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Research Article
Butterfly Gardens and Butterfly Populations: Do Host and Nectar Plant Strategies Drive Butterfly Status

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Abstract

Background and Objective: Butterfly gardens help to increase the population number and through the careful selection of host plants and restoration of habitats, a diverse assemblage of butterflies could be sustained even in urban areas. It is necessary to gather information on the impact of habitat creation through such gardens and their effectiveness in increasing the population. The objective was to study the diversity and seasonal abundance of butterflies in the Butterfly Safari at Thenmala in Kerala, India. **Methodology:** The butterflies were recorded using a standard transect counting method. Butterflies encountered along a fixed transect route of 300 m length and 25 m width, traversing the Safari were recorded daily, from September, 2008-August, 2010. For sampling, butterflies encountered at an approximate distance of 5 m on either side of transect were recorded. Seasonal index of butterflies was calculated by seasonal index formula. **Results:** A total of 13,104 individuals belonging to 99 butterfly species representing 70 genera under 5 families were recorded, of which six species have protected status under the Indian Wildlife Act, another five were endemic to the Western Ghats region and five were rare. Nymphalidae with 42 species was the most dominant family followed by Lycaenidae (22 species), Papilionidae (15 species), Hesperiidae (11 species) and Pieridae (9 species). **Conclusion:** The butterfly population showed an increasing trend during the monsoon season (June-October) reaching its peak in November. The population remained low during the summer months (March-May). The study showed the significant benefit of such parks in biodiversity conservation, recreation and education.

Key words: Host plants, butterflies, nectar plants, shendurney wildlife sanctuary, thenmala butterfly safari

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Butterfly gardening is conservation-cum educational program. Butterfly gardening as an art of growing plants to attract butterflies. Butterfly gardens can be set up in any location by introducing butterfly host plants and by recreating suitable habitats[1]. Generally, locations that are close to natural forests or natural vegetation will attract more species compared to urban areas. Similarly, larger gardens are likely to contain higher diversity and abundance compared to smaller gardens. By establishing butterfly gardens, it was possible to gain insight into the life history, behaviour and role of butterflies in sustaining natural ecosystems[2].

In India, the importance of butterfly gardens for the *in situ* conservation and propagation of butterflies has been studied in detail[3,4]. Information pertaining to the life history patterns, host range and habitat associations of various butterflies is essential prior to designing the garden. There are two major phases in the life cycle of butterflies, a juvenile or caterpillar stage which feeds on the foliage of specific plants and an adult butterfly stage which feeds on nectar in flowers or sap of over-ripe fruits, sappy exudations from plants or the fluid content of excreta of animals and birds[5].

Thenmala is a thickly populated area and agriculture is the main vocation of the people. Being a forest area, there were not many job opportunities for the people and unemployment is rampant. As a result, many people depend on the forests for their livelihood leading to forest degradation. In order to minimize dependence of local people on the forest, various programs are underway, of which the most important is the formation of the Thenmala Ecotourism Promotion Society. Under this, the Thenmala Ecotourism Project was formed for promoting ecotourism in the area and for generating rural employment opportunities. Besides various entertainment activities such as mountain trekking, boating, bird watching etc., themes promoting environmental education of the public such as herbal gardens, astrological parks, fern collection etc., are also set up in the area. Butterfly Safari is a new item that has been recently added to these projects in order to achieve butterfly conservation and to generate conservation awareness among the visitors.

Butterflies are taxonomically well known group, which have received a reasonable amount of attention throughout the world[6]. Many butterfly species are strictly seasonal and prefer particular habitats[7]. Information boards as well as models depicting butterfly life can be set up in the garden to provide information on the life of butterflies[8]. As the butterfly population increases, a variety of organisms including praying mantis, spiders, lizards and birds can also colonize the area leading to a stabilization of habitats and improved functioning of ecosystems[9,10].

Recent studies investigating the ecological impacts of urbanization in mostly tropical regions have shown distinct changes in species richness and composition along rural-urban gradients, local extinctions of native species, increases in the number of exotic species toward centers of urbanization and the persistence of certain native species in urban areas[11-14]. A current challenge is to understand the different responses of individual species to urbanization, including their underlying mechanisms, in order to identify vulnerable species and to develop effective measures for their conservation. Due to large scale destruction of habitat and environmental unfriendly agricultural practices, many species are on the verge of extinction. Butterfly gardens help to increase the population number and through the careful selection of host plants and restoration of habitats, a diverse assemblage of butterflies could be sustained even in urban areas. It is necessary to gather information on the impact of habitat creation through such gardens and their effectiveness in increasing the population. Information on seasonality and population assemblage in butterfly gardens are also required to make modifications in future plans. The objective of this study was to study the role of butterfly gardens in conserving the butterfly population and the seasonal trends in population abundance at Thenmala butterfly safari.

MATERIALS AND METHODS

Study area: The study was carried out in the Butterfly Safari set up at Thenmala located at 8°57'0"N and 77°4"0"E situated in the Shendurney Wildlife Sanctuary, in Kollam District, Kerala (Fig. 1). The name Shendurney has reference to the presence of an endemic tree Gluta travancorica locally known as 'Chenkurunji'. The Sanctuary has an area of 171 km^2 including the reservoir of the Kallada Dam which covers 13.72 km^2. The terrain was undulating with elevation ranging between 100-600 m (m.a.s.l). The Sanctuary was permeated by the Shendurney River, which support dense forests on either side. Temperature varies from 17-35°C with March-May being the hottest months. Maximum temperature recorded during daytime in the hottest month was about 39°C. December and January were the coldest months. Annual rainfall varied from 2600-3000 mm. The area was proclaimed as a Wildlife Sanctuary in 1984[15].

