Bioved, **30**(2) : 167–183, 2019 bioved.post@gmail.com http://biovedjournal.org/

The role of butterflies towards creating ecological balance and biodiversity conservation in southern part of Western Ghats (Palani Hills)

Dinesh Raja, J.[1], Jainul Yasmin. J[1], Melba Priyadharshini A.[2], Athif P.[1], Sadiq Bukhari . A[*], and Syed Mohamed H.E.[1]

1. P.G. & Research Department of Zoology, Jamal Mohamed College (Autonomous), (Affiliated to Bharathidasan University, Tiruchirappalli-620024, Tamilnadu) Tiruchirappalli-620020, Tamil Nadu, India

2. Department of Biotechnology and Bioinformatics, Bishop Heber College (Autonomous), (Affiliated to Bharathidasan University, Tiruchirappalli-620024, Tamilnadu) Tiruchirappalli -620 017, Tamil Nadu, India

Received May17, 2019 and Accepted July 30, 2019

ABSTRACT : In Southern Part of Western Ghats (Tamilnadu), four tropical habitats with different disturbance levels were monitored for diversity and seasonal patterns in the community of butterfly species. Species richness occurred highest in late monsoon and early in winter. Majority of the butterfly species also showed abundance peaks in these seasons. Pollution and Climatic factors played a vital role in determining species composition in the afflicted areas and affected flight periods of some species but did not affect species richness. Loss of Biodiversity had a major impact on species composition and it favored only those *Lycaenids* and *Nymphalids* whose caterpillars feed on herbs. In case of one of the sites where phenophases of the larval food plant and population trend of a small *Lycaenid* was documented, the population showed rapid increase at the time when the plants were in suitable phenophase for growth of the caterpillars. A possible evolutionary interaction between herb-feeding and non-herb-feeding *Lycaenids* is proposed.

Key Words : Butterfly communities, population dynamics, species richness, climatic factors, pollution.

Butterflies and moths (order *Lepidoptera*) has given very good opportunities for the studies on population and community ecology (Pollard 1991). Many species of butterflies are strictly seasonal, preferring only a particular set of habitats. In spite of this, butterflies has been generally neglected by community ecologists and there may be very few studies available on their community structures, population dynamics and the Eco climatic factors which affect the species. Being good indicators of climatic conditions as well as seasonal and ecological changes, the Butterflies can serve in formulating strategies for conservation. However, they have been largely ignored by the conservation biologists and policy-makers as well. It is hence encouraging that butterflies are included in biodiversity studies and biodiversity conservation prioritization programmes (Gadgil, 1996). The present study has started with a view to examine the dynamics of butterfly population across seasons and habitats. With quantitative data on butterfly populations gathered from a variety of habitats, the questions became more apparent (Arun, 2002). The present analysis is intended to reveal the seasonal patterns in butterfly populations, and interactions among the species, the plants on which they depend, and their Eco climate. Despite its limitations, this study did attempt, perhaps for the first time, short-term butterfly monitoring in Southern Part of Western Ghats (Palani Hills).

Materials and Methods

The Palani Hills are a mountain range in the states of Kerala and Tamil Nadu in South India. The Palani Hills are an eastward extension of the Western Ghats ranges, which run parallel to the west coast of India. The Palani Hills adjoin the high Anamalai range (Kerala) on the west, and extend east into the plains of Tamil Nadu, covering an area of 2,068 square kilometres (798 sq mi). The highest part of the range is in the southwest, and reaches 1,800-2,500 metres (5,906-8,202 feet) elevation; the eastern extension of the range is made up of hills 1,000-1,500 m (3,281-4,921 ft) high.

Monitoring butterfly populations is an important means of measuring change in the environment as well as the state of habitats for biodiversity. Butterfly monitoring make it possible to assess the trends of butterfly populations. The transects are a way of monitoring the number and variety of butterflies present at a study areas. Butterflies are counted along fixed routes, known as transects, which are divided into smaller sections, throughout the butterfly season under good weather condition that meet minimum criteria. Counts should ideally be made once every week. Present Diversity survey recorded from December 2018 to March 2019. All species transects are labor intensive and require a commitment to carry out weekly recording, throughout the main period in Palani hills area (Poombarai, Kavunji,

Adukkam, Silver Falls)

Sampling Techniques (Transect Walk Method) : Transects methods took about 45-60 minutes to walk and are about 1-2 km in length. A route (transect walk) that provides a fair representation of the habitats and other features present in our study area. Some thoughts have been given to show how the site might change over time, and the route were designed to include areas that are likely to become more suitable for butterflies in future (e.g. through site management).

All butterflies seen along the transect line were counted and listed. Recording were taken place once a Week from December 1st week to the end of March. Week 1 runs from 2018, December 2-6, week 2 runs from 8-l2 December, and so on, regardless of the day of week and used a separate weekly recording from each of these 16 regarding weeks. Transect counts were ideally made between 10:30 and l4:45 hours. Between 10:00 and 17:00 hours are usually allowable, though butterfly activity may drop off rapidly during the late afternoon so later times were avoided. Transect walks were carried out in warm (13°C or more) and at least bright weather. The minimum criteria are 13-17°C with at least 60% sunshine, or over 17°C and not raining.

Photographing Specimens : Like any nature photography, chasing butterflies with a camera is an absorbing pursuit. The best part of butterfly photography is that butterflies are most easily approachable unlike birds or other animals. With patients and the art of stalking it is easier to photograph butterflies. The best time for butterfly photographing is soon after sunrise when butterflies come out for basking behavior to regulate or increase their body temperature. Most butterflies spread their wings flat and align themselves for maximum exposure to sunlight. Butterflies are easily approachable at that time. The photographing was done throughout the month on every morning after sunrise. When the temperature is slightly cooler they are easily approachable Specimens were photographed with Canon: DSLR (EDS 1100D) camera. As the flight period is less during immediate sun rays, photographing butterflies is easier at those times. “As clear the photo so exact the identification”.

Data Collection : Field survey was made regularly for a period of four months from December 2018 to March 2019. The total number of each species observed was entered in the data sheet kept in the laboratory. The raw data were fed to a computer for further analysis. For population studies, the total number of butterflies censused was recorded and then released. The data collected were statistically analyzed using the following diversity indices and population measures.

The statistical calculation have been performed by using “PAST” Data Software, the 3.23 version. The software is used to identify the Species Richness, Species Diversity and Species Evenness.

Shannon diversity index (H’): It measures how rare or common the species are, in a community. Shannon’s diversity index (1963). It takes into account the number of species and the evenness of species and is calculated as

$$H' = \Sigma ipi \ln (pi)$$

Where;

pi is the proportion of the individuals in the total sample belonging to the species *i* and *ln* is the natural logarithm.

H = the Shannon diversity index

P_i = fraction of the entire population made-up of species i

S = numbers of species encountered

Σ = sum from species 1 to species S

Note: The power to which the base e (e = 2.718281828.....) must be raised to obtain a number is called the **natural logarithm** (ln) of the number.

Species Evenness : Pielou’s evenness index (J’): It expresses how evenly the individuals are distributed among the different species. Pielou’s evenness index (1966). It is calculated as

$$J' = H'/\ln S,$$

Where

$$\ln S = H' \max$$

H’ max (the maximum value of Shannon diversity) is what H’ would be if all the species in the community had an equal number of individuals; S is the number of species.

Identification : Identification of Photographed specimens was done by comparison with identification books such as “The Book of Indian Butterflies” and “Fauna of British India”.

Indian Butterflies version 6.0 developed by NATURE WEB (android mobile app)I Butterflies Version 1.1 developed by Ladybird environmental consulting (android mobile app).

