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Seasonal dynamics of butterfly population in DAE Campus, Kalpakkam, Tamil Nadu, India

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Abstract: Seasonal population trends of butterflies inhabiting the campus of Department of Atomic Energy (DAE) at Kalpakkam were recorded by setting a permanent line transect of 300m and recording all species of butterflies observed within a 5m distance. The survey yielded 2177 individuals of 56 butterfly species, belonging to the families Nymphalidae, Pieridae, Lycaenidae, Papilionidae and Hesperiidae. Nymphalidae were found to be the dominant family during all seasons. Species richness and abundance were highest during the northeast monsoon and winter periods, indicating that in the southern plains of India butterflies prefer cool seasons for breeding and emergence. The taxonomic structure of the butterflies sampled resembles that of the Western Ghats and other regions of India in two ways: (a) dominance of nymphalids and (b) peak abundance during wet seasons. A detailed study of ecologically important local butterfly fauna and their host plants is in progress, to construct a butterfly garden in Kalpakkam to attract and support butterflies.

Keywords: Butterfly, DAE campus, dominance, Kalpakkam, peak abundance, seasonality.

INTRODUCTION

Seasonality is a common phenomenon in insect populations. Seasonal fluctuations are often influenced by environmental factors including temperature, photoperiod, rainfall, humidity, variation in the availability of food resources, and vegetation cover such as herbs and shrubs (Anu 2006; Anu et al. 2009; Shanthi et al. 2009; Tiple & Khurad 2009). Butterflies have important ecosystem roles including pollination, and they are useful in studies of population and community ecology (Pollard 1991) as indicators of ecosystem health because they are very sensitive to changes in microclimate and habitat (Erhardt 1985; Kremen 1992). Many species are strictly seasonal (Kunte 1997), and their population dynamics are generally considered to be governed by environmental factors. In India butterflies have been documented since the turn of 19th century (Williams 1927, 1930, 1938), however, little information is available concerning butterflies in the southern plains region. The purpose of this study is to determine trends in butterfly species constellations and identify their

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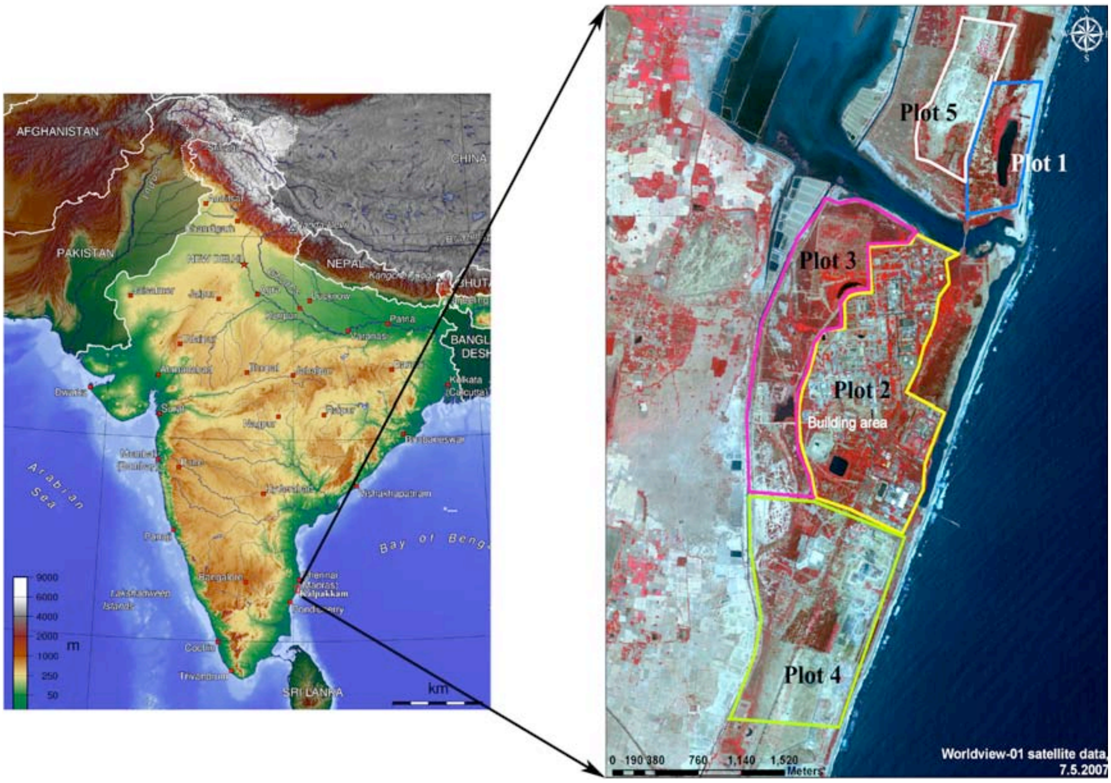

Image 1. Study area

temporal variation, diversity and abundance.

