Biodiversity Journal, 2021, 12 (3): 741–754 https://doi.org/10.31396/Biodiv.Jour.2021.12.3.741.754

Butterfly species richness, diversity and temporal variation in Maduru Oya National Park, Sri Lanka

Praneeth Silva, Tharanga Dananjani, Dulan Jayasekara, Chamara Prabhath & Dharshani Mahaulpatha*

Wildlife Circle, Department of Zoology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
*Corresponding author, email: mahaulpatha@sjp.ac.lk

ABSTRACT The butterflies are an extremely diverse group of enticing insects in Sri Lanka, comprising 248 known species, of which 26 are endemic species. Present study was conducted from January 2019 to December 2019 in the Maduru Oya National Park with the main objectives of estimating the butterfly diversity and its temporal variation throughout the year. The field method was based on standardized "Pollard walk" method. Line transects of about 1000 meter were applied in length in each habitat types and each transect was divided into five segments of 200 meters. Survey was carried out three days per month in the microhabitat types of Vegetated Cover, Open Grassland and Non-vegetated Area during 0700 to 1700 hours. Shannon Diversity index was used to estimate the butterfly diversity of each microhabitat types. During the survey, 5040 butterfly count, consisting of 5 families and 33 species, including two endemics, were recorded in the park. Butterfly density was high in October 12.74% and lower in June 09.07%. Species richness was high in February (n= 31), May (n= 28), June (n= 27), November (n= 28) and December (n= 27) months. The main reasons for monthly fluctuations of both mentioned parameters were the seasonal changes with weather fluctuations and the influence of flowering and fruiting season. Papilionidae 24.25%, Pieridae 29.46%, Nymphalidae 26.43%, Lycaenidae 18.49% and Hesperiidae 1.37% counts were recorded in each family. The highest species richness was observed in Vegetated Cover 42.86% (n=33) and the lowest was recorded in Non-Vegetated Area 25.97% (n=20). The present study discloses the fact that Maduru Oya National Park is a hidden paradise for butterflies and encourages more research studies of butterfly fauna to be conducted in national parks as this is the second study which has been carried out in a national park of Sri Lanka and first study in the Maduru Oya National Park.

KEY WORDS Butterflies; Maduru Oya National Park; Diversity; Temporal variation.

Received 19.01.2021; accepted 28.07.2021; published online 22.09.2021

INTRODUCTION

Lepidoptera is the second largest order in the class Insecta, approximately made up of 1, 50,000 species (New & Collins, 1991). Butterflies are very fascinating flying insects among lepidopterans and essential bioindicators of ecology and evolutionary studies.

There are about 19000 (19,238) species of butterflies distributed around the world (Heppner, 1998). The Western Ghats - Sri Lanka region is a global biodiversity hot spot characterized by a large number of endemic species. The butterfly fauna in this area accounts for 331 species while Sri Lanka accounts for 248 species including 26 endemics representing six families, namely: Hesperiidae, Lycaenidae, Nymphalidae, Riodinidae, Papilionidae and Pieridae. Of the total butterfly species in the island, 21 are categorized as critically endangered, while 38 endangered, 40 vulnerable

and 21 near threatened (Van der Poorten, 2012). Furthermore, the conservation status of 29 species of butterflies has not been evaluated, due to the lack of adequate data (Karunarathna et al., 2012).

Butterflies play a vital role in maintaining the stability of the ecosystem as performing multi-directional activities: pollination, energy transformation (Naeem et al., 1994; Tilman et al., 1996). Other than their aesthetic value, butterflies are considered useful organisms to monitor environmental changes due to their diversity, wide distribution, specificity to vegetation type, rapid response to perturbation, taxonomic tractability, statistically significant abundance and ease of sampling.

The distribution of butterflies in the island is governed principally by climate, topography and vegetation. Some species are distributed island-wide, with differences in their relative abundance related to bioclimatic zones and other biotic factors (Van der Poorten, 2014).

Investigating the literature on global studies, most of the butterfly researches have been focused on diversity estimations (Majumder & Lodh, 2015; Mukherjee et al., 2016; Al Haidar & Ahsan, 2018) and fewer studies carried out on phylogenic analysis (Decaens & Rougerie, 2008; Spitsyn et al., 2015; Hinojosa et al., 2018). Though this phenomenon is the same for the local status, a huge imbalance of gathering data of butterfly distribution throughout the country has emerged, as only three studies account for Dry Zone (Asela et al., 2006; Asela et al., 2009; Samarasinghe et al., 1996) and one study represents butterfly diversity in Arid Zone (Karunarathna et al., 2012). Moreover, Samarasinghe et al. (1996) is the sole survey which was performed in a national park of Sri Lanka. These evidence further highlights Van der Poorten (2012) and pushes to conduct island-wide researches representing all bioclimatic zones to estimate the absolute distribution, abundance and diversity of butterfly fauna.

To bridge the gap of information on the butterfly fauna, a sustained exploration was undertaken in the Maduru Oya National Park. Butterfly species diversity, species composition and its temporal variation throughout the year were evaluated with the ultimate goal of disclosing the butterfly diversity profile of the area and declaring the conservation priority of the species (see also Silva et al., 2020; Mahaulpatha et al., 2021).

MATERIAL AND METHODS

Study area

The Maduru Oya National Park lies between 700 40' – 700 25' northern latitudes and 810 0'–810 15' eastern longitudes with an area of 58,850 ha extending the Eastern, Uva and North- central Provinces of Sri Lanka (DWC, 2004; IUCN, 1990). The altitude of the National Park varies from 30 m to 150 m, reaching a maximum at 685 m (Gabadage et al., 2015). The national park provides habitats for the displaced wildlife and provide refuge for many other native fauna and flora, particularly elephants and harbors for thousands of aquatic birds (DWC, 2004) (Fig. 1).

Surveying of butterfly richness and abundance

Field survey was conducted from January 2019 to December 2019, over one-year time period. Survey was made over 36 days, spending 720 person-hours in the field throughout the study period.

The field method was based on standardized "Pollard walk" method (Pollard et al., 1977). Line transects of about 1000 meter were applied in length and each was divided into five segments of 200 meters and laid in each micro-habitat types: Vegetated Cover (a landscape dominated by *Heliotropium indicum, Lantana camara* and *Stachytarpheta jamaicensis*), Open Grassland (an area of land mainly composed of *Panicum maximum*), and Non-vegetated Area (comprised of roads and water banks). Sampling was carried out during 0700 to 1700 hours during the sunny days, with uniform pace of 45–50 minutes in a transect providing equal effort (Royer et al., 1998; Majumder et al., 2013). Each sampling site was visited once a month. Butterflies observed within 2.5 meters either side of transect line and five meters to the front of recorder were recorded (Parandhaman et al., 2012). The survey team with at least two people walked at a uniform pace and recorded all butterflies seen within an imaginary $5 \times 5 \times 5$ m^3 box in front and above of the observer were recorded (Kudavidanage et al., 2012). Every effort was made to avoid counting butterfly more than once. Stoppages were made along transect to resolve identification problems either by photograph or closer examination for the direct identification and recording was resumed from