Results and Discussion

Species composition and abundance of butterflies: The present study demonstrated that 55 different species of butterflies (Fig. 1-5) belonging to 6 families are present in the Palani Hills. A total number of 824 butterflies were recorded during the study period

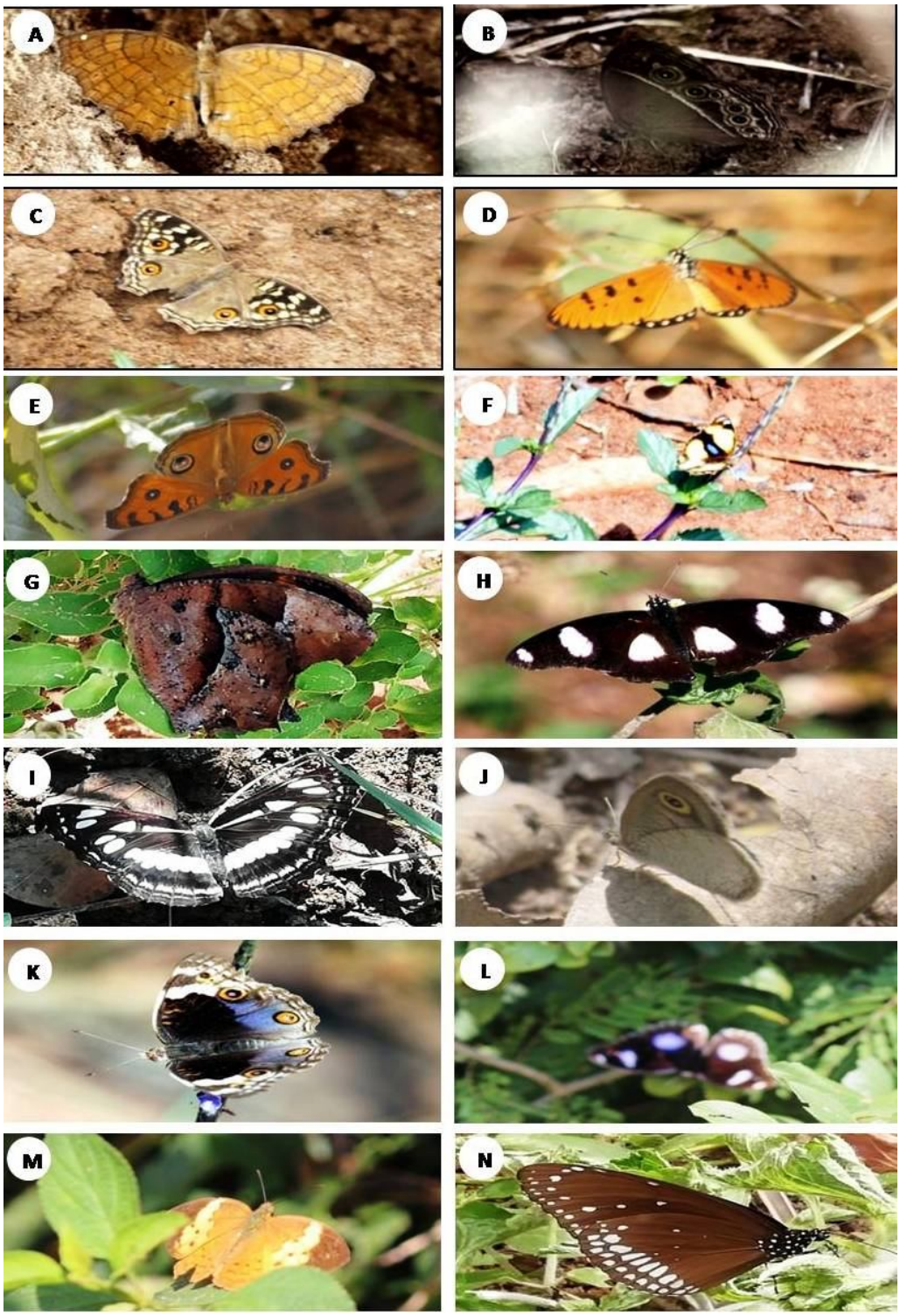

Fig.-1: Photographs of butterflies in the Palani Hills (Family: *Nymphalidae*)

[A) Angled Castor (*Ariadne ariadne*), B) Dark-Branded Bush Brown (*Mycalesis mineus*), C) Lemon Pansy (*Junonia lemonias*), D) Tawny Coster (*Acraea terpsicore*), E) Peacock Pansy (*Junonia almana*), F) Yellow Pansy (*Junonia hierta*), G) Dark Evening Brown (*Melanitis leda*), H) Danaid Eggfly (*Hypolimnas misippus*), I) Short-banded Sailer (*Phaedyma columella*), J) Mottled Argus (*Loxerebia narasingha*), K) Blue Pansy (*Junonia orithya*), L) Great Eggfly (*Hypolimnas bolina*), M) Common Leopard (*Phalanta phalantha*) and N) Chocolate Pansy (*Junonia iphita*)]

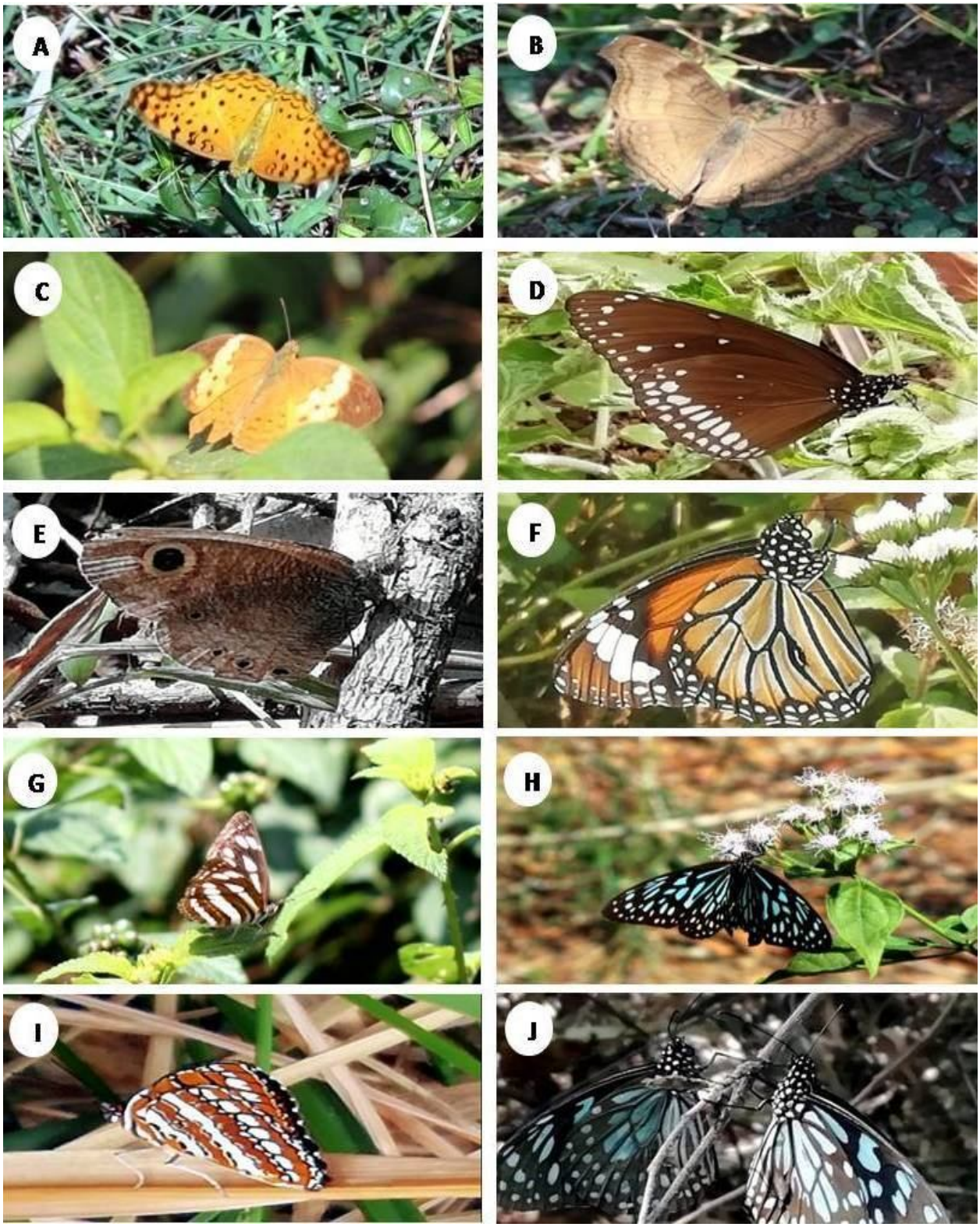

Fig.-2: Photographs of butterflies in the Palani Hills (Family: *Nymphalidae*)

[A) Rustic (*Cupha erymanthis*), B) Common Indian Crow (*Euploea core*), C) Common Four-Ring (*Ypthima huebneri*), D) Striped Tiger (*Danaus genutia*), E) Common Sailor (*Neptis hylas*), F) Dark Blue Tiger (*Tirumala septentrionis*), G) Joker (*Byblia ilithyia*) and H) Blue Tiger (*Tirumala limniace*)]

Fig.-3: Photographs of butterflies in the Palani Hills (Family: Lycaenidae)

[A) Common Cerulean (*Jamidas boeticus*), B) Gram Blue (*Euchrysop cnejns*), C) Pea Blue (*Lampides boeticus*), D) Pale Grass Blue (*Pseudozizeeria maha*), E) Silver Forget-Me-Not (*Catochrysops panormus*), F) Plum Beous Silver Line (*Spindasis schistacea*), G) Siva Sunbeam (*Curetis siva evans*), H) Zebra Blue (*Leptotes plinius*), I) Dark Grass Blue (*Zizeeria karsandra*), J) Common Pierrot (*Castalius rosimon*), K) Slate Flash (*Rapala manea*) and L) True Forget-Me-Not (*Catochrysops Strabo Strabo*)]