MATERIALS AND METHODS

Study area: The DAE campus at Kalpakkam (12^{0}33.7’N & 80^{0}10.5’E, ~2500 acres), Tamil Nadu, encompasses seashore and a vast plain area of the Bay of Bengal (Image 1). The coastal system forms a complex natural site where intense interactions occur among land, sea and atmosphere. This unique ecosystem spreads through the biologically diverse and productive habitat of native flora and fauna and is aesthetically blended with introduced vegetation. The main natural vegetation observed at 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 & Ragupathy 2002).

Butterfly census technique: Butterfly species abundance was assessed quantitatively across different seasons. To determine abundance, field work was carried out from June 2008 to May 2009 using the line transect count method as per Kunte (1997) with minor modification. In this method five permanent 300-line transects were set up in each plot using Global Positioning System (GPS) (Garmin, 76CSx). Transects covered all microhabitats including gardens, scrub, riparian corridors, sandy areas and monoculture *Casuarina* plantation. Each transect was slowly traversed at a uniform pace for 30 minutes from 0930 to 1130 hr during good weather periods (no heavy rain and strong wind). This is a suitable method adopted by others for surveying butterflies in a wide range of habitats (Walpole & Sheldon 1999; Caldas & Robbins 2003; Koh & Sodhi 2004). All individuals were identified in the field using standard guides (Gunathilagaraj et al. 1998; Kunte 2000; Hussain et al. 2008).

Data analysis: For the interpretation of collected data, the year was divided into four periods: southwest monsoon - SWM (June to September), northeast monsoon - NEM (October to December), winter (January to February) and hot summer (March to May). Data on mean temperature, mean relative humidity, monthly rainfall and number of rainy days were collected from the meteorological station at IGCAR,

Table 1. Total number, percentage of genus, species and individuals collected per family

	Family	No. of genera	No. of species	No. of individual
1	Papilionidae	4 (9%)	5 (9%)	144 (6.6%)
2	Pieridae	11 (25%)	15 (26.7%)	635 (29%)
3	Lycaenidae	12 (27.2%)	12 (21.4%)	209 (9.6%)
4	Nymphalidae	13 (29.5%)	20 (35.7%)	1176 (54%)
5	Hesperiidae	4 (9%)	4 (7%)	13 (0.5%)
	Total (5)	44	56	2177

Kalpakkam. Pearson's correlation analysis was carried out to assess correlations between abiotic factors and richness and abundance of the butterfly populations. Species richness (sample based rarefaction) at different seasons and seasonal species composition (cluster analysis) were calculated using Biodiversity Pro software version 2 (McAleece et al. 1997).

RESULTS AND DISCUSSION

Community composition of butterfly fauna: A total of 2177 individuals comprising 56 butterfly species from five families and 44 genera were recorded during the present study. Nymphalidae was the dominant family in terms of species richness (20 species; 29.5% of genera) and abundance, followed by Pieridae (15 species, 25% genera), Lycaenidae (12 species, 27.2% genera) and Papilionidae (five species, 9% genera). Hesperiidae was represented by only four species in the surveyed area (Table 1). A similar pattern has been reported from the northern and southern parts of the Western Ghats, and also from other regions of India (Kunte 1997; Devy & Priya 2001; Sreekumar & Balakrishnan 2001; Bhalodia et al. 2002; Chandra et al. 2002; Nair 2002; Soniya & Palot 2002; Arun & Azeez 2003; Palot & Soniya 2003; Borkar & Komarpant 2004; Rane & Ranade 2004; Ambrose & Raj 2005; Bhuyan et al. 2005; Eswaran & Promod 2005; Padhye et al. 2006; Chandra et al. 2007; Chandrakar et al. 2007; Kumar et al. 2007; Rufus & Sabarinathan 2007; Dolia et al. 2008). Interestingly, 62.5% of the species, and 83% of the individuals collected belonged to two families (Nymphalidae and Pieridae). The greatest number of species was observed in the month of October (32 species), representing 57% of total species