Butterfly Safari: The Butterfly Safari located in the Thenmala Ecotourism project area is Asia's largest outdoor butterfly

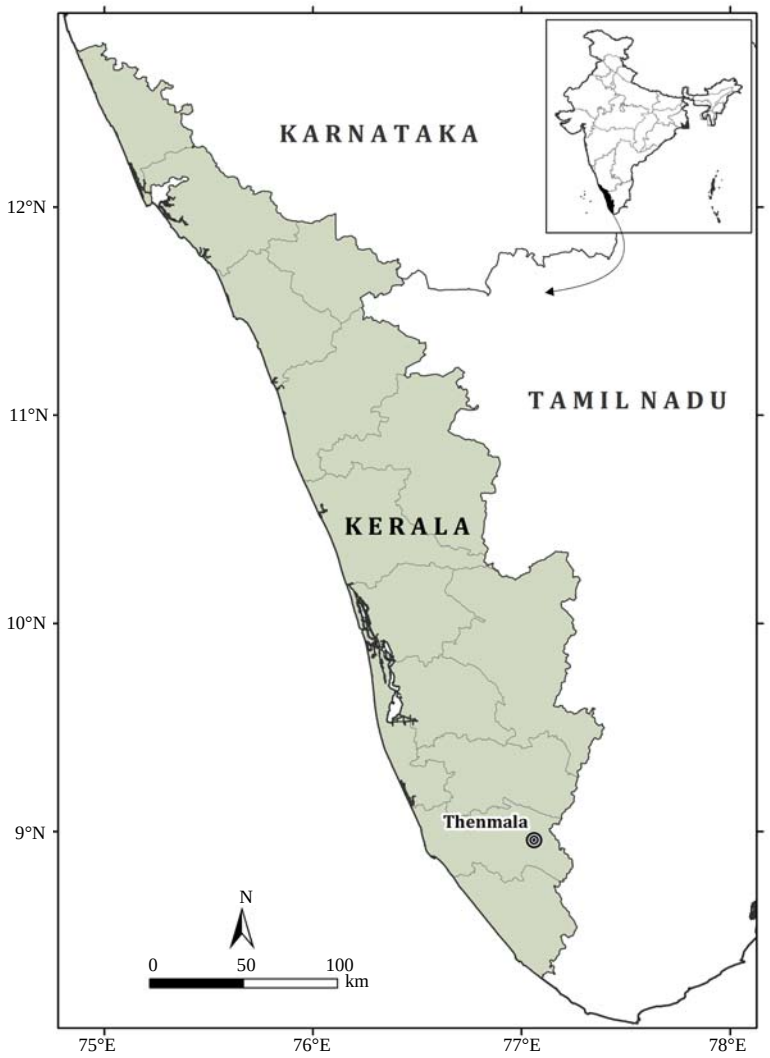

Fig. 1: Map of Kerala State showing the location of Thenmala Butterfly Safari

conservatory and situated in a 3 ha forest. The main entrance of the Safari leads to an interpretation centre where the visitors are briefed on the significance and role of butterflies in nature. The interpretation centre has an area of 58.26 m^2 with a central hall in which information boards pertaining to the distribution, biology, ecology and conservation aspects of butterflies are set up. There is also a curio shop for generating income to run the Safari.

The Interpretation Centre leads to a 500 m long nature trail traversing different butterfly habitats that have been created in the project area. The path is 1.5 m wide and is paved with laterite stones. Since the forest patch is already rich in butterfly fauna, care has been taken to keep the forest intact with minimal disturbance. Introduction of butterfly host plants was undertaken in a 1.5 m width laid out on either side of the path. Selection of host plants was based on preferences of the local butterfly fauna. A list of plants present in the Safari is given in Appendix I. Butterfly habitats such as areas with bright sunshine, shade, bushes, streams, ponds and lianas were set up for sustaining various groups of butterflies. In order to maintain appropriate micro climate particularly temperature and humidity, waterfalls, ponds, streams and sprinklers were set up. To provide information on the biology, ecology and behaviour of butterflies, information boards and models of butterflies were also set up along the trek path.

Monitoring of butterflies: The butterflies were recorded using a standard transect counting method[16]. For this, butterflies encountered along a fixed transect route of 300 m length and 25 m width, traversing the Safari were recorded daily, from September, 2008-August, 2010. For sampling, butterflies encountered at an approximate distance of 5 m on

Appendix I: List of Nectar and host plants introduced in the butterfly Safari Thenmala