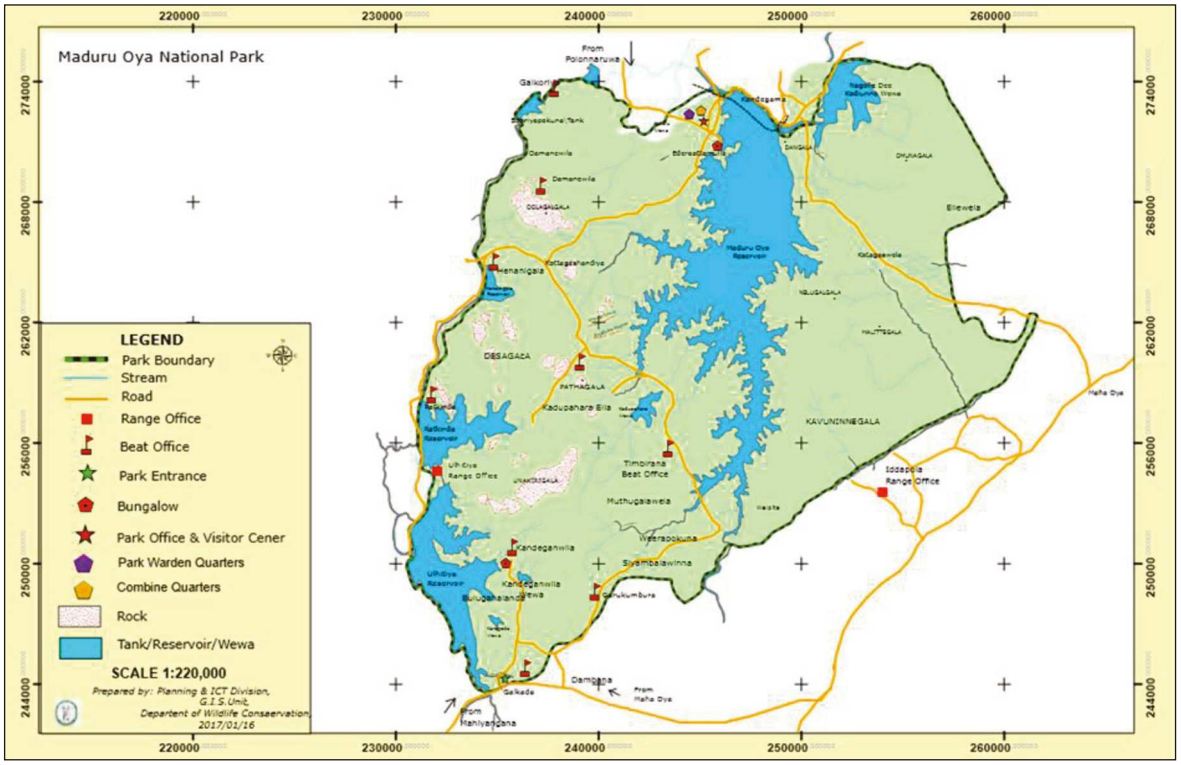


Figure 1. Map of the study area (DWC, 2004).

the point where the walk was interrupted. The status of butterflies was determined on the basis of total encounter during field study and grouped into four categories. Those species of butterflies which were encountered more than 75% times have been categorized as Very Common (VC); 51–75% as Common (C); 26–50% Uncommon (UC) and less than 25% as Rare (R). Families, generic names, and species names in the checklist list of butterflies were arranged in the alphabetical order (Al Haidar & Ahsan, 2018).

Methods

Identification of butterflies was primarily made directly in the field. A pair of binoculars was used to identify butterflies seen along transects and a hand lens was used for closer identification if necessary. Butterflies which were harder to identify in the field were photographed (Nikon digital camera D5300) for the later identification using standard guides (Jayasinghe et al., 2013; Gamage, 2014; Wijeyeratne, 2015; Jayasinghe, 2015).

Rainfall measures of the sampling months were taken from the Department of Meteorology. Vegetation of the each micro habitat types were identified using guides (Ashton et al., 1997; de Vlas & de Vlas-De Jong, 2008).

Microsoft Excel 2013 software was used for graphical representations.

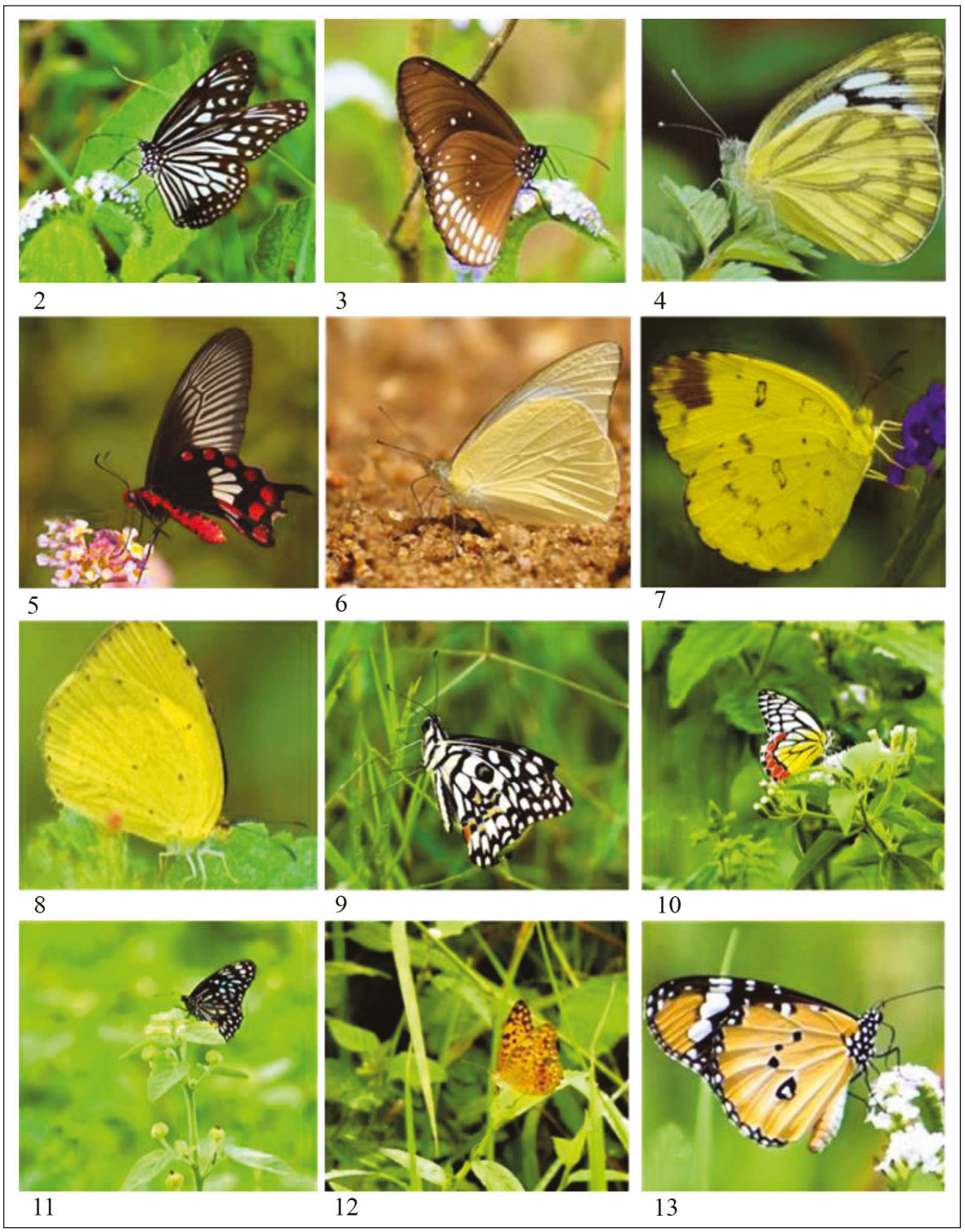
Species diversity was calculated using Shannon diversity index (H' = - ∑Pi ln Pi) and Shannon evenness was calculated using the formula; E = H' / ln S, where, H' = Shannon diversity index, and Pi = Proportional abundance of the species, E = Shannon evenness and S = Total number of species in habitat (species richness) (Magurran, 1988).