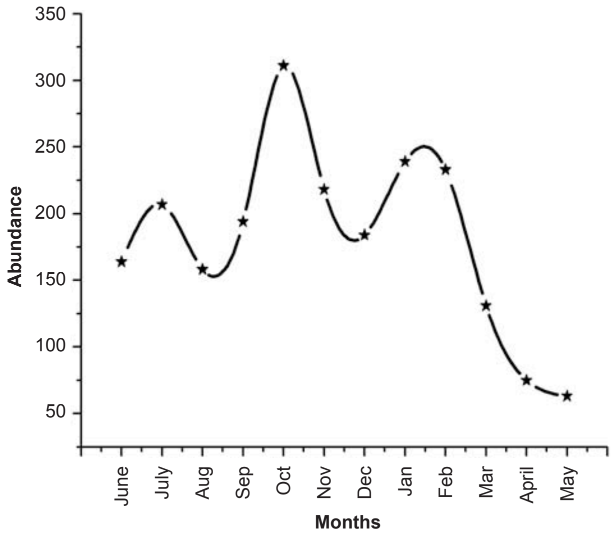

Figure 1. Abundance profile for butterflies observed in different months

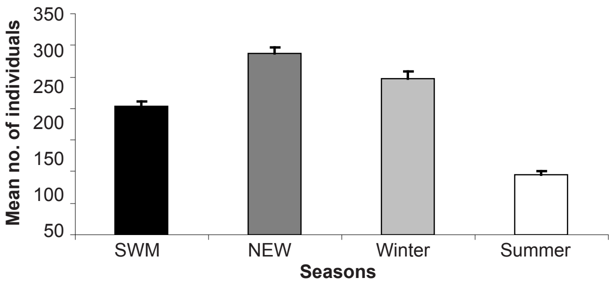

Figure 2. Seasonal abundance patterns of butterfly communities in Kalpakkam

(8 species were represented by a single individual). Some species, namely, *Danaus chrysippus*, *Acraea violae*, *Tirumala septentrionis*, *Eurema hecabe* and *Ariadne merione* were observed regularly and more commonly (Appendix 1).

Temporal abundance and seasonality profile of butterflies: The observed butterfly numbers from all transects were pooled and considered as a

Table 2. Seasonality of butterflies in different seasons in Kalpakkam

	SWM	NEM	Winter	Summer
Richness (number of species)	31	43	33	16
Abundance (Average)	204	287	248	95
Unique species	4	13	2	-
Rainfall (Mean mm)	224	744.5	18.5	35
Temperature °C (Average)	30.6	28.4	27.7	31

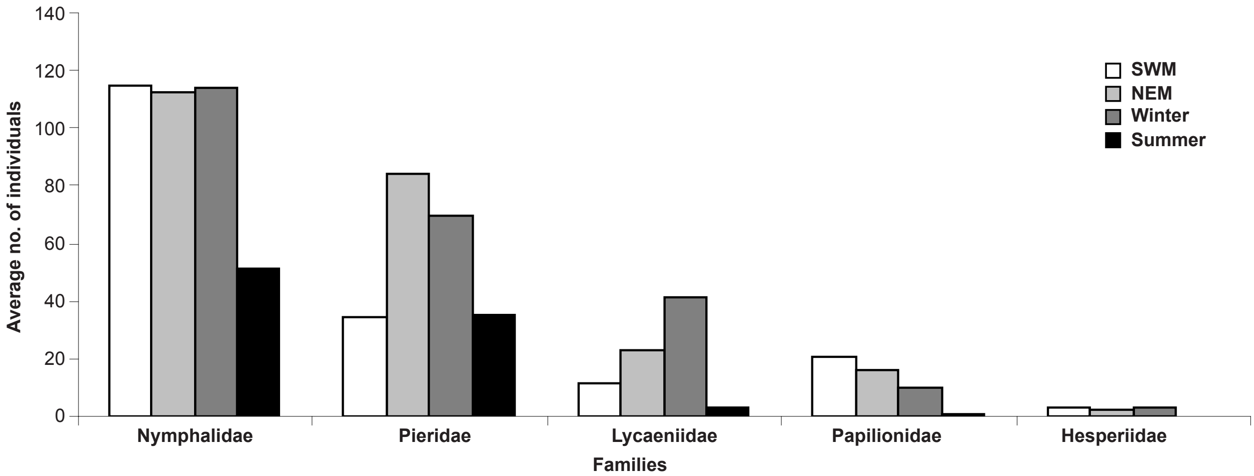

Figure 3. Population trends of butterfly families in different seasons

month of collection. Butterfly population fluctuated monthly. At DAE campus three major abundance peaks were observed in the months of July, October and January/February (Fig. 1). Earlier, Kunte (2005) had observed peak butterfly activity from October to January/February at Nilgiri and Anamalai Hills of southern Western Ghats. Our results are in accordance with his observation. Butterfly population rapidly declined during the period March to June. Usually, in southern India, these months are very hot (Maximum temperature 34^{0}C). Moreover, factors such as scarcity of water, poor nectar and dry vegetation, results in less butterfly abundance and lower survival ability of most species. Swaay (1990) suggests that butterflies, like any other insects are very vulnerable to changes in their environment because of their specialized life cycle. Any minor to major abiotic stress may lead to substantial decline to complete dwindling of the butterfly species and thus the change in butterfly diversity can be used as an indicator of environmental degradation.