Scientific names	Local name	Remarks
Mucuna pruriens	Naykaruna	Nectar and host plant
Tragia involucrata	Kodithoova	host plant
Passiflora subpeltata	Poodappazham	Nectar and host plant
Thottea siliquosa	Alpam	host plant
Aristolochia indica	Garudakkodi	host plant
Atalantia racemosa	Kattunarakam	host plant
Cassia alata	Aanathakara	host plant
Xylosma longifolium	Kariyilanji	-
Cassia fistula	Kanikonna	host plant
Glycosmis arborea	Paanal	host plant
Wattakaka volubilis	Vattakkakkakodi	host plant
Tylophora indica	Vallippala	host plant
Hydnocarpus pentandra	Marotti	host plant
Hydnocarpus alpina	Kaattumarotti	Larval host plant
Yellow Palm (Arecaceae)	Manja Alankarappana	host plant
Phoenix sp.	Pachappana	host plant
Ischaemum sp.	Polappullu	host plant
Citrus sp.	Narakam	host plant
Calotropis gigantea	Erukku	host plant
Polyalthia longifolia	Aranamaram	host plant
Murraya koenigii	Kariveppu	host plant
Flacourtia montana	Vayankatha	host plant
Poaceae (Bamboos)	Mula	host plant
Evodia roxburghiana	Kaattu Rubber	host plant
Kalanchoe pinnata	Ilamulachi	host plant
Kalanchoe laciniata	Paaramashi	host plant
Acronychia pedunculata	Veettu kanali	host plant
Abrus precatorius	Kunni	host plant
Passiflora edulis	Passion fruit	host plant
Ixora sp.	Thetti	Nectar host plant
Pisum sp.	Payar	host plant
Dioscorea sp.	Kachil	host plant
Cassia siamea	Manjathakara	host plant
Cassia sophera	Ponthakara	host plant
Ziziphus rugosa	Vanthudali	host plant
Ziziphus oenoplia	Cheruthudali	host plant
Ricinus communis	Avanakku	host plant
Miliusa tomentosa	Kana	host plant
Nerium oleander	Arali	host plant
Mussaenda sp.	Mussaenda	Nectar host plant
Oxalis corniculata	Puliyarila	-
Helicteres isora	Idampiri Valampiri	-
Flacourtia sp.	Loovikka	host plant
Cinnamomum sp.	Vayana	host plant
Tinospora sp.	Kaattamruthu	-
Murraya sp.	Kaattu kariveppu	host plant
Quisqualis indica	Nakshathra mulla	-
Hemidesmus indicus	Naruneendi	Larval host plant
Neolamarckia cadamba	Aatuthekku	Larval host plant
Olea dioica	Edana	-
Albizzia sp.	Nenmeni vaka	host plant
Albizzia sp.	Mullan vaka	host plant
Smilax sp.	Kaattu kariyilanji	-
Cinnamomum sp.	Karukappatta	host plant
Annona sp.	Aatha	host plant
Uvaria narum	Narum panal	host plant
Sida rhombifolia	Kurunthotti	Nectar plant
Phoenix sp.	Ennappana	host plant
Calamus rotang	Chooral	host plant
Phoenix sp.	Pachappana	host plant

either side of transect were recorded. A thirty minutes visual survey was done during each transect walk and the walking pace was slow but constant. A plot outside the Safari but in the natural forest area containing wild sources of nectar and native tree species were also selected. Two observations were made each day viz., a forenoon count between 10.30 and 11:30 h and an afternoon count between 14:30 and 15:30 h. Besides the identity of butterflies, date of observation, the number of species and individuals encountered, as well as weather parameters viz., temperature, humidity and rainfall were also recorded. For identification of butterflies, standard books/field guides were consulted[5,17-19]. The reference insect collection of the Kerala Forest Research Institute, at Peechi, was also consulted.

Data analysis: The seasonal index of butterflies of each family was calculated by using the formula:

$$\text{Seasonal Index} = \frac{\text{Month-wise mean}}{\text{Overall mean}} \times 100$$

Where, the month-wise mean is the number of butterflies for a given family sighted during the study period and the overall mean is the mean of all month-wise means. By calculating the seasonal index, the mean occurrence of each butterfly in a month in relation to the overall mean monthly sightings can be interpreted.

RESULTS AND DISCUSSION

Community composition of butterfly fauna: A total of 13,104 individuals belonging to 99 species of butterflies from 5 families and 70 genera were recorded from the Butterfly Safari at Thenmala, of which three species have protected status under different schedules of the Indian Wildlife Protection Act, five species are endemic to the Western Ghats and another fifteen species are extremely rare[5,18-20] (Appendix II). Nymphalidae was the dominant family in terms of species abundance (42%) followed by Lycaenidae (22.2%) and Papilionidae (15.3%). Pieridae was represented by only 9 species in the surveyed area (Table 1).

With regard to butterfly sightings, Nymphalidae had maximum sightings with 6549 individuals and were the most abundant family during September, October and November. *Tirumala limniace* (Blue Tiger), *Euploea core* (Common Indian Crow), *Cirrochroa thais* (Tamil yeoman), *Cupha erymanthis* (Southern Rustic), *Parantica aglea* (Glassy Blue Tiger) were the most abundant species. Roosting of Danaid butterflies on