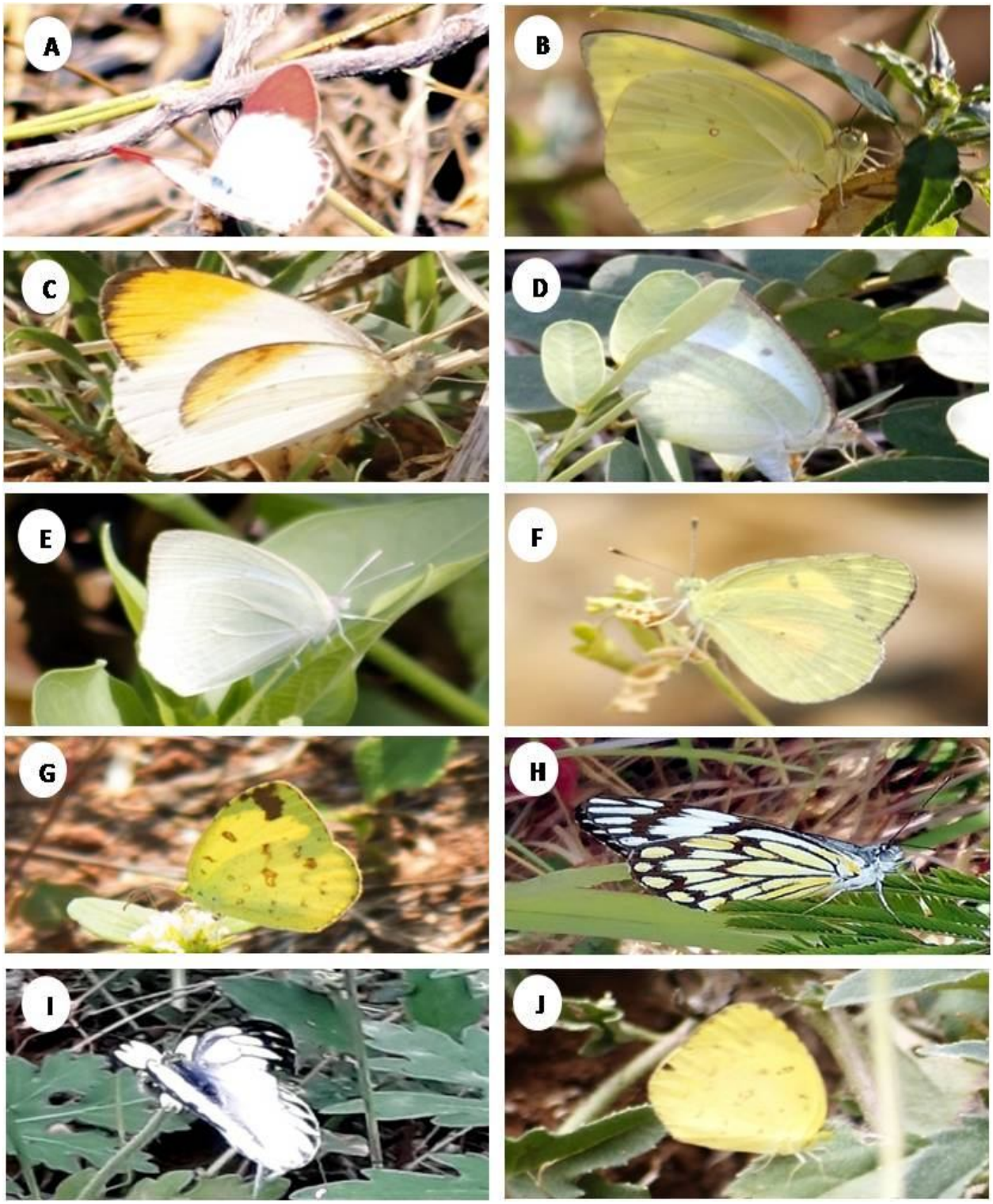

Fig.-4: Photographs of butterflies in the Palani Hills (Family: Pieridae)

[A) Crimson Tip (*Colotis danae*), B) Mottled Emigrant (*Catopsilia pyranthe*), C) Yellow Orange Tip (*Ixias pyrene*), D) Common Albatross (*Appias albina*), E) Striped Albatross (*Appias libythea*), F) Large Salmon Arab (*Colotis fausta fausta*), G) Common Grass Yellow (*Eurema hecabe*), H) Pioneer (*Belenois aurota*), I) Common Gull (*Cepora nerissa*) and J) One-Spot Grass Yellow (*Eurema andersoni*)].

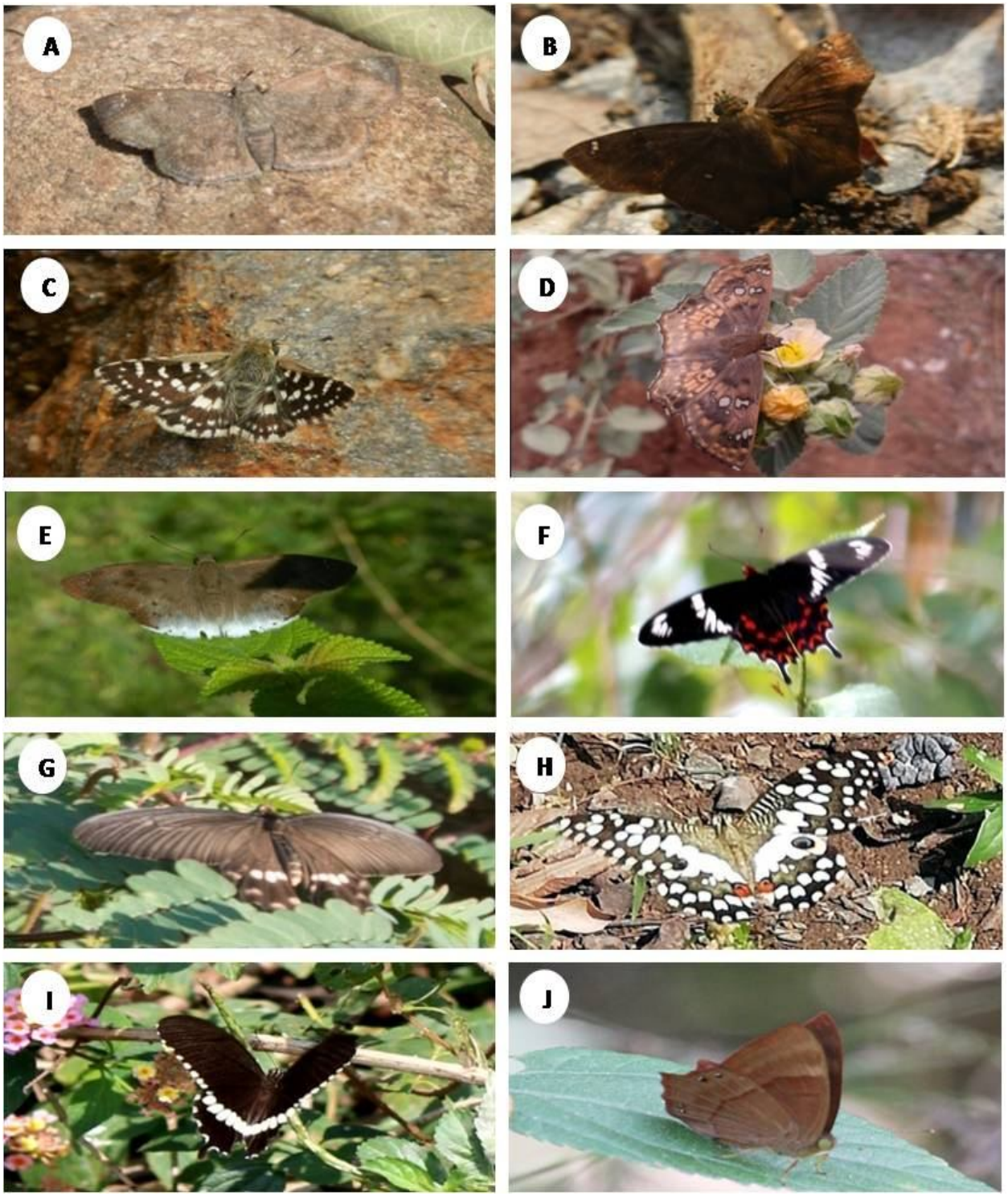

Fig.-5: Photographs of butterflies in the Palani Hills (Family: Hesperidae (A-E), Family: Papilionidae (F-I), Family: Riodinidae (J))

[A) Common Small Flat (*Sarangasa dasahara*), B) Black Angle (*Tapena thwaitesi*), C) Indian Grizzled Skipper (*Spialia galba*), D) Golden Angle (*Caprona ransonnettii*), E) Common Snow Flat (*Tagiades japetas*), F) Crimson Rose (*Pachliopta hector*), G) Common Rose (*Pachliopta aristolochiae*), H) Common Lime Butterfly (*Papilio demoleus*), I) Common Mormon (*Papilio polytes*), J) Straight Plum Judy (*Abisara echerius*)]

Table-1: List of butterflies recorded in Palani hills (Western Ghats) during the study.