Figure 2 describes butterfly abundance patterns during different seasons. More number of adult butterflies were observed during the periods of NEM and winter followed by SWM and summer. In southern plains, ideal breeding season for most of the butterflies is NEM and it continues till winter. This is due to the fact that during these seasons Tamil Nadu receives sufficient rain (Mean 744.5mm) and prevalence of conducive temperature (28^{0}C) (Table 2). These two factors are vital to both butterflies as well as larval host plants. In tropical region with distinct wet and dry seasons, many insect species attain maximum adult abundance during the wet seasons (Didham & Springate 2003; Tiple & Khurad 2009). In agreement with above observation, the present study also revealed that the butterfly abundance and species diversity were more during wet season (NEM) than in other periods. In India the monsoons govern, distribution of butterfly communities (Didham & Springate 2003; Hill et al. 2003; Kunte 2005; Padhye et al. 2006; Tiple & Khurad 2009) to a large extent. Many researchers have reported that butterflies are good responders to changes in the environment (Kunte 1997; Arun 2002; Borkar & Komarpant 2004; Kunte 2005; Padhye et al. 2006; Tiple et al. 2006; 2007; Joshi 2007; Mathew & Anto 2007; Krishnakumar et al. 2008). The relationships between butterflies and climate are complex, involving all four stages of the life cycle. Food habits among species (Gilbert & Singer 1975; Kitahara et al. 2000) also influence the relationships between climate and butterfly diversity and abundance (South wood 1975). Some predominant host plants such as, *Lantana camara, Lucas aspera, Tridax procumbens*, *Mimosa pudica, Gomphrena serrata, Vernonia cinerea, Tephrosia purpurea, Canthium dicoccum, Euphorbia antliquaram, Crotalaria verucosa, Heliotropium indicum, Calotropis gigantean* have appeared to play major role on diversity and abundance patterns of butterfly communities at Kalpakkam. Some butterfly species were observed in more numbers and a few of them were seen at particular season. In our observation 13 unique species (seen only in single season) were recorded during NEM. Similarly four unique species

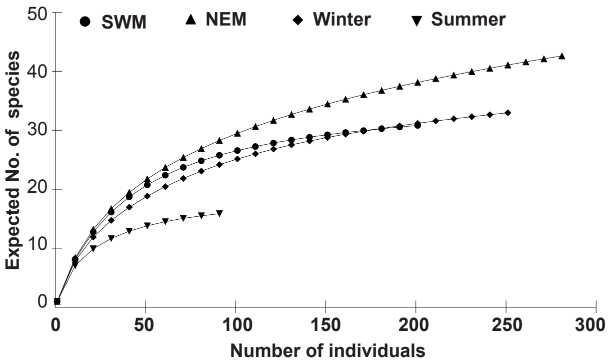

Figure 4. Sample based rarefaction curve for the different seasons

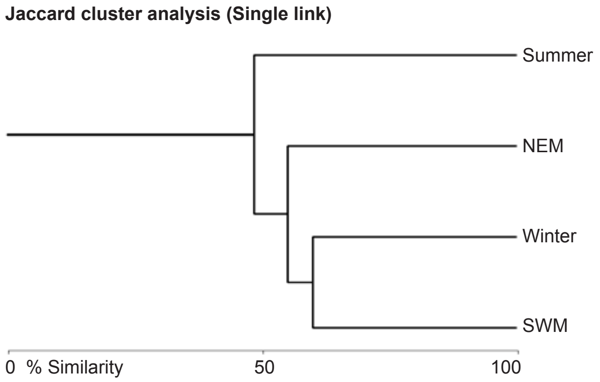

Figure 5. Jaccard similarity matrix dendrogram (presence and absence) comparing different seasons by their butterfly species assemblage

were observed in the SWM and only two unique species were observed during the winter (Table 2). This interesting pattern is not only due to the density/availability of the host plants, but also probably due to the phenophases of the host plants (Kunte 2000-01).

Among overall family abundance, the Nymphalidae was preponderant during all the seasons, followed by Pieridae, Lycaenidae and Papilionidae. Abundance of Nymphalidae remained same during all seasons except during summer. On other hand, Pieridae and Lycaenidae populations fluctuated widely during all the seasons. Pieridae abundance was more during NEM, whereas Lycaenidae was more during winter. Seasonal preference of different groups could be the possible reasons and this gives rise to the emergence of unique species. Thus the presence of the unique species altered the entire population trend and changed the community composition (Fig. 3).

Seasonal richness: Estimates of species richness during different seasons are expressed through sample based rarefaction (Fig. 4). Expected number of species have been plotted against occurrence of individuals. This plot provides a measure of species diversity which is robust to sample size effect permitting comparison between communities. Steep curves indicate more diverse communities. A striking point of an examination of the rarefaction curves is that during NEM period highest curvature was noticed indicating more diverse communities which also coincided with field observation. This means that species richness per occurrence of individuals was highest in this season. The other extreme season was summer during which relatively low species richness was observed.