Appendix II: Butterflies recorded from the Butterfly Safari

Family/species/common names	Observations	Status/remarks
Papilionidae		
Troides minos (Southern Birdwing)	January-October. Common in July	Endemic, Not rare
Pachliopta aristolochiae (Common Rose)	February-May	Common
P. hector (Crimson Rose)	December-May	Endemic WG/SL, Protected, Schedule I, Common
P. pandiyana (Malabar Rose)	January-December. Egg laying noticed during July and December	Endemic WG, Locally common
Graphium sarpedon (Common Blue Bottle)	Throughout the year. Egg laying observed during May-June	Common
G. doson (Common Jay)	January-April, August, November and December	Locally common
G. agamemnon (Tailed Jay)	Throughout the year	Common
G. antiphates (Five bar Sword-tail)	April	Rare
Papilio clytia (Common Mime)	February-July, September, November-December	Not Rare
P. demoleus (Lime Butterfly)	January-April, June-July, September and December. Egg laying noticed during December	Very Common
P. polytes (Common Mormon)	October-December. Very common in January to July	Very Common
P. polymnestor (Blue Mormon)	Throughout the year	Not Rare
P. liomedon (Malabar Banded Swallowtail)	July-December. Egg laying observed in September	Endemic WG, Protected, Schedule I, Rare
P. dravidarum (Malabar Raven)	April-October and December. Egg laying observed in May	Endemic WG, Uncommon
P. paris (Paris Peacock)	October-November. Egg laying observed in October	Not Rare
Pieridae		
Catopsilia Pomona (Common Emigrant)	Throughout the year	Common
C. pyranthe (Mottled Emigrant)	Throughout the year except September	Common
Eurema hecabe (Common Grass Yellow)	Throughout the year	Common
Delias eucharis (Common Jezebel)	Throughout the year except May-September	Common
Leptosia nina (Psyche)	January-February, July-September and November	Common
Pareronia valeria (Common Wanderer)	September-October	Common
Hebomoia glaucippe (Great/Giant Orange Tip)	February, April-June and November	Common
Appias indra shiva (Plain Puffin)	February-April	Rare
A. libythea (Striped Albatross)	February-July	Uncommon
Nymphalidae		
Melanitis leda (Common Evening Brown)	January-September	Common
M. zitenius gokala (Great Evening bush Brown)	February-April	Rare
Elymnias hypermnestra (Common Palmfly)	September-November, March-May. Egg laying observed in April and September	Common
Mycalesis perseus (Common Bush Brown)	January to September and December. Very common in July	Common
M. patnia (Glad-eye Bush brown)	Throughout the year	Endemic WG, Common
Orsotrioena medus (Nigger)	January-March, August to October and December	Locally common
Phalanta phalantha (Common Leopard)	January-February. Common in November-December	Common
P. alcippe (Small Leopard)	April to July and September to October. Egg laying observed in May	Locally common
Ypthima huebneri (Common Five-ring)	Throughout the year	Common
Ypthima ceylonica (White/Ceylon Four-ring)	January-March, November-December. Common in March	Locally common
Y. baldus (Common Five-ring)	January-February, June-October	Common
Polyura athamas (Common Nawab)	February-March. Egg laying observed in October	Locally common
Acraea violae (Tawny Coster)	January-September, November, February-March	Common
Cethosia nietneri (Tamil Lacewing)	April-March, September-November	Endemic WG/SL, Locally common
Cupha erymanthis (Southern rustic)	March-August, October. Egg laying in observed in May	Common
Cirrochroa thais (Tamil lioman)	April-December, Egg laying observed in April-June	Locally common
Neptis jumbah (Chestnut-streaked Sailer)	January-June	Common
N. hylas (Common Sailor)	February-October	Common
Pantoporia hordonia (Common Lascar)	January and March	Common
Athyma ranga (Black-vein Sergeant)	October-November. Egg laying observed in November	Not rare
Limenitis procris (The Commander)	January, April, August-November. Egg laying observed during October to December	Common
Parthenos sylvia (Clipper)	January, March-May, July, October-November	Rare
Tanaecia lepidea (Grey Count)	May-September	Rare
Euthalia aconthea (Common Baron)	March-May	Common
Ariadne ariadne (Angled Castor)	January-June, September-October. Egg laying observed in October	Uncommon
Junonia atlites (Grey Pansy)	March-May	Locally common
J. lemonias (Lemon Pansy)	January-May, September-December	Common
J. almana (Peacock Pansy)	January-March	Common
J. iphita (Chocolate Pansy)	Throughout the year	Common
J. hierta (Yellow Pansy)	Throughout the year	Common
Kaniska canace (Blue admiral)	January-April, June-November. Aggregation noticed in September-October	Not common
Hypolimnas bolina (Great Egg-fly)	June-July and October	Common
Hypolimnas misippus (Danaid Egg-fly)	January-May	Protected, Schedule I, Common
Doleschallia bisaltide (Autumn-leaf)	March-May, August-October and December	Rare
Parantica aglea (Glassy Blue Tiger)	Throughout the year. Aggregation during September-November	Common
Tirumala limniace (Blue Tiger)	January-April, June-November. Aggregation during September-November	Common
Tirumala septentrionis (Dark Blue Tiger)	June-October. Aggregation during September-October	Common
Danaus chrysippus (Plain Tiger/Common Tiger)	January, September-November	Common
Danaus genutia (Striped tiger)	February-March, August-November	Common
Euploea core (Common Indian Crow)	Throughout the year	Common
Charaxes solon (Black Rajah)	After rains (November-January)	Not common
Amathusia phidippus (Palm King)	September-November	Rare

Appendix II: Continue

Family/species/common names	Observations	Status/remarks
Lycaenidae		
Spalgis epius (Ape fly)	January-February, April, September and November	Not common
Bindahara phocides (Plane)	January-February, April and September	Protected, Schedule II, Not rare
Rachana jalindra macarita (Banded Royal)	January-February	Rare to very rare
Catochrysops strabo strabo (Forget-me-not)	January-February	Common
Zizula hylax (Tiny Grass Blue)	Throughout the year	Common
Euchrysops cnejus cnejus (Gram Blue)	Throughout the year	Protected, Schedule II, Common
Castalius rosimon (Common Pierrot)	January-September	Protected, Schedule I, Common
Caleta caleta (Angled Pierrot)	January-July and September to December	Not rare
Discolampa ethion (Blue Banded Pierrot)	September-November. Egg laying in November	Locally common
Neopithecops zalmora (Quaker)	October-November	Common
Pseudozizeeria maha (Pale Grass Blue)	January-March, September to December	Common
Zizeeria karsandra (Dark Grass Blue)	April-May	Common
Zizina otis (Lesser Grass Blue)	Throughout the year. Egg laying in February-March	Common
Jamides celeno (Common Cerulean)	February-April, June-September	Common
Talicada nyseus (Red Pierrot)	January-March. Very common in March	Locally common
Thaduka multicaudata (Many tailed Oak Blue)	February-May	Uncommon
Surendra quercetorum (Common Acacia Blue)	October-November	Locally common
Spindasis vulcanus (Common Silver-line)	January-March, October and December	Common
Loxura atymnus (Yam-fly)	March-April, July-December	Common
Rathinda amor (Monkey Puzzle)	January, July-September	Not rare
Rapala manea (Slate Flash)	January-March	Common
Zeltus amasa (Fluffy Tit)	January-February. Found in mud paddling aggregation in February	Not common
Hesperiidae		
Hasora chromus (Common Banded Awl)	August	Common
H. vitta (Plain Banded Awl)	August	Not Common
Tagiades obscurus (Suffused Snow Flat)	March-April, October-December	Not Rare
T. litigiosa (Water snow Flat)	March-November. Egg laying in July-August	Not Rare
Pseudocoladenia dan (Fulvous Pied Flat)	March	Common
Sarangesa dasahara (Common Small Flat)	January-March	Common
Gangara thyrsis (Giant Red Eye)	July-August	Not Rare
Taractrocera maevius (Common Grass Dart)	March-June	Locally common
T. ceramas (Tamil Grass Dart)	June-September	Locally common
Borbo cinnara (Rice Swift)	August-October	Common
Lambrix salsala lutipinnis (Chestnut Bob)	June-September	Common