Scientific name	December	January	February	March	Total
		Family: Nymphalidae			
Ariadne ariadne	5	3	4	7	19
My calesis mineus	1	-	3	5	9
Junonia lemonias	5	8	7	4	24
Acraea terpsicore	7	2	6	5	20
Dananus cherysippus	10	15	10	18	53
Junonia almanac	7	9	12	5	30
Junonia hierta	6	3	8	5	30
Melanitis leda	0	4	3	2	9
Hypolimnas misippus	5	4	8	7	24
Phaedyma columella	4	3	-	6	13
Loxerebia narasingha	-	1	4	2	7
Junonia orithya	6	5	7	5	23
Hypolimnas bolina	3	1	5	2	11
Phalanta phalantha	2	4	1	3	10
Junonia iphita	3	5	6	1	15
Cupha erymanthis	2	2	1	3	8
Euploea core	10	13	9	10	42
Ypthima huebneri	3	2	5	2	12
Danaus genutia	10	12	8	6	36
Neptis hylas	-	2	4	1	7
Tirumala septentrionis	8	6	5	4	23
Bybilia ilithyia	0	3	2	3	8
Tirumala limniace	10	14	9	12	45
		Family: Lycaenidae			
Jamidas celeno	2	5	7	8	22
Euchrysop cnejns	5	3	-	4	12
Lampides boeticus	4	-	6	2	12
Pseudozizeria maha	3	1	4	2	10
Catochrysops panormus	4	4	2	3	13
Spindasis schistacea	-	1	1	-	2
Curetis siva evans	2	1	1	1	5
Leptotes plinius	3	2	1	1	7
Zizeeria karsandra	1	3	1	1	6
Castalius rosimon	-	3	1	2	6
Rapala manea	1	1	2	1	5
Catochrysops strabostrabo	3	1	2	1	7
Family: Pieridae					
Colitis danae	2	3	1	1	7
Catopsilia pyranthe	5	4	6	8	23

Ixias pyrene	1	2	2	3	8
Appias albino	4	3	1	4	12
Appias libythea	3	3	1	2	9
Colitis fausta fausta	7	8	5	4	10
Eurema hecabe	6	5	6	4	21
Eurema hecabe	2	3	4	1	24
Belenois aurota	3	1	2	1	10
Cepora nerissa	6	5	6	4	7
		Family: Hesperidae			
Sarangasa dasahara	-	1	1	-	2
Tapena thwaitesi	1	1	1	1	4
Spialia galba	2	2	-	1	5
Caprona ransonnetti	3	4	3	2	12
Tagiades japetas	4	2	1	3	10
		Family: Papilionidae			
Pachiopta hector	3	6	7	6	22
Pachioptaaristolochiae	8	5	4	5	22
Papilio demoleus	3	2	4	2	11
Papilio polytes	6	5	3	4	18
		Family: Riodinidae			
Abisara echerius	-	1	1	-	2
Total No. of individuals	**824**				

Table-2: Monthly distribution of butterfly families in the Palani hills.

Family Name	December	January	February	March	Total
Nymphalidae	107	121	127	123	478
Papilionidae	20	18	18	17	73
Lycaenidae	28	25	28	26	107
Pieridae	38	34	29	30	131
Riodinidae	0	1	1	0	2
Hesperidae	10	10	6	7	33
Total	**203**	**209**	**209**	**203**	**824**

Table-3: Diversity indices of butterflies in the Palani hills.

Diversity Index	December	January	February	March
Species Richness	47	53	52	52
Individuals	203	209	209	203
Dominance_D	0.02866	0.0323	0.02887	0.03322
Simpson_1-D	0.9713	0.9677	0.9711	0.9668
Shannon_H	3.682	3.682	3.701	3.658
Evenness_e^H/S	0.8449	0.7498	0.7786	0.746

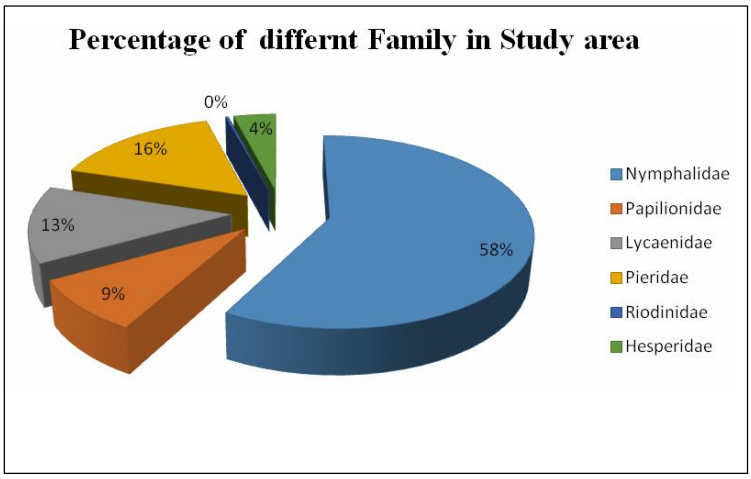

Fig.-6: Percentage distribution of different families of butterflies in the Palani Hills.

(Table-1), in which the family *Nymphalidae* dominanted with 22 species, followed by *Lycaenidae* (12), Pieridae (10), Hesperidia (5), *Papilionoidae* (4) and *Riodinidae* (1). From the results, it is also evident that *Danaus cherysippus* was the most dominant species (11%) and *Loxerebia narasingha* was the lowest species (1%) among the *Nymphalidae* family and they constituted of 53 and 7 butterflies respectively. Similarly, *Eurema hecabe* was the highly dominant species of Pieridae family which constituted of 18% of total individuals (n=24) and *Colotis danae* was the most lowest species (5%) that comprised of 7 butterflies. *Jamidas celeno* was the dominant species of Lycaenidae family, which constituted of 21% of total individuals (n=22) and *Spindasis schistacea* (n=2) was the lowest species constituted of 2%. Among the collected butterflies of *Papilionidae* family, *Pachlipta aristolochiae* was the dominant species (22), which constituted of 30% of total individuals and the *Papilio demoleus* was the lowest recorded species (n=11) consist of 15% of total individuals of the family. It is clear that the species *Caprona ransonnettii* was the dominant one (37%) and the species *Sarangasa dasahara* was the lowest one (6%) in and that constituted of 12 and 2 butterflies respectively. Only a single species (*Abisara echerius*) was observed in the family Riodinidae.

Table-2 shows the monthly distribution of different butterfly families in the study area, which revealed the presence of total 203 butterflies belonging to 47 species in December 2018; where as 209 butterflies were recorded in January 2019 that comprised of 53 species. Similar butterfly population was observed in February 2019 and they were belonging to 52 species. However in the month of March 2019, 203 butterflies belonging to 52 species were recorded.

Fig.-6 depicted the percentage distribution of different families of butterflies collected from study area and it revealed that the butterflies belonging to the family *Nymphalidae* dominanted (58%) and it constituted of 478 butterflies. This was followed by the families Pieridae (16%), Lycaenidae (13%), *Papilionidae* (9%) and Hesperidae (4%), which were constitutes of 131, 107, 73 and 33 butterflies respectively.

Species diversity, richness and evenness of butterflies : Table-3 shows the species richness, diversity and evenness calculated during the study period. Across the study period, Shannon-wiener diversity Index (H') was recorded for the butterfly communities. Moreover, maximum species diversity was recorded in February month (3.701) and the minimum in March (3.658). Similarly the maximum species richness was observed in January (53), followed by February (52) and March (52), whereas the minimum species diversity was observed in December (47). Pielou's Evenness index (J') revealed that the species were evenly distributed. Moreover, maximum species diversity was recorded in December (0.8449), followed by February (0.7786), January (0.7498) and the minimum was in March (0.746). Simpson 1-D index also revealed that the species were evenly distributed and maximum species diversity was recorded in March (0.9668) and January (0.9677), followed by February (0.9711) and the minimum range was observed in December (0.9713).

Butterflies perform an important role and often play crucial functions in the environment. They act as pollinators for many species of plants, and they help, to some extent, in the propagation of wild vegetation communities. The importance and abundance of butterflies in any system mean that they are particularly studied

for their use as indicators of biodiversity, ecosystem health and landscape degradation (Ambrose, 2005). The butterfly distribution is expected to cover with the distribution of the host plants even at small scales and types of vegetation may reflect difference in the composition of butterfly communities among habitats at the generic and family level (Beccaloni, 1997).