Table 3. Abiotic and butterfly variation in different months

Year-Month	Temperature (°C)	Humidity (%)	Rainfall (mm)	Rainy days	Richness	Abundance
2008-June	32.7 (30.5)*	53.7 (73.1)*	12.5	3	21	164
2008-July	31.2 (30.7) *	65.5 (73.5) *	43	7	28	207
2008-August	30.0 (29.3) *	72.9 (75.8) *	104.5	11	24	158
2008-September	28.9 (29.3) *	73.9 (79.8) *	64	9	19	194
2008-October	28.8 (28.2) *	75.0 (83.8) *	307	16	32	311
2008-November	28.6 (26.5) *	71.9 (83.7) *	349	16	24	218
2008-December	28.0 (26.3) *	67.5 (80.9) *	88.5	2	26	184
2009-January	27.3 (27.3) *	65.9 (80.0) *	18.5	5	29	239
2009-February	28.2 (27.4) *	65.2 (79.8) *	Nil	0	25	233
2009-March	29.1 (27.9) *	71.4 (81.7) *	13	2	16	131
2009-April	31.4 (31.2) *	68.6 (81.9) *	Nil	0	13	75
2009-May	32.6 (30.6) *	65.5 (77.4) *	22	3	11	63

*Data in parenthesis is mean of 10 years (source: Kalpakkam Meteorological Station)

Table 4. Correlation between weather parameter and butterfly population in DAE Campus, Kalpakkam

Factors	Temp. (°C)	Humidity	Rainfall (mm)	Rainy day	Richness	Abundance
Temp. (°C)	1					
Humidity	-0.506	1				
Rainfall (mm)	-0.316	0.524	1			
Rainy day	-0.237	0.561*	0.889**	1		
Richness	-0.578*	0.111	0.454	0.489	1	
Abundance	-0.652*	0.225	0.547	0.566*	0.918**	1

* significant at < 0.05; ** significant at < 0.01

SWM period appeared to have comparatively steeper rarefaction curve, indicating relatively high evenness as compared with most other communities, whereas winter has relatively low evenness.

Cluster analysis: The clustering of species based on their presence and absence during different seasonal periods was compared by using Jaccard single linkage clustering (Fig. 5). The similarity matrix showed that SWM and winter formed a single cluster group. This indicated that both periods having the similar species composition, while NEM and summer periods behaved as independent period. Eventhough the above finding conforms the seasonal variability in species composition, the scale of variability was just 10-15 %, which is not significant. This clearly showed that entire butterfly community was made up of large proportion of common species of general nature.

Abundance, richness and their correlation with weather parameters: Butterflies prefer a suitable climatic condition and they respond reasonably to even subtle the change in climate, which has been attributed to the fact that their entire life directly depend on temperature and monsoons. Mathew & Anto (2007) have reported that temperature ranges between 27-29 ^{0}C and humidity ranging between 60-80 % are the most favourable for butterfly growth. In present study, the period between September to February (NEM and winter) was found to be conducive for butterfly community, which was mainly due to the optimum temperature and high humidity. Earlier studies (Kunte 2000-01; Padhye et al. 2006; Tiple & Khurad 2009) also suggest that temperature and precipitation are two vital factors which influence butterflies richness and population directly. Their abundance and richness increased with decreasing temperature and increasing humidity, the abundance drastically decreased at higher temperature during summer months which ranged from March to May (Tables 2 & 3).

Increase in temperature during summer and increase in relative humidity during rainy seasons significantly influenced the population buildup and communities at Kalpakkam. Similar findings have been reported from elsewhere where in the population was correlated negatively with temperature and positively with relative humidity (Mathew & Anto 2007).

The correlation analysis between weather parameter and butterfly diversity and abundance at Kalpakkam is given in Table 4. During the present study increased number of butterfly species was associated with wetter seasons, and their abundance fluctuation was positively correlated with richness ($R = 0.918$, $p = <0.01\%$) (Woods et al. 2008; Tiple & Khurad 2009). Temperature was negatively correlated with richness ($R = -0.578$, $p = <0.05$) and abundance ($R = -0.652$, $p = <0.05$). It is known fact that high temperature negatively affects butterfly abundance, life cycle and activity (Roy et al. 2001). It is known that elevated atmospheric temperature affects adversely the butterfly abundance, life cycle and their psychological activity (Roy et al. 2001). In the present investigation the Plain Tiger and Tawny Castor were observed during all the seasons and significant numbers were observed even during summer. In this context it is worth mentioning that species present during summer and presumed to be well adapted species are hardly the ones well adapted to other seasons.