Table 1: Data on the genera and species of butterflies recorded from the Safari

Family	Number of genera represented (%)	Number of species recorded (%)
Papilionidae	4 (5)	15 (15.3)
Pieridae	7 (11.5)	9 (9.1)
Lycaenidae	22 (30.4)	22 (22.4)
Nymphalidae	29 (40.5)	42 (42)
Hesperiidae	8 (11.5)	11 (11.2)
Total	70	99

Crotalaria retusa was noticed during August-November months. Aggregations of large populations of Blue Tiger, Common Indian Crow, Glassy Blue Tiger and Dark Blue Tiger were noted with individuals ranging from 250-500 per *Crotalaria retusa* and *Heliotropium keralense*. In addition to the above, *Hypolimnas misippus* (Danaid Egg-fly), which is a protected species and *Parthenos sylvia* (Clipper), *Junonia iphita* (Chocolate Pansy) and *Tirumala septentrionis* (Dark Blue Tiger), which are rare species have been recorded in Butterfly Safari (Appendix II).

Pieridae was represented by 9 species, with 1440 sightings during the entire study period. Lycaenidae were high in number during February and Hesperiidae had maximum species during July-October. In all families, the population count was high in the second year than the first year.

Mud puddling by the lycaenid *Zeltus amasa* was observed during February. Roosting of Danaine butterflies on *Crotalaria retusa* was noticed during September-October months. This was due to the fact that the *Crotalaria retusa* is a major source of Pyrrolizidine alkaloids, which is a precursor of Danaids pheromone defense chemical called Danaidone[21]. Interestingly, Danaidone is not available from the plants that the larvae feed on and must be obtained by the adults after emergence. All Danaids are irresistibly attracted to these plants and hence, the adult Danaid density was more during September-October months when these plants were flourished. The population trends of various groups of butterflies in the Butterfly Safari were presented below. A steady increase in the butterfly population count among all families showed the importance of such Safaris in attracting and sustaining butterfly population.

Seasonal Index of different butterfly populations in the Safari

Papilionidae: The population was present throughout the year with maximum being observed in November, 2008. The population showed a sharp decline in December, 2008 probably due to the heavy wind characteristic of this month.