RESULTS

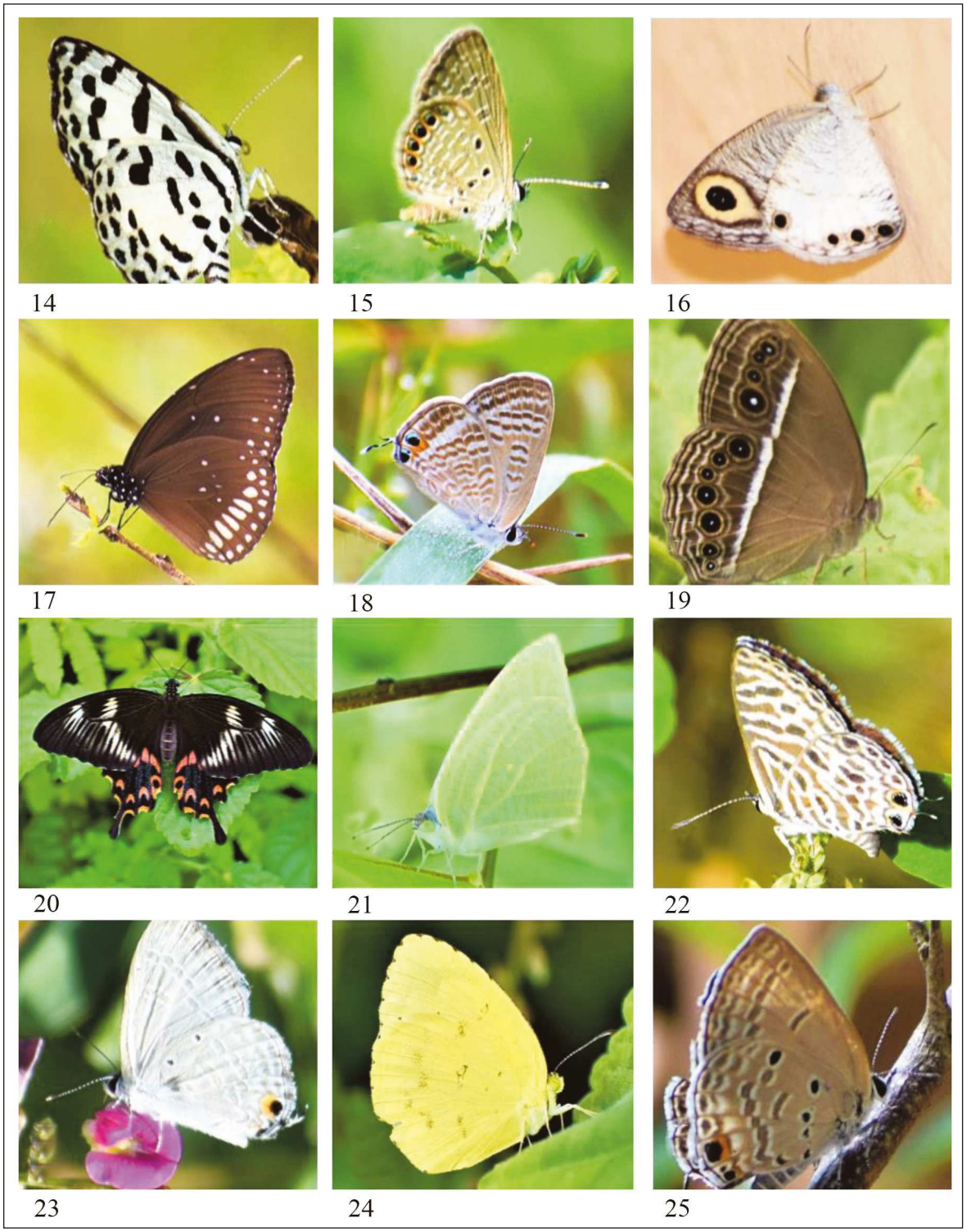
During the course of study, a total of 5,040 individuals of 33 species of butterflies belonging to 5 families (Table 1, Figs. 2–34) were observed. The butterfly abundance was high in October 12.74% (n=642), November 11.83% (n=596) and December 10.97% (n=553) while less counts were marked in January 05.93% (n=299), July 03.37% (n=170) and September 06.37% (n=321). February

No	Family	Species name	Common name	Status
1	Papilionidae	*Papilio polytes* Linnaeus, 1758	Common mormon	LC
2		*Pachliopta aristolochiae* Fabricius, 1775	Common rose	LC
3		*Pachliopta hector* Linnaeus, 1758	Crimson rose	LC
4		*Papilio demoleus* Linnaeus, 1758	Lime butterfly	LC
5	Pieridae	*Eurema hecabe* Linnaeus, 1764	Common grass yellow	LC
6		*Cepora nerissa* Fabricius, 1775	Common Gull	LC
7		*Delias eucharis* Drury,1773	Jezebel	LC
8		*Catopsilia pomona* Fabricius, 1775	Lemon emigrant	LC
9		*Colotis amata* Fabricius, 1775	Small salmon arab	LC
10		*Eurema brigitta* Stoll, 1780	Small Grass Yellow	LC
11		*Appias galena* Felder et Felder, 1865	Sri Lankan Lesser Albatross	LC
12		*Eurema blanda* Boisduval, 1836	Three-spot grass yellow	LC
13		*Catopsilia pyranthe* Linnaeus, 1758	Mottled emigrant	LC
14		*Eurema ormistoni* Watkins, 1925	Sri Lankan One-spot Grass Yellow	LC
15	Nymphalidae	*Junonia iphita* Cramer, 1779	Chocolate soldier	LC
16		*Euploea core* Cramer, 1779	Common crow	LC
17		*Phalanta phalantha* Drury, 1773	Common Leopard	LC
18		*Danaus chrysippus* Linnaeus, 1758	Plain tiger	LC
19		*Tirumala septentrionis* Butler, 1874	Dark Blue Tiger	NT
20		*Mycalesis mineus* Linnaeus, 1758	Dark-Brand Bushbrown	LC
21		*Euploea sylvester* Fabricius, 1793	Double Branded Crow	NT
22		*Parantica aglea* Stoll, 1782	Glassy Tiger	LC
23		*Junonia almanac* Linnaeus, 1758	Peacock Pansy	LC
24		*Ypthima ceylonica* Hewitson, 1865	White Four Ring	LC
25	Lycaenidae	*Castalius rosimon* Fabricius, 1775	Common pierrot	LC
26		*Catochrysops strabo* Fabricius, 1793	Forget-me-not	LC
27		*Freyeria putli* Kollar, 1844	Grass Jewel	LC
28		*Lampides boeticus* Linnaeus,1767	Pea Blue	LC
29		*Chilades pandava* Horsfield,1829	Plains Cupid	LC
30		*Amblypodia anita* Hewitson,1862	Purple Leaf Blue	NT
31		*Leptotes plinius* Fabricius,1793	Zebra Blue	LC
32		*Chilades lajus* Stoll, 1780	Lime blue	LC
33	Hesperiidae	*Ampittia dioscorides* Fabricius, 1793	Bush Hopper	LC