The butterflies of Palani hills are found to be habitat-specific to some extent. In habitats like this, the potential role of plant varieties has been given more importance for rich diversity and population density of butterflies. This study reveals the relationship between habitats and butterfly species richness and Shannon diversity index, Shannon evenness. The present study on butterflies emphasizes the role of variety of habitats, associated with various environmental factors such as temperature, humidity, and rainfall and wind velocity on species richness of butterflies.

In the present study, it is observed that the butterfly species diversity is higher in both the habitats than the other habitats studied during the months of favorable environmental factors as well as during unfavorable seasons. The different varieties of plants in the Palani hills habitats provide a wide range of nutrient-rich nectar, pollen, and palatable food plants to foliage-feeding butterflies. Fruiting trees, flowering plants and other leaves of the Palani hills serve to attract many butterflies. Moreover, their availability throughout the year was another advantage to the butterflies. The results indicated that the characteristic features of habitats along with climate influence the distribution and the diversity of butterflies and other insects in the Palani hills.

The Palani hills climatic conditions that were observed in the study area were one of the major and suitable factors. Moreover, in this system, the presence of some species of butterflies throughout the study period suggested that they are either susceptible to the minor environmental changes, or the environment is effectively non-seasonal, although, rainfall was considered as an important factor for encouraging plant growth and flowering richness. Saxena (1996) supported this by explaining the relationship of water and moist air for butterfly diversity and stressed the importance of a water body to increase immediate survival value. In addition to the pond, a number of permanent trees, herbs and shrubs found in this habitat also provided the roosting places for many adult butterflies. *Jamidas celeno, Pachlipta hector, Pachliopta aristolochiae, Eurema anderson, Catopsilia pyranthe, Eurema hecabe, Danaus chrysippus, Junonia almana, Hypolimnas msippus, Euploea core, Dnaus genutia, Tirumala limniace* and few others were observed as predominant species of this ecosystem. Although they exhibited seasonal or periodical peaks, they occurred almost in all the four months.

Seasonal distribution of many butterfly species was found related to temperature fluctuations. Temperature is probably the single most important environmental factor influencing insect behavior, distribution, population size, development, survival and reproduction (Petzoldt and Seaman, 1992; Ward, 1992). Muralirangan *et al.* (1993) observed that high humidity stimulates fungal attack, and high temperature causes a decrease in insect population. However, butterflies are highly sensible to predict cyclic seasonal changes and the quality of air. The ability to recognize the slightest difference in humidity enables them to move to favorable areas (Saxena, 1996). In the present study, almost all observed members of butterflies belonging to different families were very limited during high temperature and humidity months such as April, May and June (Thanasingh, 2003), while it was available in plenty during the favorable season between October to January during which season the plant foliage and nectar are available in plenty (Didham and Springate, 2003).

In the Palani hills all the butterflies belonging to the six families studied were at the maximum numbers during the post January month. Fluctuations in their number in most of the families largely coincided with the February and December months only. Low population density was exhibited by most of the families during March month during which the environmental conditions prevailed was not favorable for them. Several studies have shown that Palani hills provide additional opportunities for different species to live together. Since a steady and continuous supply of food being the most important characteristic of two habitats, insects enjoy this habitat. The abiotic environment includes the principal factors such as extremes of temperature, relative humidity, and rainfall and wind velocity. They may exert their effects on butterflies either directly or indirectly. In a managed ecosystem, such as in Palani hills, the pesticide applications may also have some indirect effects on distribution of lepidopteran species though normally it causes only temporary changes in the relative abundance of them. Widespread use of organic pesticides has been considered as a major factor responsible for loss of butterfly population, but it has rarely resulted in the extinction of the species.

The present study reveals that the study area provides favorable ecological conditions and habitat for butterflies. The highest number of species was recorded in January 2019. Maximum butterflies were recorded during the show season. It might be due to the presence

of sufficient host plants and favorable climatic conditions for the development and growth of butterflies. The least number of butterflies were collected during the month December 2018, when the adequacy of host plants and unfavorable climatic conditions were observed. Although, study area supports a good number of butterfly species but much has still to be explored. In addition, it is necessary to identify the rare butterfly species and conserve them by establishing a Butterfly conservatory to conserve and protect the species and creating awareness to the local tribe group and the visitors towards conserving the Biodiversity of Western Ghats of Palani Hills.

Acknowledgment

Authors were thankful to Dr. A.K. Khaja Nazeemudeen Sahib, Secretary and Correspondent, Dr. S. Ismail Mohideen, Principal and Dr. I. Joseph Antony Jerald, Head, P.G. and Research Department of Zoology, Jamal Mohamed College (Autonomous), Tiruchirappalli for Institutional support. We profoundly thank Principal Chief Conservator of Forests & Chief Wildlife Warden, Chennai for permitting to carry out the research work. We are also thankful to Distrcit Forest Officer & Wildlife Warden, Kodaikanal Wildlife Sanctuary and District Forest Officer, Dindigul Forest Division for their timely helps.

References

Arun, P.B. and Azeez, P.A., 2003. On the butterflies of Puyankutty forest, Kerala, India. *Zoo's Print. J.*, **18**(12): 1276-1279.

Arun, P.R., 2002. Butterflies of Siruvani forest of Western Ghats, with notes on their seasonality. *Zoo's Print. J.,* **18**(2): 1003-1006.

Arora, G.S., 1995. Lepidoptera: Rhopalocera. Fauna of Western Himalaya, Himalayan Ecosystem Series Part I, Uttar Pradesh. Zoological Survey of India. Calcutta. 61-73.

Asher, J.; Warren, M. and Fox, R., 2001. The millennium atlas of butterflies in Britain Oxford University Press Oxford. 433.

Ambrose, D.P., 1995. Insect diversity and conservation. *Zoo's Print.*(October issue): 9-11.

Arun, P.R., 2000. Seasonality and Abundance of Insects with special Reference to Butterflies (Lepidoptera: Rhopalocera) in a Moist Deciduous Forest of Siruvani. Nilgiri Biosphere Reserve. South India [Ph.D. thesis]. Bharathiar University. Coimbatore. 236 p.

Asaithambi, P., 1994. Butterflies of Mundumali wildlife sanctuary, *Tamil Nadu Zoos Print*, **9:** 1-1.

Asaithambi, P.; Baskar, N. and Rao, N.J., 1998. Butterflies of Arignar Anna Zoological Park. Madras. Zoos' Print. (October issue): 7.

Antram, C.B., 2002. Butterflies of India, Mittal Publication, New Delhi, p.226.

Ambrose, D.P. and Senthil Raj, D., 2005. Butterflies of Kalakad Mundanthurai Tiger Reserve,Tamil Nadu. *Zoo's Print Journal,* **20**(12): 2100-2107.

Arun. P.R., 2003. Butterflies of Siruvani Forests of Western Ghats, with notes on their seasonality. *Zoo's Print J.*, **18**(2): 1003-1006.

Agelopoulos, N.; Birkett, M.A. and Hick, A.J.. 1999. Exploiting semiochemicals in insect control. *Pestic. Sci*., **55:** 225–235.

Azevedo, R.B.R.; James, A.C.; McCabe, J. and Partridge, L., 1998. Latitudinal variation of wing: thorax size ratio and wingaspect ratio in *Drosophila melanogaster*. *Evolution*, **52:** 1353–1363.

Brown, K.S., 1998. Diversity, disturbance, and sustainable use of neotropical forests: insects as indicators for conservation monitoring. *Journal of Insect Conservation,* **1**(1): 25-42.

Bhumannavar, B.S. and Singh, S.P., 1983. Studies on population dynamics of Citrus Leaf-miner Phyllocnistiscitrella Stainton (Lepidoptera:Phllocnistidae). *Entomon*., **8**(4):397-400.

Baltenswelier, W.G.; Benz, P.; Bovey, P. and Delucchi, V., 1977. Dynamics of Larch Bud Moth Populations. *Ann. Entomol.,* **22 :** 79-2000.

Baksha, M.W.and Crawley, M.J., 1998. Population dynamics of teak defoliator, *Hyblaea puera* Cram.(Lep., Hyblaeidae) in teak plantations of Bangladesh. *J. Appl. Ent.,* **122 :** 79-83.

Babjan, B. and Archana, N., 1999. Butteflies of Krishnapuram Grams panchayath. Alappuzha district Kerala. *Zoos' Print Journal,* **14:** 42.

Berryman, A.A., 1986. On the dynamics of black headed budworm populations. *Can. Entomol*., **118**(8) : 775-779.

Borges, R.M.; Gowda, V. and Zacharias, M., 2003. Butterfly pollination and high contrast visual signals in a low density distylous plant. *Oceologia*, **136 :** 571-573.

Bingham, C.T., 1905-1907. The Fauna of India, including Ceylon, Burma, Butterflies, Vols. I-II. Taylor and Francis Ltd. London.Biodiversity Assessment of a threatened mountain system. A report submitted.