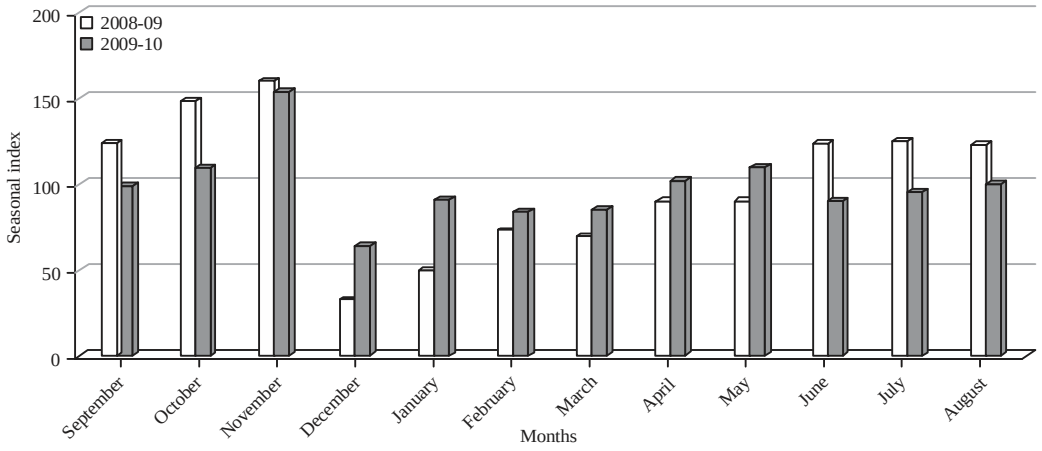

Fig. 2: Population trends of Papilionidae

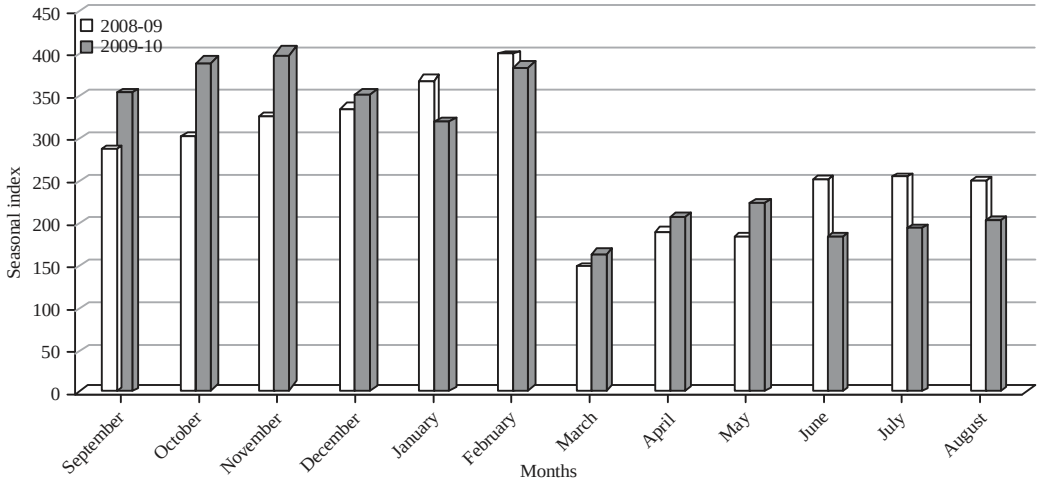

Fig. 3: Population trends of Pieridae

From June onwards, the population showed an increase in population and reached its peak during September-November. The population remained moderate during the remaining months (Fig. 2). Among the Papilionidae, the Malabar Rose (*Pachliopta pandiyana*), Common Bluebottle (*Graphium sarpedon*), Tailed Jay (*G. agamemnon*) and Blue Mormon (*Papilio polymnestor*) were observed during all months of the year. Almost all Papilionidae were found to lay their eggs during September-November when their population showed maximum count. In the case of the Malabar Banded Swallowtail (*Papilio liomedon*) an endemic, protected butterfly, adults were observed from July-December and the immature stages during September. The Southern Birdwing (*Troides minos*), was very common in July and Malabar Raven (*Papilio dravidarum*), during April-October. Egg laying of this species was noted after the commencement of the monsoon in June. Sightings of certain rare of Papilionidae such as Paris Peacock (*Papilio paris*), Five bar Swordtail (*G. antiphates*) was recorded in the safari during October-November and April, respectively. The immature stages of Southern Birdwing and Malabar Rose were very common in June-September. Sightings of certain rare Papilionidae such as Red Helen (*Papilio helenus*) were recorded in the Safari during August-November.

Pieridae: Population was present throughout the year. Maximum number of sightings was in November 2009 and moderate population was observed during December, January and February after which, there was a sharp decline from March - August in both the years (Fig. 3). The number of sightings was highest during 2009-2010 than in the previous years, which might be due to the establishment of host plants that have been introduced. While certain species such as *Catopsilia pomona, C. Pyranthe*, *Eurema hecabe*

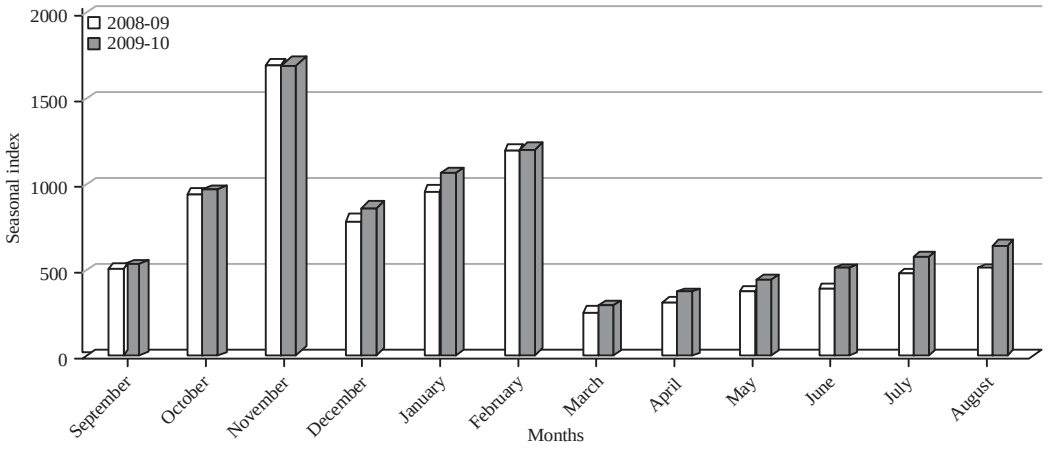

Fig. 4: Population trends of Nymphalidae

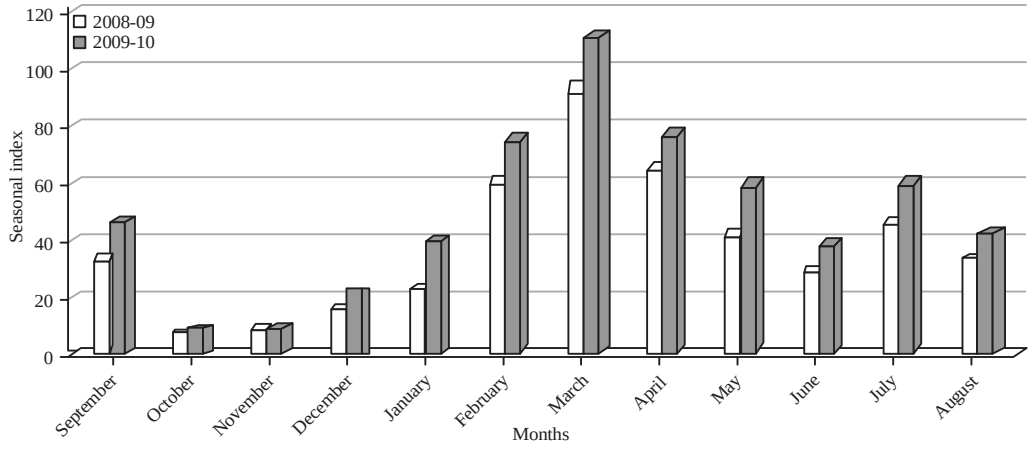

Fig. 5: Population trends of Lycaenidae

and *Delias eucharis* (an endemic species) were observed during all months of the year, species such as *Pareronia valeria* (September-October) and *Appias indra* shiva (February-April) were noted only during certain months of the year as indicated in parenthesis.