Table 1. Systematic list of the Butterflies recorded in Maduru Oya National Park.



Figures 2–13. The representative butterfly species encountered during the study period. Fig. 2: Glassy Tiger (*Parantica aglea*). Fig. 3: Double Branded Crow (*Euploea sylvester*). Fig. 4: Common Gull (*Cepora nerissa*). Fig. 5: Common Rose (*Pachliopta aristolochiae*). Fig. 6: Sri Lankan Lesser Albatross (*Appias galena*). Fig. 7: Three-spot Grass Yellow (*Eurema blanda*). Fig. 8: Small Grass Yellow (*Eurema brigitta*). Fig. 9: Lime Butterfly (*Papilio demoleus*). Fig. 10: Jezebel (*Delias eucharis*). Fig. 11: Dark Blue Tiger (*Tirumala septentrionis*). Fig. 12: Common Leopard (*Phalanta phalantha*). Fig. 13: Plain Tiger (*Danaus chrysippus*).



Figures 14–25. The representative butterfly species encountered during the study period. Fig. 14: Common Pierrot (*Castalius rosimon*). Fig. 15: Grass Jewel (*Freyeria putli*). Fig. 16: White Four Ring (*Ypthima ceylonica*). Fig. 17: Common Crow (*Euploea core*). Fig. 18: Pea Blue (*Lampides boeticus*). Fig. 19: Dark-Brand Bushbrown (*Mycalesis mineus*). Fig. 20: Common Mormon (*Papilio polytes*). Fig. 21: Mottled Emigrant (*Catopsilia pyranthe*). Fig. 22: Zebra Blue (*Leptotes plinius*). Fig. 23: Forget-me-not (*Catochrysops Strabo*). Fig. 24: Sri Lankan One-spot Grass Yellow *(Eurema ormistoni*). Fig. 25: Plains Cupid (Chilades pandava).

Figures 26–34. The representative butterfly species encountered during the study period. Fig. 26: Small Salmon Arab (*Colotis amata*). Fig. 27: Crimson Rose (*Pachliopta hector*). Fig. 28: Bush Hopper (*Ampittia dioscorides*). Fig. 29: Peacock Pansy (*Junonia almanac*). Fig. 30: Purple Leaf Blue (*Amblypodia anita*). Fig. 31: Lime blue (*Chilades lajus*). Fig. 32: Chocolate Soldier (*Junonia iphita*). Fig. 33: Lemon Emigrant (*Catopsilia pomona*).

(n= 31), May (n= 28) and November (n= 28) months were noted with significant number of species richness (Fig. 35). There was a steady increase during the time period between August and November, in contrast diversity indexes were lower in the last months of the study period and continuously raised over the initial months of the survey (Fig. 36).

Of the recorded species during the field study, 01 was Very Common, 04 were Common, 19 were Uncommon and 09 were Rare. Following mentioned families have been recorded in under mentioned percentages: Papilionidae 24.25% (n=1222), Pieridae 29.46% (n=1485), Nymphalidae 26.43% (n=1332), Lycaenidae 18.49% (n=932) and Hesperiidae 1.37% (n=69), respectively (Fig. 37).

These families included 33 species and of them one was endemic. The 33 species of butterflies recorded during the study represents 13.31% of the total Sri Lankan butterfly fauna described to date. The species diversity within the families such as, Papilionidae 12.12% (n=4), Pieridae 30.30%

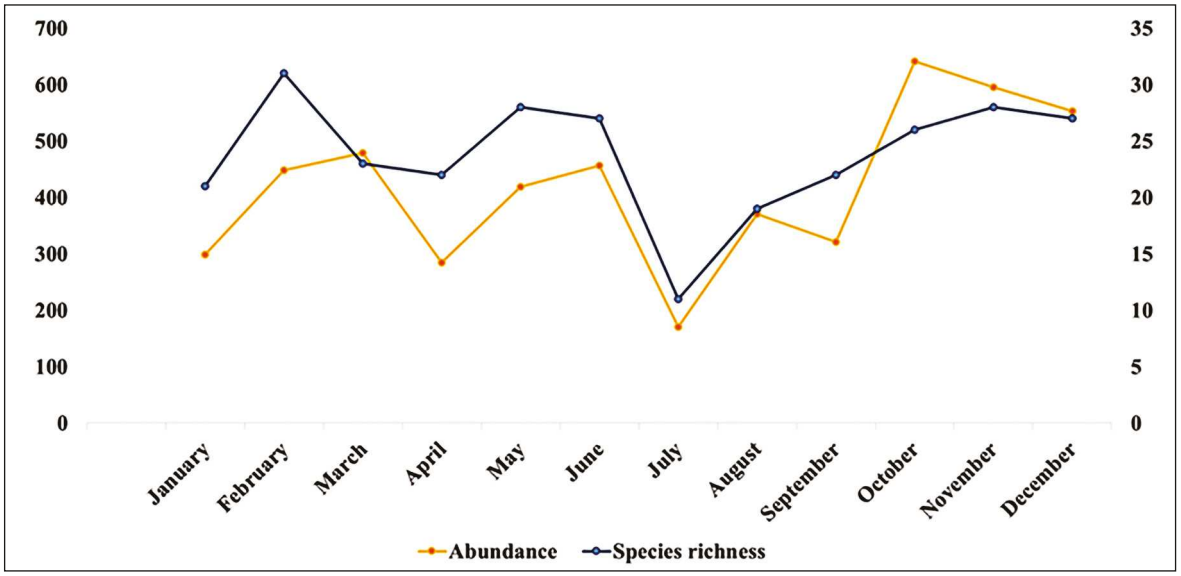


Figure 35. Monthly variation of butterfly abundance and species richness in Maduru Oya National Park.