CONCLUSION

Nymphalidae was found to be the dominant family during all seasons, and October and January appeared to be the most favourable period for butterflies in the DAE campus. Moreover, the NEM periods followed

Appendix 1. Seasonal abundance (mean) and list of butterfly species recorded in Kalpakkam

	Family / Subfamily	Scientific name	Common name	SWM	NEM	Winter	Summer
	Papilionidae						
1	Papilioninae	*Atrophaneura aristolochiae* (Fabricius, 1775)	Common Rose	5		2	
2	Papilioninae	*Graphium agamemnon* (Linnaeus, 1758)	Tailed Jay (Image 2)		1	1	
3	Papilioninae	*Papilio polytes* (Linnaeus, 1758)	Common Mormon	2	2	3	1
4	Papilioninae	*Pachliopta hector* (Linnaeus, 1758)	Crimson Rose	9	13	5	
5	Papilioninae	*Papilio demoleus (Linnaeus, 1758)*	Lime Butterfly (Image 3)	5	2		
	Pieridae						
6	Coliadinae	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant		41	1	
7	Coliadinae	*Catopsilia Pomona* (Fabricius, 1775)	Common Emigrant	6	18	1	2
8	Coliadinae	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow (Image 4)	11	12	29	7
9	Pierinae	*Anaphaeis aurota* (Fabricius, 1793)	Pioneer (Image 5)	13	9	11	9
10	Pierinae	*Appias libythea* Fabricius, 1775	Striped Albatross	1	2	2	
11	Pierinae	*Cepora nerissa* (Fabricius, 1795)	Common Gull	5	6		
12	Pierinae	*Colotis amata* (Fabricius, 1775)	Small Salmon Arab	4	2	4	2
13	Pierinae	*Colotis danae* (Fabricius, 1775)	Crimson Tip (Image 6)		5		
14	Pierinae	*Colotis etrida* (Boisduval, 1836)	Little Orange Tip			1	
15	Pierinae	*Colotis eucharis* (Fabricius, 1775)	Plain Orange Tip		1		
16	Pierinae	*Delias eucharis* (Drury, 1773)	Common Jezebel		3		
17	Pierinae	*Hebomoia glaucippe* (Linnaeus, 1758)	Great Orange Tip		3		
18	Pierinae	*Pareronia valeria* (Cramer, 1776)	Common Wanderer		3	5	3
19	Pierinae	*Leptosia nina* (Fabricius, 1793)	Psyche (Image 7)	3	5	20	13
20	Pierinae	*Ixias pyrene* (Linnaeus, 1764)	Yellow Orange Tip		1		
	Nymphalidae						
21	Biblidinae	*Ariadne merione* (Cramer, 1777)	Common Castor (Image 8)	5	15	16	9
22	Danainae	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger (Image 9)	42	39	33	19
23	Danainae	*Danaus genutia* (Cramer, 1779)	Striped Tiger (Image 10)	4	1	8	1
24	Danainae	*Euploea core* (Cramer, 1780)	Common Crow (Image 11)	7	4	4	4
25	Danainae	*Tirumala limniace* (Cramer, 1775)	Blue Tiger (Image 12)	8	9	3	
26	Danainae	*Tirumala septentrionis* (Butler, 1874)	Dark Blue Tiger	16	15	5	4
27	Heliconiinae	*Acraea violae*(Fabricius, 1793)	Tawny Coster	21	20	36	14
28	Heliconiinae	*Phalanta phalantha* (Drury, 1773)	Common Leopard	5	5	2	
29	Limenitidinae	*Neptis hylas* (Linnaeus, 1758)	Common Sailer (Image 13)	1	1	4	3
30	Nymphalinae	*Hypolimnas bolina* (Linnaeus, 1758)	Great Eggfly (Image 14)		4		
31	Nymphalinae	*Hypolimnas misippus* (Linnaeus, 1764)	Danaid Eggfly		4	1	
32	Nymphalinae	*Junonia orithya* (Linnaeus, 1764)	Blue Pansy	2		1	
33	Nymphalinae	*Junonia iphita* (Cramer, 1779)	Chocolate Pansy (Image 15)		2	1	
34	Nymphalinae	*Junonia atlites* (Linnaeus, 1763)	Grey Pansy (Image 16)	5			
35	Nymphalinae	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy (Image 17)	6	1	2	1
36	Nymphalinae	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy (Image 18)	1		3	
37	Nymphalinae	*Junonia hierta* (Fabricius, 1798)	Yellow Pansy (Image 19)		1		
38	Nymphalinae	*Cynthia cardui* (Linnaeus, 1758)	Painted Lady (Image 20)	2			
39	Satyrinae	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	1			
40	Satyrinae	*Mycalesis perseus* (Fabricius, 1775)	Common Bush Brown		1		