Borkar, M.R. and Komarpant, N., 2004. Diversity, abundance and habitat association of butterfly species in Bondlea wildlife sanctuary of Goa, India, *Zoos' Print Journal* **19**(10): 168-1653 (plus wep supplement).

Boggs, C.L.; Watt, W.B. and Ehrlich, P.R., 2003. Environmental variation, life histories, and allocation. *Butterflies Ecology and Evolution Taking Flight* : 185 – 206, University of Chicago Press, Chicago.

Bull, L.B.; Culvenor, C.C.J. and Dick, A.T., 1968. The

pyrrolizidine Alkaloids, North – Holland Publ. Co., Amsterdam.

Buckland, S.T.; Anderson, D.R.; Burnham, K.P.; Laake, J.L.; Borchers, D.L. and Thomas, L., 2004. *Advanced Distance Sampling: Estimating Abundanceof Biological Populations*. Oxford University Press, Oxford, UK. 416pp.

Buckland, S.T.; Anderson, D.R.; Burnham, K.P.; Laake, J.L.; Borchers, D.L. and Thomas, L., 2001. *Introduction to Distance Sampling*: *Estimating Abundance of Biological Populations*. Oxford University Press, Oxford,UK. vi+xv+432pp.

Bernays, E.A. and Chapman, R.F., 1994. Host-plant Selection by Phytophagous Insects, Chapman & Hall.

Bernays, E. and Graham, M., 1988. On the evolution of host specificity in phytophagous arthropods. *Ecology*, **69:** 886-892.

Brower, L.P. and Fink, L.S., 1958. A natural toxic defence system: Cardenolides in butterflies versus birds. pp171-188.In: Experimental Assessments and Clinical Applications of conditioned Food Aversions, (eds) N.S. Braveman and P. Bronstein, New York Academy of Science, New York.

Caughley, G., 1994. Directions in conservation biology. *Journal of Animal Ecology*, **63:** 215-244.

Chaudry, Z.A. and Alikhan, M.A., 1996. Effects of temperature and relative humidity on the development and the fecundity of the red pumpkin beetle, *Aulacophora foveicollis* Lucas (Chrysomelidae:Coleoptera). *Indian. J. Em.*, **52**(2) : 274-278.

Clausen, H.D.; Holbeck. B.H. and Reddersen, J., 2001. Factors influencing abundance of butterflies and burnet moths in the uncultivated habitats of an organisms in Denmanrk. *Biologicals Conservation*, **98 :** 167-178.

Dolia, J.; Devy, M.S.; Aravind, N.A. and Kumar, A., 2008. Adult butterfly communites in coffee plantations around a protected area in the Western Ghats, India. *Animal Conservation*, **11 :** 26-34.

Danks, H.V., 1993. Patterns of diversity in the Canadian insect fauna. *Mem. Ent.Soc. Can.* **165:** 51-74.

Dover, J.W., 1996. Factors affecting the distribution of satyrid butterflies on arable farm land. *Journal of Applied Ecology*, **33:** 723-734.

Dover, J.W.; Sparks, T.; Clarke, S.; Gobbett, K. and Glossop, S. 2000. Linear features and butterflies: the importance of green lanes. *Agriculture, Ecosystems and Environment.* **80:** 227-242.

Dethier, V.G., 1941. Chemical factors deter mining the choice of food plants by Papilio larvae. *Amer. Nat.*, **75:** 61-73.

Dover, J.W.; Sparks, T.H. and Greatorex-Davies, J.N., 1997. The importance of shelter for butterflies in open landscpapes. *Journal of Insect Conservation*, **1 :** 89-97.

Downey, J.C., 1962. Host-plant relations as data for butterfly classification. *Syst. Zool*., **11 :** 150-159.

Denno, R.F. and McClure, M.S., 1983. Variable plants and herbivores in natural and managed systems. Academic Press, New York.

Dudley, R., 2000. The Biomechanics of Insect Flight: Form, Function, Evolution. Princeton University Press, Princeton.

Ehrlich, P.R. and Raven, P.H., 1965. Butterflies and plants: a study in coevolution. *Evolution*, **18 :** 586-608.

Eswaran, R. and Pramod, P., 2005. Structure of butterfly community of Anaikatty hills, Western Ghats, *Zoo's Print. J.*, **20**(8): 1939-1942.

Elkinton, J.S. and Liebhold, A.M., 1990. Population dynamics of gypsy moth in North America. *Annu. Rev. Entomol.*, **35 :** 571-596.

Emmet, A.M. and Heath, J., 1990. The Butterflies of Great Britain and Ireland vol.7 Part 1. Harley books. Colchester. 370.

Edwin, J., 1997. Distribution, diversity and population dynamics of chosen insects in the Courtallam tropical evergreen forest. Ph.D. Thesis, Madurai Kamaraj University, Madurai. 287.

Faeth, S.H., 1985. Host leaf selection by leaf miners: interactions among three trophic levels. *Ecology*, **66 :** 870-875.

Freitas, A.V.L.; Francini, R.B. and Brown, K.S., 2003. Insect oscomo indica doresambientais pp,125-151. In (eds) L.Cullen JR; R. Rudran and C. Valladares-Padua., UFBA.

Fraenkel, G.S., 1959. The raison d'e(tre of secondary plant substances. *Science*, **129:** 1466-1470.

Feeny, P.; Stadler, E.; Ahman, I. and Carter, M., 1989. Effects of plant odor on oviposition by the black swallowtail butterfly, *Papilio polyxenes* (Lepidoptera: Papilionidae). *J. Insect Behav*., **2:** 803–827.

Gilpin, M. and Hanski, I., 1991. Metapopulation dynamics: empirical and theoretical investigations. Academic Press, London.

Gaonkar, H., 1996. Butterflies of the Western Ghats, India, including Sri Lanka: a biodiversity assessment of a threatened mountain system. Unpublished report, 51pp.

Gerell, R., 1997. Management of road side vegetation: Effects on density and species diversity of butterflies in Scania, South Sweden, *EntomoTidskr*., **118 :** 171-176.

Gunathilagaraj, K., 1998. Some south Indian Butterflies, Tamilnadu, India: Nilgris Wildlife and Environmental Association, Udagamandalam, Nilgris. 274.

Gay, T.L.; Kehimkar, D.; Chandra, J. and Punitha, P.C., 1992. Butterflies of India. Oxford University.

Gadagkar. R.; Chandrasekaran, K. and Nair, P., 1990. Insect species diversity in the tropics: Sampling methods and a case study. *J. Bom. Nat. Hist. Soc.,* **87**(3): 337-353.

Gadgil, M., 1996. Documenting diversity: An experiment. *Curr. Sci. India,* **70 :** 36 - 44.

Haribal, M., 1992. The Butterflies of Sikkim and their Natural History, Sikkim Nature Conservation Foundation, Gangtok, 217pp.

Holl, K.D., 1995. Nectar resources and their influence on butterfly communities on reclaimed coal surface mines. *Restoration Ecology,* **3:** 76-85.

Hatcher, P.E., 1995. Three-way interactions between plant pathogenic fungi, herbivorous insects and their host plants. *Biol. Rev.*, **70:** 639-694.

Harrington, R.; Woiwod, I. and Sparks, T., 1999. Climate change and trophic interactions. *Trends in Ecology and Evolution*, **14:** 146–150.

Hill, J.K. and Hamer, K.C., 1995. Using species – abundance models as indicators of habitat disturbance in tropical forests. *Journal of Applied Ecology,* **35:** 458-464.

Hansson, L., 1991. Dispersal and connectivity in metapopulations. *Biological Journal of the Linnean Society*, **42:** 89-103.

Jha, C.S.; Dutt, C.B.S. and Bawa, K.S., 2000. Deforestation and land use changes in Western Ghats, India. *Current Science*, **79:** 231-238.

Janzen, D.H., 1969. Seed-eaters versus seed size, number, and toxicity and dispersal. *Evolution,* **23 :** l-27.

Kunte, K.; Joglekar, A.; Utkarsh, G. and Pramod, P., 1999. Patterns of butterfly, bird and tree diversity in the Western Ghats. *Curr. Sci. India*, **29 :** 1-14.

Kunte, K.J., 1997. Seasonal patterns in butterfly abundance and species diversity four tropical habitats in northern Western Ghats. *Journal of Biosciences*, **56 :** 593-603.

Krishnakumar, N.; Kumaraguru, A.; Thiyagesan, K. and Asokan. S., 2008. Diversity of papilonid butterflies in the Indira Gandhi wildlife sanctuary, Western Ghats, southern India. *Tiger Paper,* **35:** 1-8.

Kunte, K., 2008. The Wildlife (Protection) Act and conservation prioritization of butterflies of the Western Ghats, southwestern India. *Curr. Sci. India*, **94 :** 729-735.

Kunte, K., 2005. Species composition, sex-ratios and movement patterns in Danaine butterfly migrations in southern India. *J. Bombay Nat. Hist. Soc*., **102**(3): 280-286.