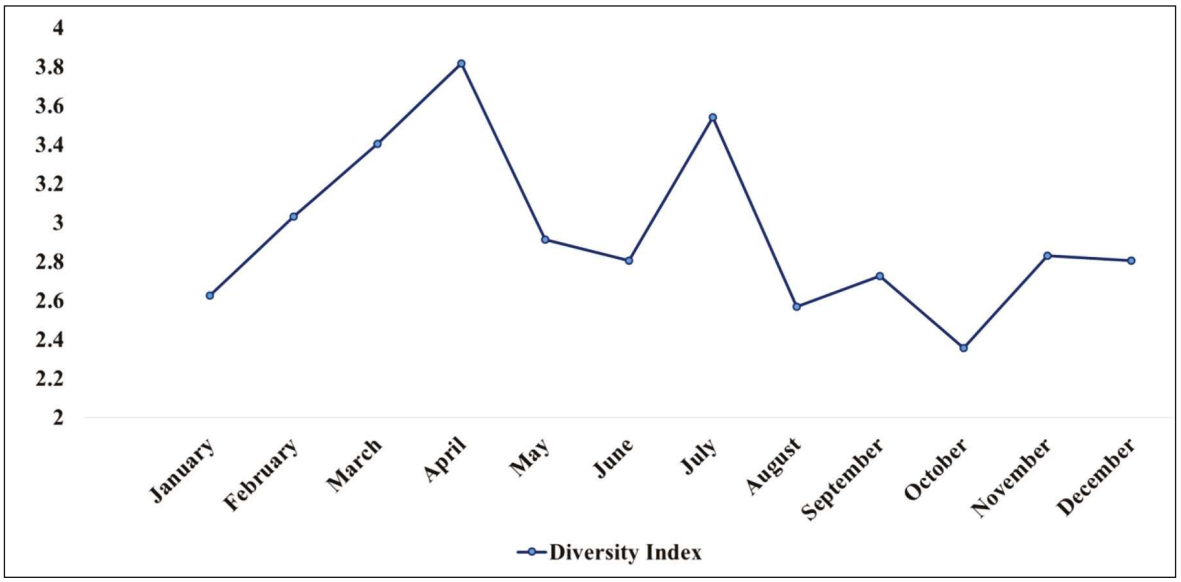


Figure 36. Monthly fluctuation of Shannon Diversity index of butterfly fauna throughout the study period.

(n=10), Nymphalidae 30.30% (n=10), Lycaenidae 24.24% (n=8) and Hesperiidae 03.03% (n=1), respectively. Among the species recorded, three species are considered as Near Threatened.

Habitats differed in the butterfly species diversity and Vegetated area had the highest (100.00%), followed by Grassland Zone (72.72%), and the lowest Non-Vegetated Area (60.60%). Moreover, Vegetated area had the highest diversity index in both dry and wet seasons (Fig. 38).

In the present study, the maximum number of species and individuals were observed in the Vegetated Area, where availability of diverse plants and access to host plants; *Sida cordifolia* (Flannel Weed), *Phyllanthus polyphyllus* (Shrub Amla Tree), *Triumfetta rhomboidea* (Diamond Burbark), *Cro-*

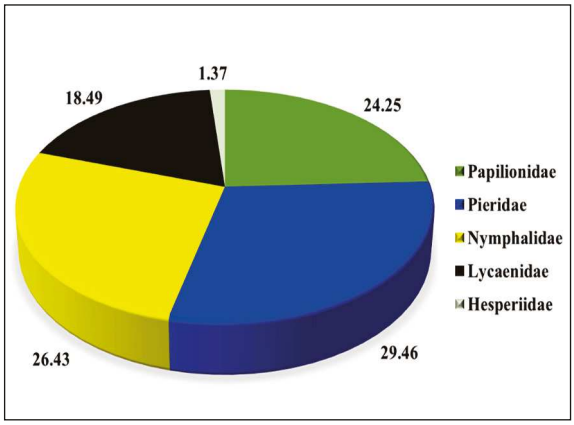


Figure 37. Percentage of recorded butterfly species belong to different families of the study area.

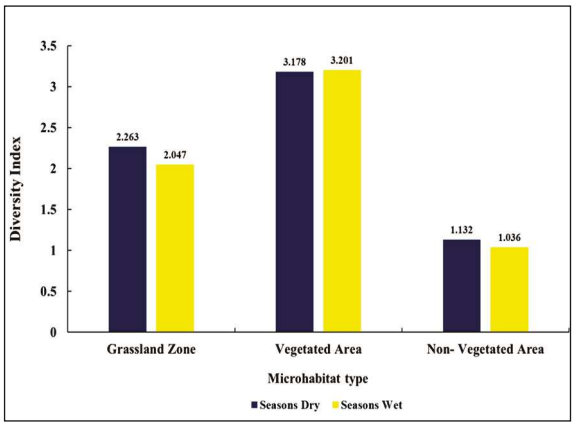


Figure 38. Comparison of diversity indices of butterfly fauna of different microhabitat types within dry and wet seasons.

talaria walker (Walker's Rattlepod), *Croton bonplandianus* (Ban Tulsi), *Abutilon indicum* (Country Mallow), *Cassia occidentalis* (Coffee Senna) , *Solanum virginianum* (Yellow-fruit nightshade), Tephrosia purpurea (Wild Indigo), *Ageratum conyzoides* (Billygoat Weed), *Heliotropium indicum* (Indian Heliotrope), *Sida mysorensis* (India Mysore Fanpetals), *Hibiscus micranthus* (Tiny Flower Hibiscus), *Mimosa invisa* (Giant Sensitive plant), *Stachytarpheta jamaicensis* (Blue porterweed), *Ziziphus oenoplia* (Jackal Jujube), *Lantana camara* (Lantana) (Fig. 39).

Here, comparing the monthly fluctuation of butterfly abundance and richness with monthly rainfall throughout the study period high numbers were observed in last and initial months of the year meanwhile high rainfalls were experienced in the same months (Figs. 40, 41).

DISCUSSION

Distinct differences in individual richness of months might be governed by climatic conditions of the area, as poikilothermic organism's biological cycle, activity, distribution and abundance are influenced by monthly temperature (Dennis, 1993; Hill et al ., 1999; Roy & Sparks, 2000) and rainfall (Roy et al., 2001).

Weather parameters affect positively and negatively the biological cycle of butterflies.

Beirne (1955), Larsen (1987), Pollard (1988) and Tiple & Khurad (2009) findings state that the butterflies benefit greatly from cold winters and found very positive significant associations with winter weather. In contrast, warm dry weather conditions tend to decrease butterfly abundance. Pollard (1977) states that high environmental temperatures reduce the butterfly diversity index value of the habitats which indicates environmental temperature is negatively associated with butterfly diversity.

These findings coincide with the present study as high species abundance and richness were recorded in the months of the wet season (October–February) and low counts were experienced in the dry season (March–September) (Pearson & Dawson, 2003).

Normally, Strong, dry and constantly blowing Southwest Monsoon wind prevails between May and September could be the main reason for recording less number of butterflies. Furthermore, flowering and the fruiting season of the study area lies within the wet season between the October and February which indirectly affect to raise the butterfly diversity as in such months occasional showers are common.

