Suastus gremius* (Fabricius,1798)	Indian palm pop
3	Pyrginae	*Gomalia elma* (Trimen, 1862)	African mallow skipper
4	Pyrginae	*Spialia galba* (Fabricius, 1793)	Indian grizzled skipper
	Lycaeniidae		
5	Curetinae	*Curetis thetis* (Drury, 1773)	Indian sunbeam
6	Polyommatinae	*Azanus ubaldus* (Stoll, 1782)	Bright babul blue
7	Polyommatinae	*Castalius rosimon* (Fabricius, 1775)	Common pierrot
8	Polyommatinae	*Catochrysops strabo* (Fabricius,1793)	Forget me not
9	Polyommatinae	*Chilades lajus* (Stoll, 1780)	Lime blue
10	Polyommatinae	*Everes lacturnus* (Godart, 1824)	Indian cupid
11	Polyommatinae	*Jamides celeno* (Cramer, 1775)	Common cerulean
12	Polyommatinae	*Leptotes plinius* (Fabricius, 1793)	Zebra blue
13	Polyommatinae	*Megisba malaya* (Horsfield,1828)	Malayan
14	Theclinae	*Spindasis vulcanus* (Fabricius,1775)	Common silverline
15	Unassigned	*Pseudozizeeria maha* (Kollar,1844)	Pale grass blue
	Nymphalidae		
16	Biblidinae	*Ariadne merione* (Cramer, 1777)	Common castor
17	Danainae	*Danaus chrysippus* (Linnaeus, 1758)	Plain tiger
18	Danainae	*Danaus genutia* (Cramer, 1779)	Striped tiger
19	Danainae	*Euploea core* (Stoll, 1780)	Common crow
20	Danainae	*Tirumala limniace* (Cramer, 1775)	Blue tiger
21	Danainae	*Tirumala septentrionis* (Butler, 1874)	Dark blue tiger
22	Heliconiinae	*Acraea violae* (Fabricius, 1793)	Tawny coster
23	Heliconiinae	*Phalanta phalantha* (Drury,1773)	Common leopard
24	Limenitidinae	*Neptis hylas* (Linnaeus,1758)	Common sailer
25	Nymphalinae	*Hypolimnas bolina* (Linnaeus, 1758)	Great eggfly
26	Nymphalinae	*Hypolimnas misippus* (Linnaeus, 1764)	Danaid eggfly
27	Nymphalinae	*Junonia orithya* (Linnaeus, 1758)	Blue pansy
28	Nymphalinae	*Junonia iphita* (Cramer,1779)	Chocolate pansy
29	Nymphalinae	*Junonia atlites* (Linnaeus, 1763)	Grey pansy
30	Nymphalinae	*Junonia lemonias* (Linnaeus, 1758)	Lemon pansy
31	Nymphalinae	*Junonia almana* (Linnaeus, 1758)	Peacock pansy
32	Nymphalinae	*Junonia hierta* (Fabricius 1798)	Yellow pansy
33	Nymphalinae	*Vanessa cardui* (Linnaeus, 1758)	Painted lady
34	Satyrinae	*Melanitis leda* (Linnaeus, 1758)	Common evening brown
35	Satyrinae	*Mycalesis perseus* (Fabricius, 1775)	Common bush brown
	Papilionidae		
36	Papilioninae	*Atrophaneura aristolochiae* (Fabricius, 1775)	Common rose
37	Papilioninae	*Graphium Agamemnon* (Linnaeus, 1758)	Tailed joy
38	Papilioninae	*Papilio polytes* (Linnaeus, 1758)	Common mormon
39	Papilioninae	*Pachliopta hector* (Linnaeus, 1758)	Crimson rose
40	Papilioninae	*Papilio demoleus* (Linnaeus, 1758)	Lime butterfly

Apendix 1. Cont'd.

	Pieridae		
41	Coliadinae	*Catopsilia crocale* (Cramer, 1775)	Common emigrant
42	Coliadinae	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled emigrant
43	Coliadinae	*Eurema hecabe* (Linnaeus, 1758)	Common grass yellow
44	Pierinae	*Anaphaeis aurota* (Fabricius,1793)	Pioneer
45	Pierinae	*Appias libythea* (Fabricius. 1775)	Striped albatross
46	Pierinae	*Colotis amata* (Fabricius, 1775)	Small salmon arab
47	Pierinae	*Colotis danae* (Fabricius, 1775)	Crimson tip
48	Pierinae	*Colotis eucharis* (Fabricius, 1775)	Plain orange tip
49	Pierinae	*Colotis etrida* (Boisduval, 1836)	Little orange tip
50	Pierinae	*Cepora nerissa* (Fabricius, 1795)	Common gull
51	Pierinae	*Delias eucharis* (Drury , 1773)	Common jezebel
52	Pierinae	*Hebomoia glaucippe* (Linnaeus,1758)	Great orange tip
53	Pierinae	*Leptosia nina* (Fabricius,1793)	Psyche
54	Pierinae	*Pareronia valeria* (Cramer,1776)	Common wanderer
55	Pierinae	*Ixias pyrene* (Linnaeus, 1764)	Yellow orange tip