Karthikeyan, M., 1998. Diversity and habitat utilization of butterflies in different forest types of Hosur division, Dharmapuri District, Tamil Nadu. *Zoos' Print Journal,* **1**(11): 38.

Kunte, K.J., 2001. Butterfly diversity of Pune city along the human impact gradient. *J. Ecol. Soc*., **13/14:** 40-45.

Khan, H.R.; Bhandari, R.S.; Prasad, L. and Kumar, S., 1988. Population Dynamics of *Hyblaeapuera* Cram. (Lepidoptera: Hyblaeidae) and *Eutectona machaeralis* Walk. (Lepidoptera: Pyralidae) in Teak Forest of Madhya Pradesh (India) *Indian For.,* **114**(11): 803-813.

Kehimkar, I., 2008. The Book of Indian Butterflies. Bombay Natural History Society, India.

Kunte, K., 2000. Butterflies of Peninsular India, Universities Press Limited. Hyderabad. India. 254p.

Larsen, T.B., 1987. The butterflies of the Nilgiri Mountains of Southern India (Lepidoptera: Rhopalocera). *BNHS*, **84:** 291-316.

Larsen, T.B., 1987. The butterflies of the Nilgiri mountains of Southern India (Lepidoptera: Rhopalocera) *J. Bom. Nat. His. Soc.,* **84**(1) : 26-54.

Larsen, T.B., 1988. The butterflies of the Nilgiri mountains of Southern India (Lepidoptera: Rhopalocera) *J. Bom. Nat. His. Soc*., **84**(1) : 26-54.

Lortscher, M.; Erhardt, A. and Andzettel, J., 1995. Micro-distribution of butterflies in a mosaic like habitat. The role of nectar sources. *Ecography,* **18:** 15-26.

Lawton, J.H. and Woodroe, G.L., 1991. Habitat and the distribution of water voles: why are there gaps in species range? *Journal of Animal Ecology*, **60 :** 79-91.

Lawton, J.H.; Bignell, E.E.; Bolton, B.; Bloemers, G.F.; Eggleton, P.; Hammond, P.M.; Hodda, M.; Holt, R.D.; Larsen, T.B.; Mawdsley, N.A.; Stork, N.E.; Srivastava, D.S. and Watt, A.D., 1998. Biodiversity inventories, indictor taxa and effects of habitat modification in tropical forest. *Nature* (London), **391:** 72-76.

Lara, A.C.F. and Fernandez, G.W., 1996. The highest diversity in galling insects:*Serra doCipo*., **3**(3): 111-114.

Mani, M.S., 1986. Butterflies of Himalayas, Oxford IBH Publication New Delhi, p.210.

Myers, N., 1990. The Biodiversity Challenge Hot Spots analysis. *Environmentalist,* **10 :** 243-256.

Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; da Fonseca Gustavo, A.B. and Kent, J., 2000. Biodiversity hotspots for conservation priorities. *Nature*, **403:** 853–858.

Munguira, M.L. and Thomas, J.A., 1992. Use of road verges by butterfly and burnet populations, and the effect of roads on adult dispersal and mortality. *Journal of Applied Ecology,* **29:** 316-329.

Mathew, G. and Anto, M., 2007. In situ conservation of butterflies through establishment of butterfly gardens: A case study at Peechi, Kerala, India. *Curr. Sci. India*, **93**(3): 337-347.

Mathew, G. and Binoy, C.F., 2002. Migration of butterflies (Lepidoptera: Rhopalocera) in the new Amarambalam reserve forest of the Nilgiri biosphere

reserve. *Zoo's Print Journal,* **17**(8): 844-847.

Mathew, G. and Rahamathulla, V.K., 1993. Studies on the butterflies of Silent Valley National park, *Entomon.*, **18**(3-4): 185-192.

Mathew, K.M., 1994. A handbook of the Anglade Institute of Natural History, Shembaganur. The Rapinant Herbarium, St. Josephs College, Trichy, India.155 p.

Mathew, G. and Mohanadas, K., 2001. Insect fauna of the shola forest of Munnar and Wynad. KFRI Research Report No. **206:** 38.

Mathew, G., 1990. Studies on the lepidoptera fauna. pp.239. In: ecological studies and long term monitoring of the biological process in the silent valley National park reported submitted to Ministry of Environmental, Govt. of India, Kerala forest research institute.

Moran, P.J. and Schultz, J.C., 1998. Ecological and chemical associations among late-season squash pests. *Environ. Entomol.* **27:** 39-44.

Merz, E., 1959. Pflanzen und Raupen. Vba einige Prinzipien der Futterwahlbei.

Mohandas, T.V., 2004. Distribution of butterfly species in Kudremukh National Park during Monsoon. *Pers. Biosystematics and Diversity* : 129-134.

Munguira, M.L. and Thomas, J.A., 1992. Use of road verges by butterfly and burnet populations, and the effect of roads on adult dispersal and mortality. *Journal of Applied Ecology,* **29 :** 316-329.

Nijhout, H.F., 1991. The development and evolution of butterfly wing patterns. Washington: Smithsonian Institution Press.

Nair, V.P., 2002. Butterflies of governmend Collage Campus. Madappally, Kozhikoda District, Kerala. *Zoos' Print Journal,* **17:** 911-912.

Nair, V.P., 2003. Addition to the butterflies of governmend Collage Campus.Kozhikoda District, Kerala. *Zoos' Print Journal,* **18**(10): 12-32.

Orr, A.G. and Hauser. C.L., 1996. Kaula Belalong, Brunei: a hotspot of old world butterfly. The measurement of species diversity. *Ann. Rev. Ecol.System,* **5 :** 285–307.

Owen, D.F., 1969. Species diversity and seasonal abundance in tropical Sphingidae Kerala. *Zoos' Print Journal,* **17:** 911-912

Opler, P.A., 1983. Nectar production in a tropical ecosystem. pp.30-79. In: Temperature, rainfall and butterfly numbers. (ed) *Pollard E Journals of Applied Ecology,* **25 :** 819-828.

Ouborg, N.J., 1993. Isolation, population size and extinction: the classical and metapopulation approaches applied to vascular plants along the Dutch Rhine system. *Oikos,* **66:** 298-308.

Osborn, F.; Goitia. W.; Cabrera, M. and Jaffe, K., 1999. Ants, plants and butterflies as diversity indicators: Comparison between strata at six forest sites in Venezuela. *Stud. Nest. Faun. Environ.,* **34**(1) : 59-64.

Paramesan, C., 1996. Climate and species' 382: 765-766. Entomology and pest Management, Lowa State University, U.S.A.

Possingham, H.A., 1993. Impact of elevated CO on biodiversity: mechanistic population-dynamic 2 perspective. *Australian Journal of Botany,* **41:** 11-21.

Pai, I.K. and Priya, M., 2001. Butterfly diversity of Goa .Entomon, 26 (Special Issue): 350-352.

Prajapati, R.C., 2010. Biodiversity of Karnataka, at a glance. Forest, Environment & Ecology Department, Government of Karnataka, Bangalore, p. 25 .

Pliske, T.E., 1975b. Attraction of Lepidoptera to plants containing pyrrolizidine alkaloids. *Environm. Entomol.*, **4 :** 455-473.

Pollard, Å., 1991. Monitoring butterfly numbers; in Monitoring for conservation and ecology F.Â. Goldsmith (London: Chapman and Hall) : 87-111.

Pollard, E. and Yates, T., 1993. Monitoring butterflies for ecology and conservation. Chapman & Hall, NY.

Pant, D.N.; Das, K.K. and Roy, P.S., 1992. Mapping of tropical dry deciduous forest and landuse in part of Vindyan range using satellite remote sensing. Photonirvachak, *Journal of the Indian Society of Remote Sensing,* **20 :** 9-20

Padhye, A.D.; Dahanukar. N.; Paingankar. M.; Deshpande, M. and Deshpande, D., 2006. Season and Landscape wise distribution of butterflies in Tamhini, Northern, Western Ghats, *India. Zoos' Print. J.*, **21**(3) : 2175-2181.

Pramod Kumar, B.B.; Hosetti, H.C. and Raghavendra, G.H.T., 2007. Butterflies of the tiger lion safari, Thyavarekoppa, Shioga, Karnataka, *Zoos' Print. J.*, **22**(3): 2805.

Radhakrishnan, C. and Lakshminarayana, K.V., 2001. Insecta: Lepidoptera: Rhophalocera, In: Director Z.S.I. Kolkata, Fauna of Nilgri Biosphere Reserve, *Fauna of Conservation Area Series* 11, Surv. India. 143-158.

Rane, N.S. and Ranade, S.P., 2004. Butterflies of Tamhini Dongarwadi area, Mulshi, Maharashtra. *Zoos' Print Journal.*

Ramesh, P.; Jahir Hussain, K.; Selvanayagam, K.M.; Satpathy, K.K. and Prasad, M.V.R., 2010. Patterns of diversity, abundance and habitat associations of butterfly communities in heterogeneous landscapes of the department of atomic energy (DAE) campus at Kalpakkam, South India. *International Journal of Biodiversity and Conservation,* **2**(4) : 75-85.