Roads and water bank habitats had comparatively less diversity of butterfly as compared to Vegetated area. It may be due to habitats exposed to direct sunlight.

The structural complexity of habitat and diversity of vegetation forms have been shown to be correlated with animal and insect species diversity (Gardner et al., 1995). Southwood (1975) suggests that the herbivores are more influenced by the food quality. Host plants are utilized only when sufficient adult resources (nectar) are also available (Grossmueller & Lederhouse, 1987). Successful butterfly habitat must include sufficient larval and adult food

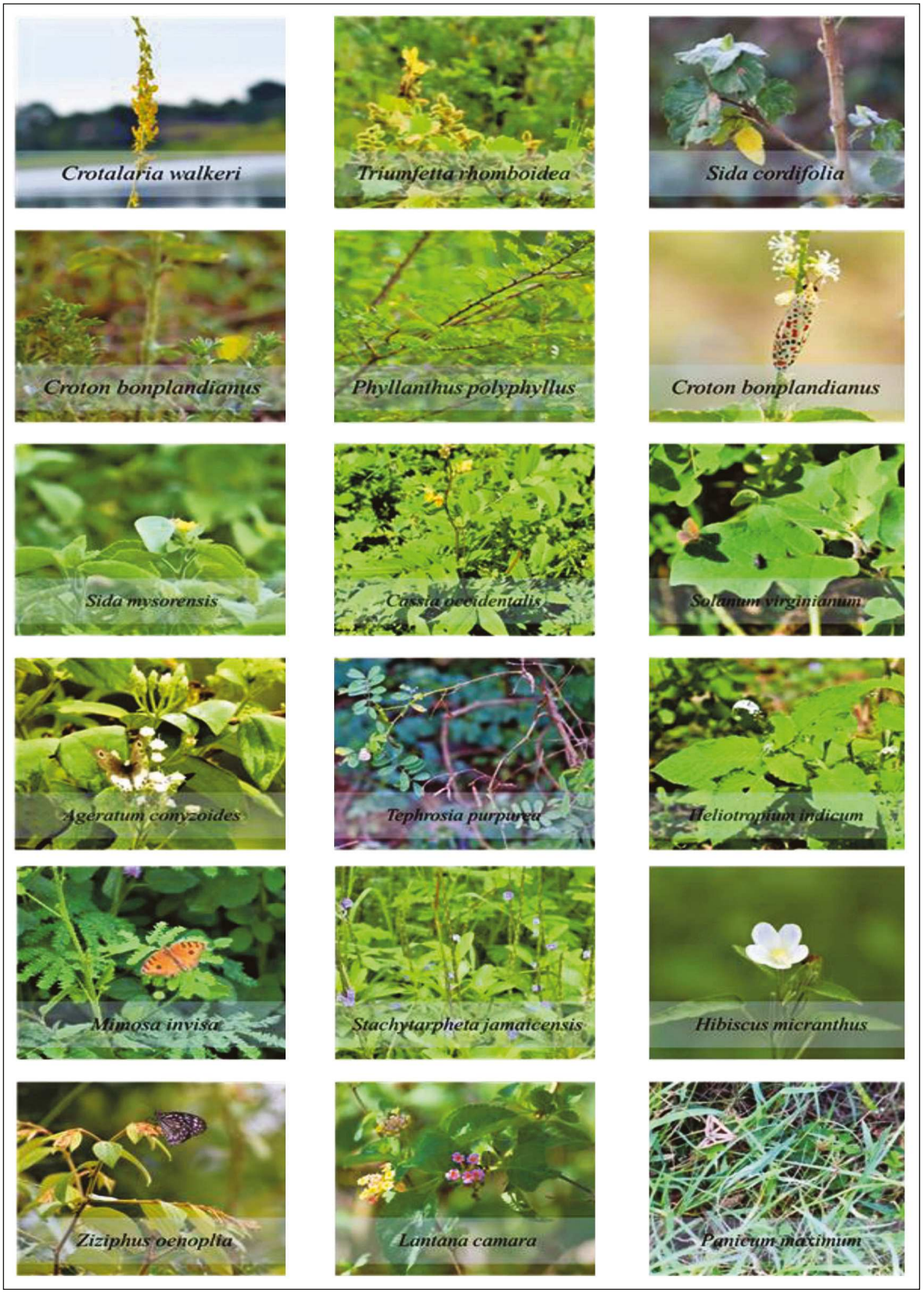


Figure 39. Larval host plants of butterflies recorded in Maduru Oya National Park.

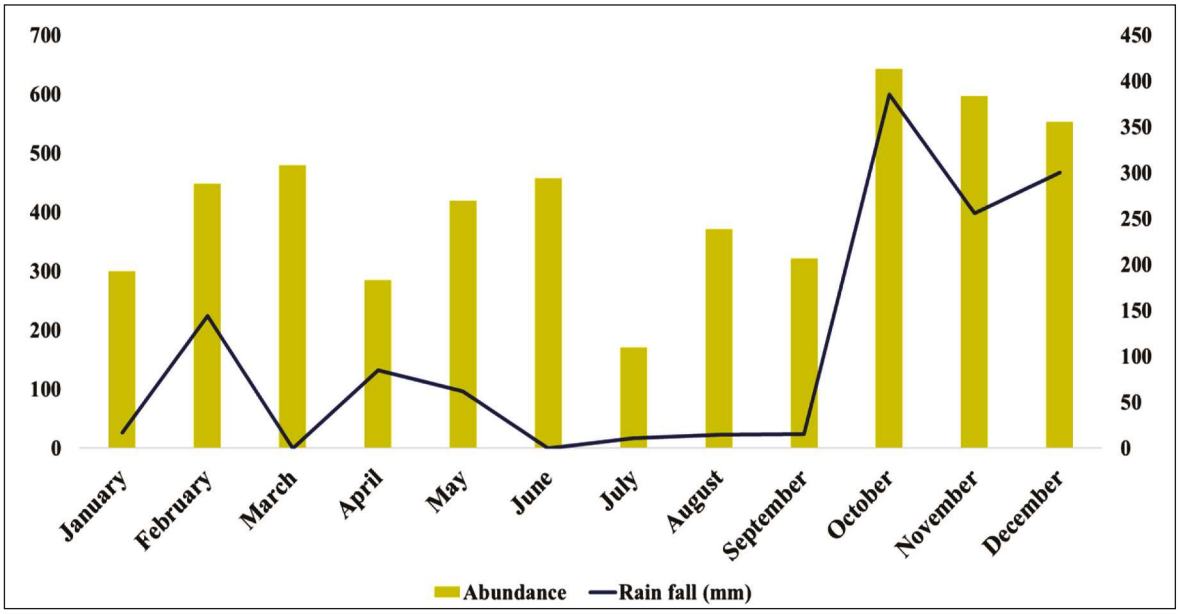


Figure 40. Monthly fluctuation of butterfly abundance with monthly rainfall throughout the study period.