Nymphalidae: Maximum number of species recorded belonged to the family Nymphalidae (Table 1) and highest count were observed during November in both the years. The population remained more or less constant till the February after which the population showed a sharp decline in March. From April onwards, the population showed a steady increase reaching its peak during November (Fig. 4). *Amathusia phidippus, Elymnias hypemenstra, Limenitis procris, Athyma ranga*, *Tanaecia lepidea*, *Junonia atlites, J. iphita, Kaniska canace, Cupha erymanthis*, *Charaxes solon solon, Mycalesis patnia* and *Melanitis zitenius* gothe kala were some of the rare Nymphalid butterflies observed in the safari.

Lycaenidae: The population registered an upward trend from October and reached its peak during February, then showed a gradual decrease till the September (Fig. 5). The population density was maximum during February 2009 and minimum during October 2008. The number of sightings was considerably high during the second year compared to the first year, which may be due to the introduction of host and nectaring plants. The drier months of the year appeared to be more favourable to these groups.

Certain Lycaenidae such as *Bindahara phocides, Euchrysops cnejus cnejus, Castalius rosimon* were sighted only from January-September. On the other hand, the Tiny Grass Blue, Lesser Grass Blue and the Angled Pierrot *Caleta caleta* were noted in almost all months of year.

Hesperiidae: Since the members of this family are not very conspicuous, the sightings were relatively low. The population of Hesperiidae was high during the monsoon months July,

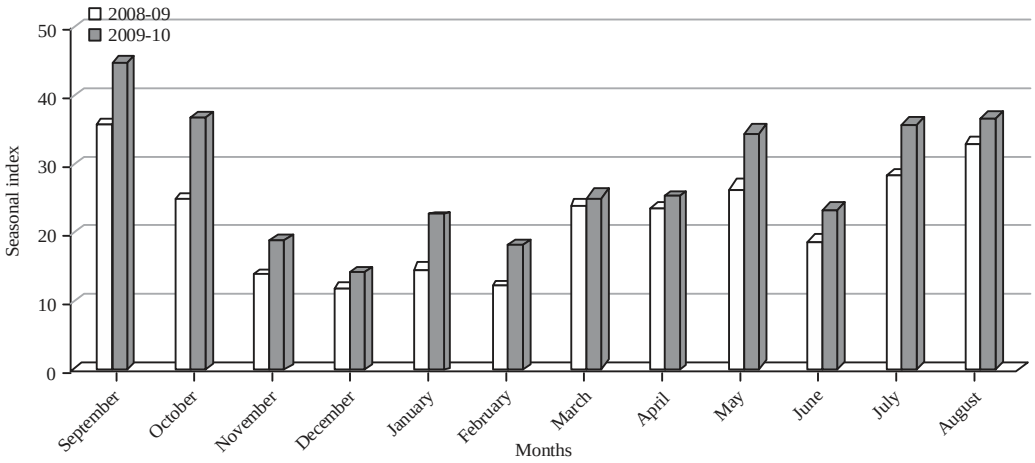

Fig. 6: Population trends of Hesperiidae

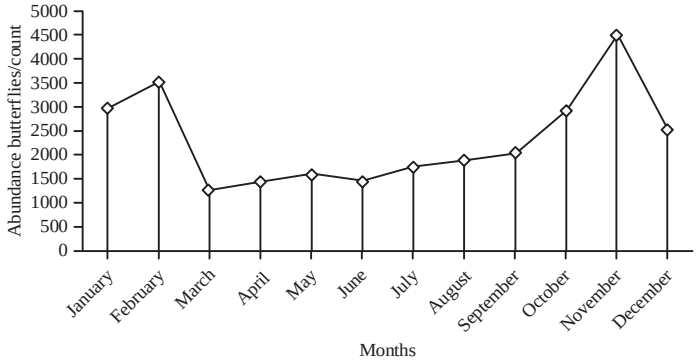

Fig. 7: Seasonal abundance of butterflies in the Butterfly Safari

August, September and the maximum sighting was during Sepetember 2009 (Fig. 6.) The seasonal index showed the highest count during July-October and then showed a declining trend from November-February after which the population number remained more or less constantly. *Hasora chromus, H. vita, Gangara thyrsis, Tagiades litigiosa, Taractrocera ceramas, Celaenorrhinus leucocera, Borbo cinnara, Ampittia dioscorides* and *Lambrix salsala* were some of the Hesperiidae commonly observed during July - August.

Overall population trend in the butterfly Safari: The overall population trend of butterflies in the Safari was shown in Fig. 7. Vegetation and favourable weather conditions were essential for the survival of butterfly populations. Temperature ranging from 24-26°C, relative humidity exceeding 85% and about 50 mm daily rainfall was found to be favourable to most butterflies[8]. The above conditions were available during the monsoon season from June-October and perhaps up to December. As a result, the butterfly population in the Safari was high during these months. The post monsoon season from January to early May was relatively dry and as a result there was a decline in the butterfly population during these months. By regulating the weather parameters (by setting up sprinklers, waterfalls etc.), it may be possible to sustain a rich butterfly populations during the off season as well in the Safari.

Habitat enrichment and introduction of suitable host plants, there was a marked increase in the number of butterflies visiting the garden, both of individuals and species. Besides the increase in the butterfly population comprising mostly of the common butterflies, there was a slow buildup of species such as autumn leaf and palm king which are considered to be rather rare in distribution. Some endemic butterflies sighted in the Safari. The increase in the frequency of sightings of many these butterflies is attributed to introduction of various butterfly host plants and conservation of local flora.