	Family / Subfamily	Scientific name	Common name	SWM	NEM	Winter	Summer
	Lycaenidae						
41	Curetinae	*Curetis thetis* (Drury, 1773)	Indian Sunbeam		3		
42	Polyommatinae	*Azanus ubaldus* (Cramer, 1782)	Bright Babul Blue	2			
43	Polyommatinae	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot (Image 21)	9	12	26	3
44	Polyommatinae	*Catochrysops strabo* (Fabricius, 1793)	* Forget Me Not				
45	Polyommatinae	*Chilades lajus* (Stoll, 1780)	Lime Blue		4		
46	Polyommatinae	*Everes lacturnus* (Godart, 1824)	Indian Cupid	3	1	1	
47	Polyommatinae	*Jamidesceleno celeno* (Cramer, 1775)	Common Cerulean			7	
48	Polyommatinae	*Leptotes plinius* (Fabricius, 1793)	Zebra Blue	1		5	
49	Polyommatinae	*Pseudozizeeria maha* (Kollar, 1844)	Pale Grass Blue		13	6	
50	Polyommatinae	*Zizina otis* (Fabricius, 1787)	* Lesser Grass Blue				
51	Theclinae	*Arhopala amantes* (Hewitson, 1862)	* Large Oakblue				
52	Theclinae	*Spindasis vulcanus* (Fabricius, 1775)	Common Silverline		1		
	Hesperiidae						
53	Hesperiinae	*Parnara guttata* (Bremer & Grey, 1852)	Common Straight Swift	3	2	3	
54	Hesperiinae	*Suastus gremius* (Fabricius, 1798)	* Indian Palm Bob				
55	Pyrginae	*Gomalia elma* (Trimen, 1862)	* African Mallow Skipper				
56	Pyrginae	*Spialia galba* (Fabricius, 1793)	Indian Grizzled Skipper		1		
			Total (56 Species)	204	287	248	95

*recorded only during inventory, hence, not included in data

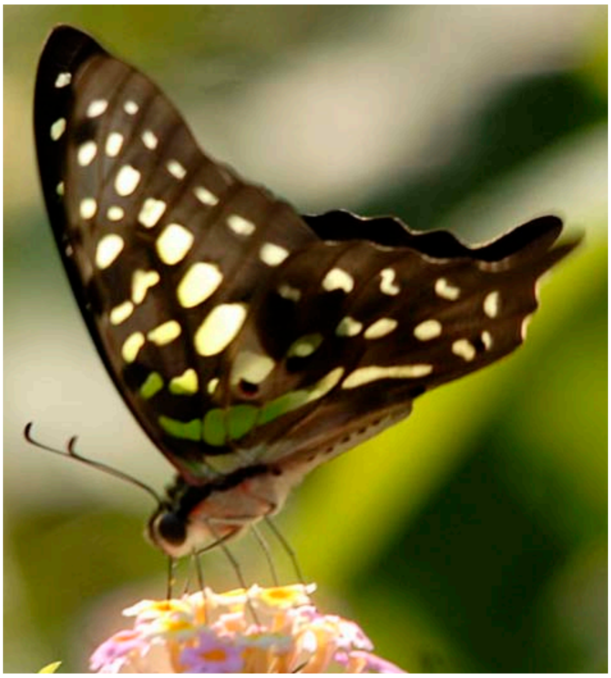

Image 2. Tailed Jay *Graphium agamemnon*

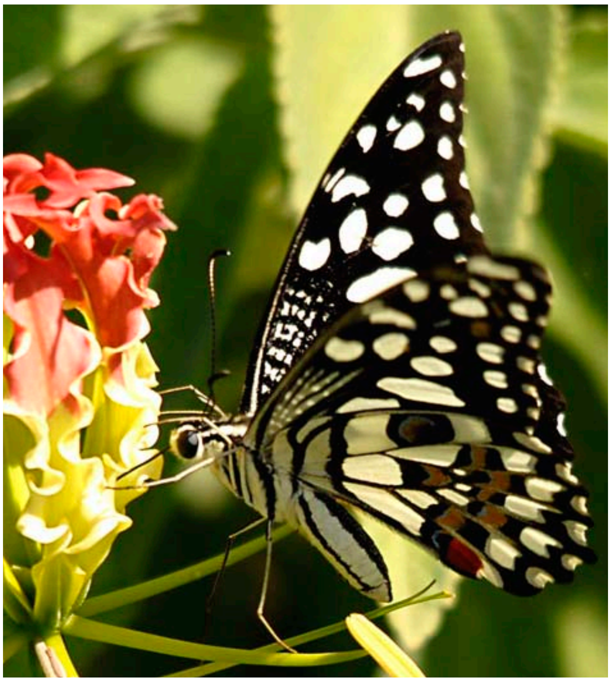

Image 3. Lime Butterfly *Papilio demoleus*

by winter are more diverse and denser seasons for these insects. From cluster analysis it was clear that the overall species assemblage variability was very meager. This was due to the dominance of generalist species rather than seasonal specialists. It was also observed that NEM harboured more seasonal specialist