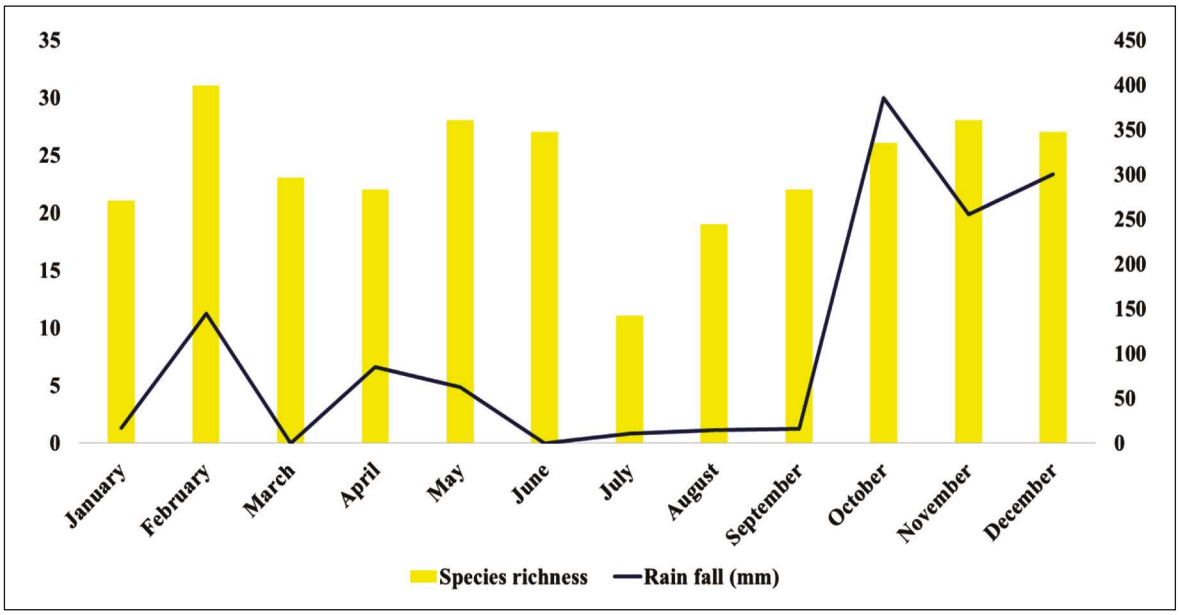


Figure 41. Monthly fluctuation of species richness of butterfly fauna with monthly rainfall throughout the study period.

resources and butterflies like shady habitats due to their cryptic canopy behaviors.

Flowering and fruiting plants promoted the butterfly richness and density. Most of these plants provide rich nectar sources to adult butterflies. In comparison to the other habitats especially, Grassland Zone and Non-vegetated Area have lesser density of vegetation. These habitats being highly disturbed due to anthropogenic activities could also account for lower butterfly colonization. The butterfly distribution is expected to cover with the distribution of their host plants even at small scales and the type of vegetation may reflect the difference in the composition of butterfly communities among habitats at the generic and family level (Beccaloni, 1997).

CONCLUSIONS

The present study discloses the fact that this Park is one of the hidden paradises for butterflies in Dry Zone with unique species and encourages more research studies of butterfly fauna to be conducted in national parks of Sri Lanka. The variations in butterfly fauna between two seasons are attributed to climatic differences of the region as a result of the interaction of biotic and abiotic factors. Favorable climatic conditions that exist in the wet season provide more opportunities for the survival of butterflies and to raise the butterfly abundance. Accordingly, October-November is the best time period for visitors to observe butterflies.

ACKNOWLEDGEMENTS

We appreciate the generous corporation of the Maduru Oya National Park staff and "Department of Wildlife Conservation" for granting permission (Permit no. WL/3/2/40/19) to conduct this research. We want to further express our gratitude to the University of Sri Jayewardenepura and Department of Zoology for the facilities granted and the financial support provided to succeed this research. We are grateful to all the members of the "Wildlife Circle" association for helping with the field work and Mr. Bathiya Gopallawa who is working in National Herbarium, Department of National Botanic Gardens, Peradeniya for contributing his expertise knowledge and experience in Sri Lankan flora for the identification of flora in Maduru Oya National Park.

REFERENCES

Al Haidar I.K. & Ahsan M.F., 2018. A comprehensive checklist of butterflies (Insecta: Lepidoptera) with their status and habitat preference in Teknaf Wildlife Sanctuary, Bangladesh. Journal of Tropical Entomology, 7: 11–34.

Asela M.D.C., Peiris R.A.K., Priyankara S.K.I.U., Jayasekara R.W. & Karunarathna, D.M.S.S., 2009. Some notes on the butterflies (Lepidoptera: Papilionoidea) of Tantirimale Archaeological Site, Anuradhapura District, Sri Lanka. Journal of Threatened Taxa, 1: 392–394. https://doi.org/10.11609/JoTT.o1763.392-4

Asela M.D.C., Rohan M., Peiris A.K. & Karunaratna D., 2006. Observations on Butterflies (Lepidoptera: Papilionoidea) in the Raswehera Archaeological forest in Kurunegala District in Sri Lanka. Loris, 24: 9–14.

Ashton M.S., Gunatilleke S., De Zoysa N., Dassanayake M.D., Gunatilleke N. & Wijesundera S., 1997. A field guide to the common trees and shrubs of Sri Lanka. WHT Publications. Colombo, Sri Lanka, 430 pp.

Beccaloni G.W., 1997. Vertical stratification of ithomiine butterfly (Nymphalidae: Ithomiinae) mimicry complexes: the relationship between adult flight height and larval host-plant height. Biological journal of the Linnean Society, 62: 313–341. https://doi.org/10.1111/j.1095-8312.1997.tb01629.x

Beirne B.P., 1955. Natural fluctuations in abundance of British lepidoptera. Entomologist's Gaz., 6: 21–52.

de Vlas J. & de Vlas-De Jong J., 2008. Illustrated field guide to the flowers of Sri Lanka: descriptions of approximately 1000 plant species, illustrated with more than 2000 colour photographs. First edition. Mark Booksellers and Distributors, Leeuwarden, Netherlands.

Decaens T. & Rougerie R., 2008. Descriptions of two new species of Hemileucinae (Lepidoptera: Saturniidae) from the region of Muzo in Colombia evidence from morphology and DNA barcodes. Zootaxa, 1944 (1): 34–52. https://doi.org/10.11646/zootaxa.1944.1.2

Dennis R.L., 1993. Butterflies and climate change. Manchester University Press.

DWC, 2004. A guide to national parks of Sri Lanka. 2nd ed. Colombo, Sri Lanka: Department of Wildlife Conservation.

Gabadage D.E., Botejue W.M.S., Surasinghe T.D., Bahir M.M., Madawala M.B., Dayananda B., Weeratunga V.U. & Karunarathna D.S., 2015. Avifaunal diversity in the peripheral areas of the Maduruoya National Park in Sri Lanka: With conservation and management implications. Journal of Asia-Pacific Biodiversity, 8: 121–132. https://doi.org/10.1016/j.japb.2015.04.005

Gamage R.N., 2014. An Illustrated Pocket Guide to the Fauna of Sri Lanka. Sri Lanka

Gardner S.M., Cabido M.R., Valladares G.R. & Diaz S., 1995. The influence of habitat structure on arthropod diversity in Argentine semi-arid Chaco forest. Journal of Vegetation Science, 6: 349–356. https://doi.org/10.2307/3236234

Grossmueller D.W. & Lederhouse R.C., 1987. The role of nectar source distribution in habitat use and oviposition by the tiger swallowtail butterfly. Journal of the Lepidopterists' Society, 41: 159–165.