A comparison of the overall abundance of butterfly community in the Butterfly Safari compared to the control plots was also made (Fig. 8). The overall butterfly abundance

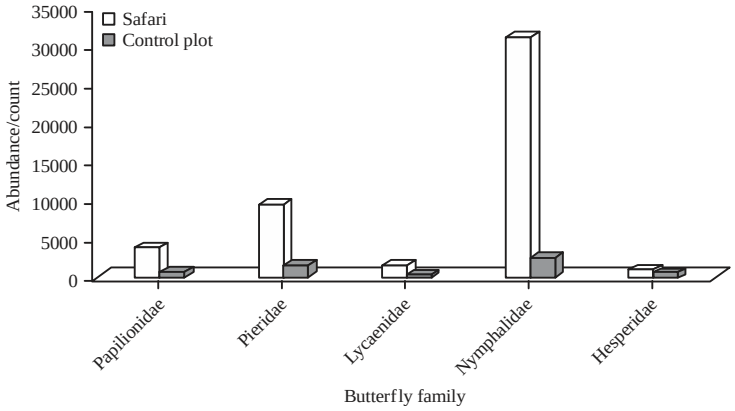

Fig. 8: Overall butterfly abundance in the Butterfly Safari compared to the natural forest (control)

showed that the Butterfly Safari had the highest population of butterflies compared to the control plots which were taken the adjoining natural forest in Thenmala. An examination of the abundance pattern of butterflies in the control plot showed that Nymphalidae was the most abundant family followed by Pieridae and Papilionidae. Nymphalidae being relatively larger and swift flying species with diverse habits were very successful in colonizing different habitats. The same was true with Pieridae and Papilionidae which rank next to Nymphalidae. Lycaenidae being relatively fragile and feeble fliers with specialized habitat requirements, their population was relatively less in all the study areas.

An analysis of the habitat preferences of butterflies showed that the natural habitats contained more of rare species compared to the carefully landscaped habitats which contained more of common species or generalists. It is well known that butterfly species diversity differs with habitats and it is related to various parameters such as vegetation diversity, host plant availability, the level of habitat disturbance etc. In general, areas with undisturbed vegetation having rich floral diversity support large butterfly communities. This observation was quite significant because it emphasizes the importance of Butterfly gardens and Safaris in the conservation of biological diversity of a region.

Butterfly garden play an important role for the *in-situ* conservation of butterflies. Habitat creation involving resource enrichment through host plant introduction and site amelioration are the key factors to be considered while setting up butterfly gardens. Butterfly gardens play an important role in conserving the local butterfly fauna and in promoting conservation awareness among the public. As a result of habitat creation and host plant introduction, as far as 99 species including five endemic, six protected and twenty five rare species could be sustained within such a limited area covering only 3 ha during the 24-months study period. This shows the tremendous significance of such parks in biodiversity conservation, recreation and education.

The relatively larger areas of forest reserves may enhance their butterfly diversities either by sustaining larger and more viable populations of species with lower risks of extinction, or by having greater diversities of microhabitat with myriad ecological niches that can support more species[22-25]. Further, the primary and old secondary vegetation in forest reserves may provide the unique microclimatic conditions (e.g., closed canopy) or specific larval host plants vital to the persistence of specialist butterfly species[26]. Koh and Sodhi[27] assessed the effectiveness of forest reserves (i.e., protected old secondary and primary forests), fragments (i.e., scattered ruderal vegetation) and urban parks (i.e., artificially revegetated habitats) in conserving butterfly diversity in a highly urbanized tropical landscape in Singapore. The result showed that urban parks adjoining forests were the second most diverse habitat and the prevalence of cultivated flowering plants in the urban parks (e.g., *Cassia fistula*, *Bauhinia blakeana*) likely support resident butterfly species that are adapted to an open canopy (e.g., *Catopsilia pomona*), as well as species from adjacent forests that forage in these parks (e.g., *Euploea phaenareta*). Forest fragments and isolated urban parks recorded the lowest butterfly diversities among the habitats in Singapore, possibly due to their small areas or impoverished floras. This study results suggest that the number of butterfly species persisting in butterfly parks is dependent on the number of potential host plants occurring in them. The proximate mechanism underlying butterfly-host plant specificity is primarily chemical in nature, although their evolutionary and ecological bases are less well understood[28,29].

Habitat association of butterflies can be directly related to the availability of food plants[30].The criterion of representative diversity which was based on the recognition of assemblages

of species that are typical for specific habitats seems more interesting[31]. 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[32-33]. Each habitat has a specific set of micro environment suitable for a species. Sustaining the biodiversity and upkeep the faunal and floral wealth is the main aspiration of any conservation programme. It has been estimated that there has been a loss of 50% forest cover in the past 50 years in the Western Ghats [34]. Due to large scale ecological disturbances, many more species are facing extinction. Varshney[35] has reported that two species of Papilionidae butterflies are threatened in India. Butterfly gardens act as an aid for conserving the wild butterfly population and to maintain the biodiversity in natural ecosystems, which in turn, may increase the existence of human beings. Hence, it is critical that more research be focused on developing viable strategies for the effective conservation of biodiversity in urban landscapes.

CONCLUSION

The butterfly population showed an increasing trend during the monsoon season (June-October) reaching its peak in November. The population remained low during the summer months (March-May). The study showed the significant benefit of such parks in biodiversity conservation, recreation and education.

SIGNIFICANCE STATEMENTS

This study discovers the seasonal population trends of butterflies in the Thenmala Butterfly Safari that can be beneficial to understand their community composition and kindred. This study will help the researcher to uncover the critical area of temporal and spatial resource enrichment through host plant introduction and site amelioration to increase the butterfly population that many researchers were not able to explore. Thus, a new theory on these microclimatic conditions that were needed to enrich the biodiversity, may be arrived at.

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