Image 4. Common Grass Yellow *Eurema hecabe*

Image 5. Pioneer *Anaphaeis aurota*

Image 6. Crimson Tip *Colotis danae*

Image 7. Psyche *Leptosia nina*

Image 8. Common Castor *Ariadne merione*

Image 9. Plain Tiger *Danaus chrysippus*

Image 10. Striped Tiger *Danaus genutia*

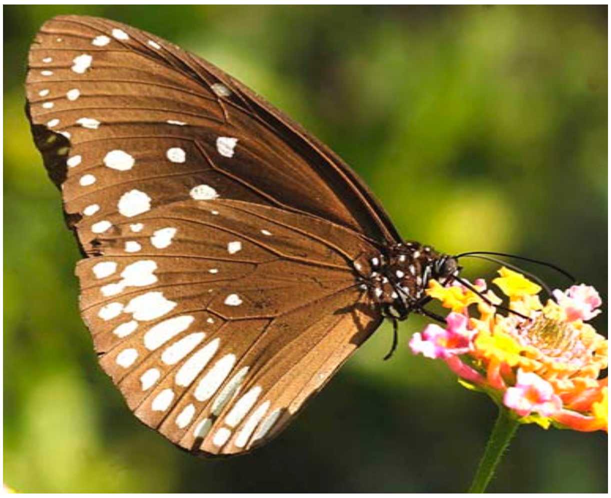

Image 11. Common Crow *Euploea core*

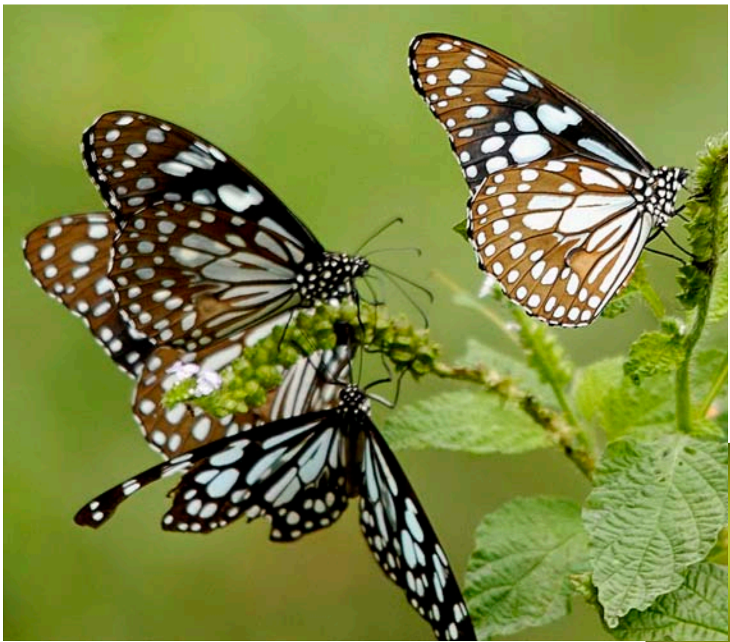

Image 12. Blue Tiger *Tirumala limniace*

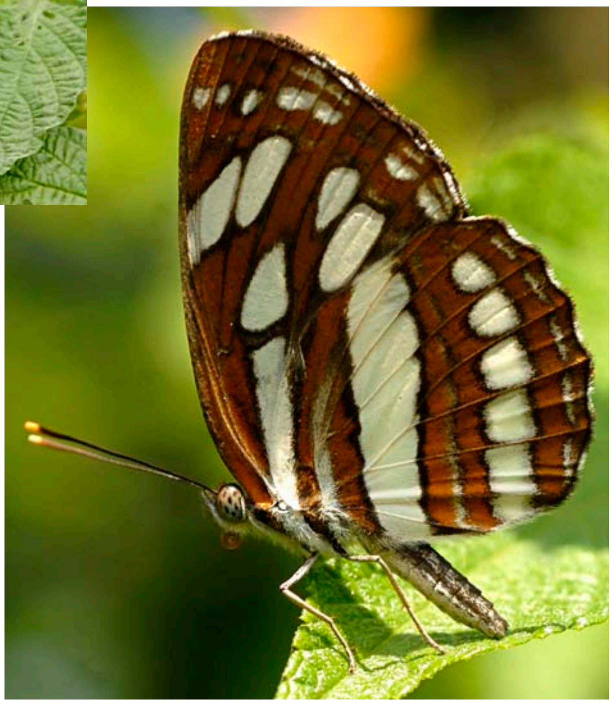

Image 13. Common Sailer *Neptis hylas*

Image 15. Choclate Pansy *Junonia iphita*

Image 14. Great Eggfly *Hypolimnas bolina*

Image 16. Grey Pansy *Junonia atlites*

Image 17. Lemon Pansy *Junonia hierta*

Image 18. Peacock Pansy *Junonia almana*

Image 19. Yellow Pansy *Junonia hierta*

Image 20. Painted Lady *Cynthia cardui*

Image 21. Common Pierrot *Castalius rosimon*

species than other seasons. In the present study we observed that the temperature range of 27-29 ^{0}C and relative humidity between 80-85 % were most suitable climatic conditions for the coastal plain butterfly assemblage.

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