Heppner J., 1998. Classification of Lepidoptera. Part I Introduction. Holarctic Lepidoptera 5: 148.

Hill J.K., Thomas C.D. & Huntley B., 1999. Climate and habitat availability determine 20th century changes in a butterfly's range margin. Proceedings of the Royal Society of London. Series B: Biological Sciences, 266 (1425): 1197–1206.

Hinojosa J.C., Mérit X. & Vila R., 2018. Genètica i distribució de la bruna de secà, Hyponephele lupina (Costa, 1836), a Catalunya (Lepidoptera: Nymphalidae). Butlletín Societat Catalana de Lepidopterologia, 109: 25–32.

IUCN. 1990. IUCN directory of South Asia protected areas. Gland, Switzerland and Cambridge, London: IUCN.

Jayasinghe H.D., 2015. Common Butterflies of Sri Lanka. Ceylon Tea Services PLC, Colombo, Sri Lanka.

Jayasinghe H.D., De Alwis C. & Rajapakshe, S.S., 2013. A pocket guide to the butterflies of Sri Lanka, Second edition. Butterfly Conservation Society of Sri Lanka, 63 pp.

Kudavidanage E.P., Wanger T.C., De Alwis C., Sanjeewa S. & Kotagama S.W., 2012. Amphibian and butterfly diversity across a tropical land-use gradient in Sri Lanka; implications for conservation decision making. Animal Conservation, 15: 253–265. https://doi.org/10.1111/j.1469-1795.2011.00507.x

Larsen T.B., 1987. The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). Journal of the Bombay Natural History Society, 84: 26–54.

Magurran A.E. 1988. Ecological Diversity and Its Measurements. Croom Helm Limited, London, 178 pp.

Karunarathna D.S., Kumarasinghe A., Madawala M.B. & Saman M.A.J., 2012. Diversity and richness of butterfly fauna in a Home Garden habitat, and its vicinity, Puttalam District in Sri Lanka. NeBIO, 3: 93–101

Majumder J., Lodh R. & Agarwala B.K., 2013. Butterfly species richness and diversity in the Trishna Wildlife Sanctuary in South Asia. Journal of Insect Science, 13: 79. https://doi.org/10.1673/031.013.7901

Mahaulpatha D., Silva P., Dasanayake T. & Dilrangi H., 2021. New Study Finds 33 Species of Butterflies at Maduru Oya National Park, Sri Lanka. Article, Feb 2021, 23 pp.

Mukherjee S., Aditya G., Basu P. & Saha G.K., 2016. Butterfly diversity in Kolkata metropolis: a synoptic check list. Check List, 12: 1858. https://doi.org/10.15560/12.2.1858

Naeem S., Thompson L.J., Lawler S.P., Lawton J.H. & Woodfin R.M., 1994. Declining biodiversity can alter the performance of ecosystems. Nature, 368 (6473): 734–737.

New T.R. & Collins N.M., 1991. Swallowtail butterflies - an action plan for their conservation. Gland: International Union for Conservation of Nature, 36 pp.

Parandhaman D., Sivasankaran K., Meerasa M.N. & Ignacimuthu S., 2012. Diversity of butterflies in different habitats from Tamilnadu part of Western Ghats (Lepidoptera: Rhopalocera). Elixir International Journal, 51: 10861–10865.

Pearson R.G. & Dawson T.P., 2003. Predicting the impacts of climate change on the distribution of species: are bioclimatic envelope models useful?. Global ecology and biogeography, 12: 361–371. https://doi.org/10.1046/j.1466-822X.2003. 00042.x

Pollard E., 1977. A method for assessing changes in the abundance of butterflies. Biological conservation, 12: 115–134. https://doi.org/10.1016/0006-3207(77)90065-9

Pollard E., 1988. Temperature, rainfall and butterfly numbers. Journal of Applied Ecology: 25: 819–828. https://doi.org/10.2307/2403748

Roy D.B. & Sparks T.H., 2000. Phenology of British butterflies and climate change. Global change biology, 6: 407–416. https://doi.org/10.1046/j.1365-2486.2000.00 322.x

Roy D.B., Rothery P., Moss D., Pollard E. & Thomas J.A., 2001. Butterfly numbers and weather: predicting historical trends in abundance and the future effects of climate change. Journal of Animal Ecology, 70: 201–217. https://doi.org/10.1111/j.1365-2656.2001.00480.x

Royer R.A., Austin J.E. & Newton W.E., 1998. Checklist and "Pollard walk" butterfly survey methods on public lands. The American midland naturalist, 140: 358–371.

Samarasinghe M.D.P., Paranagama P. & Veediyabandara S., 1996. Survey of the butterfly fauna of Udawalawa National Park. In Proceedings of International Forestry and Environment Symposium.

Silva G.K.V.P.T., Dhananjani D.M.T., Jayasekara E.G.D.P., Prabhath M.C. & Mahaulpatha W.A.D, 2020. Species diversity of butterfly fauna in Maduru Oya National Park, Sri Lanka. 7th International Conference on Multidisciplinary Approaches (ICMA - 2020). https://doi.org/10.13140/RG.2.2.11942.14400

Southwood T.R.E., 1975. The dynamics of insect populations. Insects, science and society: 151–199.

https://doi.org/10.1146/annurev.en.03.010158.000543

Spitsyn V.M., Kondakov A.V., Tomilova A.A., Karamkhudoeva M. & Potapov G.S., 2015. A taxonomic revision of the butterfly genera *Esperarge* and *Kirinia* (Lepidoptera: Nymphalidae: Satyrinae). Ecologica Montenegrina, 26: 118–126. https://doi.org/10.37828/em.2019.26.8

Tilman D., Wedin D. & Knops J., 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. Nature, 379(6567): 718–720. https://doi.org/10.1038/379718a0

Tiple A.D. & Khurad A.M., 2009. Butterfly species diversity, habitats and seasonal distribution in and around Nagpur City, central India. World Journal of Zoology, 4: 153–162.

Van der Poorten G., 2012. The Taxonomy and Conservation Status of the Butterflies of Sri Lanka. In: The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Weerakoon D.K. & S. Wijesundara Eds., Ministry of Environment, Colombo, Sri Lanka, pp. 26–41.

Van der Poorten G., 2014. Butterfly Conservation Action Plan of Sri Lanka, Battaramulla: Biodiversity Secretariat, Ministry of Environment & Renewable Energy.

Wijeyeratne G. de S., 2015. A Naturalist's Guide to the Butterflies & Dragonflies of Sri Lanka. First edition. John Beaufoy Publishing Limited, Oxford, England, 176 pp.