Rushton, S.P.; Barreto, G.W.; Cormack, R.M.; Macdonald, D.W. and Fuller, R., 2000. Modelling the e€ects of mink and habitat fragmentation on the water vole. *Journal of Applied Ecology,* **37:** 475-490.

Ramachandran, V.S.; Shivayogeswar, B. and Nandihalli, B.S., 1997. The influence of eco climatic factors on insect population dynamics in Karantaka: a case study at

Shimoga. *Kar. J. Agri. Sci.*, **10**(4): 953-956.

Rosenthal, G.A. and Berenbaum, M.R., 1992. Herbivores: In: their Interaction with Secondary Plant Metabolites, 2nd Edition. Academic Press, New York.

Rosenthal, G.A. and Janzen, D.H., 1979. Herbivores. In: Their Interaction with Secondary Plant Compounds, 2nd Edition. New York Academic Press.

Sharma, R.M., 2009. Insecta: Lepidoptera: Rhopalocera and Grypocera. Fauna of Bhimashankar Wildlife Sanctuary. *Conservation Area Series*, **42:** 257-262.

Schneider, C., 2003. The influence of spatial scale on quantifying insect dispersal : an analysis of butterfly data. *Ecological Entomology*, **28 :** 252-256.

Sreekumar, P.G. and Balakrishnan. M., 2001. Habitat and altitude preferences of butterflies in Aralam Wildlife Sanctuary, Kerala. *Trop. Ecol.*, **42**(2) : 277-281.

Soubadra Devy, M. and Priya. D., 2001. Response of wet forest butterflies to selective logging in Kalkad – Mundanthurai. Tiger Reserue : Implications for conservation. *Curr. Sci. India*, **80**(3): 400-405.

Smart, S.M.; Firbank, L.G.; Bunce, R.G.H. and Watkins, J.W., 2000. Quantifying changes in abundance of food plants for butterfly larvae and farmland birds. *Journal of Applied Ecology*, **37 :** 398- 414.

Solis, M.A.; Reaka-Kudla, M.L.; Wilson, D.E. and Wilson, E.O., 1997. Snout moths: unraveling the taxonomic diversity of a speciose group in the neotropics. Biodiversity – 2: understanding and protecting our biological resources. Joseph Henry Press, Washington. 231-242.

Saarinen, K.; Marttila, O. and Jantunen, J., 1998. Species richness and distribution of butterflies (Lepidoptera: Hesperioidea, Papilionoidea) in an agricultural environment in SEF inland. *Entomol. Fennica*, **9**(1): 9-18.

Sudheendrakumar, V.V.; Binoy, C.F.; Suresh, P.V. and Mathew, G., 2000. Habitat associations of butterflies in the Parambikulam wild life sanctuary, Kerala, India. *J. Bom. Nat. Hist. Soc.*, **97**(2): 193-201.

Schneider, D.; Boppre, M.; Schneider, H.; Thompson, W.R.; Boriack, C.J.; Petty, R.L. and J.Meinwald, 1975. A pheromone precursor and its uptake in male Danaus butterflies. *J. Comp. Physiol.*, **97 :** 245-256.

Saha, S. and Raychaudhuri, D., 1998. Moths (Lepidoptera) of *Buxa tiger* reserve, Jalpaiguri, West Bengal. *Zoos' Print.* (May issue): 24.

Setamou, M.; Schulthess, F.; Poehling, H. and Borgemeister, C., 2000. Spatial distribution of and sampling plans for *Mussidia nigrivenella* (Lepidoptera : Phyralidae) on cultivated and wild host plants in Benin. *Environ. Entomol.*, **29**(6): 1216-1225.

Spitzer, K.; Novotny, V.; Tonner, M. and Leps, J., 1993. Habitat preferences, distribution andseasonality of the butterflies (Lepidoptera, Papilionoidea) in a montancetropicalrain forest, Vietnam. *Journal of Biogeography*, **20:** 109-121.

Singh, G.P.; Sinha, R.P.; Singh, S.P. and Hameed, S.F., 1992. Population dynamics and biology of sesamum shoot and leaf webber. *Antigastra catalaunalis* Dub. *(Lepidoptera : Pyralidae) J. Ent. Res.*, **16**(4): 305-310.

Steffan-Dewenter, I. and Tscharntke, T., 1997. Early succession of butterfly and plant communities on set – aside fields. *Oecologica*, **109:** 294-302.

Slansky, F. and Wheeler, G.S., 1992. Caterpillar's compensatory feeding response to diluted nutrients leads to toxic allelochemical dose. *Entomol. Exp.Appl.*, **65:** 171-186.

Schneider, D.; Boppre, M.; Schneider, H.; Thompson, W.R.; Boriack, C.J.; Petty, R.L. and Meinwald, J., 1975. A pheromone precursor and its uptake in male Danaus butterflies. *J. Comp. Physiol.*, **97:** 245-256.

Stout, J.M.; Thaler, J.S. and Thomma, B.P.H.J., 2006. Plant mediated integrations between pathogenic microorganisms and herbivorous arthropods. *Annu. Rev. Entomol.* **51:** 663-689.

Schoonhoven, L.M.; Jermy, T. and Van Loon, J.J.A., 1998. Insect Plant Biology. From Physiology to Evolution.Chapman and Hall, London.

Shapiro, A.M., 1976. Seasonal polyphenism. Evol Biol., **9 :** 259–333.

Stearns, S.C., 1992. The Evolution of Life Histories. Oxford: Oxford Univ.Press 46.

Thomas, C.D. and Harrison, S., 1992. Spatial dynamics of a patchily distributed butterfly species. *J. Anim. Ecol.*, **61:** 437-446.

Thomas, C.D. and Malorie, H.C., 1985. Rarity, species richness, and conservation: Butterflies of the Atlas Mountains in Morocco. *Biological Conservation*, **33:** 95-117.

Thomas, J.A. andMorris, M.G., 1994. Patterns, mechanisms and rates of extinction among invertebrates in the United Kingdom. Philosophical Transactions of the Royal Society of London (B) *Biological Sciences*, **344:** 47–54.

Thomas. C.D. and Warren, M.S., 1992. Distribution of occupied and vacant butterfly habitats in fragmented land scapes. *Oecologia*, **92:** 563-567.

Thorsteinson, A.J., 1953. The chemotactic responses that determine host specificity in an oligophagous insect (*Plutella maculipennis* (Curt.) Lepidoptera). *Canad. J. Zool.*, **31:** 52-72.

Verboom, J.; Schotman, A.; Opdam, P. and Metz, J.A.J., 1991. European nuthatch metapopulation in a fragmented agricultural landscape. *Oikos*, **61:** 149-156.

Visser, J.H., 1988. Host-plant finding by insects – orientation, sensory input and search patterns. *J. Insect Physiol.* **34:** 259–268.

Visser, J.H., 1986. Host odor perception in phytophagous in-

sects. *Annu. Rev.Entomol*., **31:** 121-144.

Walters, D.R. and Ayres, P.G., 1981. Growth and branching pattern of roots of barley infected with powdery mildew. *Ann. Bot*., **47:** 159-162.

Wood, D.L., 1982. The role of pheromones, kairomones, and allomones in the host selection and colonization behavior of bark beetles. *Annu. Rev. Entomol*., **27:** 411-446.

Wermelinger, B. and Seifert, M., 1999. Temperature-dependent reproduction of the spruce bark beetle Ipstypographus, and analysis of the potential population growth. *Ecol. Entomol*., **24:** 103-110.

Windig, J.J.; Brakefield, P.M.; Reitsma, N. and Wilson, J.G.M.; 1994. Seasonal polyphenism in the wild: survey of wing patterns in five species of Bicyclus butterflies in Malawi. *Ecol Entomol*., **19 :** 285–298.

Williams, C.B., 1927. A study of butterfly migration in south India and Ceylon, Green, J.C.F. Fryer and W. Ormiston. *Trans. Ent. Soc. Lond*., **75:** 1-33.

Work, T.T. and McCullough, D.G., 2000. Lepidopteran communities in two forest ecosystems during the first gypsy moth outbreaks in northern Michigan. *Environ. Entomol*., **29**(5): 884-900.

Whittaker, J.B., 2001. Insects and plants in a changing atmosphere. *Journal of Ecology* **89:** 507–518.

Wynter-Blyth, M.A., 1944. Butterflies of the Nilgiris. *Journal of the Bombay Natural History Society*, **44:** 601-602.

Xavier, A., 2006. Butterfly fauna of government arts science college campus, Kozhikode, Kerala. *Zoo's Print. J.*, **21**(5): 2263-2264