Research Article

Effect of Ecological Factors on Butterflies of Various Agro-Climatic Landscapes in Mysore District, Karnataka, India

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ABSTRACT

Aim: Butterflies survival is strongly interlinked with environmental factors such as temperature, humidity and rainfall. The aim of this study was to find out the influence of ecological factors namely: temperature, humidity, rainfall and wind flow across different agro-climatic landscapes of Mysore district, Karnataka. **Materials and Methods:** Prevailed environmental factors such as temperature, humidity and rainfall constitute the local climate which was collected using a digital thermo-hygrometer. Wind speed data was obtained using the website www.timeanddate.com and site wise rainfall data was collected from https://chrsdata.eng.uci.edu. Different standard methods namely: all-out search method, variable width line transect method and point count method were adopted to survey butterflies across various human-modified and managed habitats of rural and urban landscapes of Mysore district, Karnataka, during August, 2022 to October, 2023. **Results:** Correlation between butterfly abundance and ecological factors was calculated using Microsoft excel 2019. Results indicated that abundance of butterflies was high at cultivable land for agriculture, followed by park, road verge, aquatic habitat, institutional campus, nursery, residential area and weedy vegetation. Correlation coefficient for temperature (r=-0.54, t=-2.32) and relative humidity (r=0.51, t=2.16) was significant at institutional campus. Correlation coefficient for wind speed was significant at the vicinity of aquatic habitat, road verge and cultivable land for agriculture (r=0.67, 0.55 and 0.31) (t=2.59, 2.91 and 2.34). The correlation coefficient for rainfall was not significant at any of the agro-climatic landscapes. **Conclusion:** Perhaps environmental factors might have influenced the life cycle of many butterfly species and showed sensitivity to the changing environmental conditions. Thus, butterflies' survival is strongly interlinked with the locally prevailed environmental factors; their ecology depends on optimum temperature and relative humidity. Rainfall indirectly influences species composition by maintaining vegetation diversity. Therefore, restoration of a good local climate is thus important to protect locally existing butterfly fauna midst agro-climatic landscapes for human advantage. This kind of investigation is very needed in the present context to undertake suitable conservation measures to protect the locally existing butterflies and in turn to protect the local biodiversity.

Keywords: Ecological factors, Butterfly population, Managed agro-climatic landscapes.

INTRODUCTION

Climate variables and butterfly species richness are strongly interlinked.[1] Climate is determined by environmental factors such as temperature, humidity and rainfall along with local vegetation cover helps distribute butterflies in a different pattern.[2] Majority of butterfly species life cycle and survival is depended on various ecological factors which constitute local climate.[3] Butterflies are ectotherms, their survival is influenced by external environment that regulate their body heat and, hence vulnerable to changing temperature.[4] Any minor changes in their habitat affect butterflies population because they are highly sensitive nature

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to changing environmental conditions.[5] Decline of butterfly population is due to their inability to adjust to change the habitat and the prevalence of unfavorable weather conditions.[6] Surprisingly, many butterfly species are monophagous; their distribution is restricted to certain landscapes, which are more prone to climate change than the widespread generalist butterfly species.[7] Further, local seasonal variation and temperature influences butterfly metamorphosis from egg to adult.[8] The persistence of adverse environmental conditions as the season proceeds affects the survival of butterflies by altering the number of generations they live in.[9] Many researchers have reported on the influence of ecological variables on butterflies.[10] has recorded the effect of temperature and rainfall on butterfly numbers. [11] has studied the influence of climate change on the phenology of butterflies in the northwest Mediterranean Basin. The influence of temperature and habitat factors on butterfly diversity was studied by.[1] The influence of temperature and rainfall on butterfly morphology was recorded.[12] Rainfall influences host plant phenology.[13] Effect of environmental factors on the abundance of butterflies was recorded by.[14] The influence of weather patterns on the butterfly community in a temperate ecosystem was reported by[15,16] have recorded the influence of life cycle stages in butterflies due to climate pattern. Response of butterflies to climate change was studied by.[17] Weather conditions affected the variation and dispersion in butterflies[18,19] have recorded the effect of temperature and drought on the early stages of few butterflies[20] have recorded the diversity of butterflies in relation to environmental factors at Manonmaniam Sundaranar University, Tamil Nadu, India. Influence of temperature and humidity gradients on butterfly assemblages in sub-tropical urban landscape was studied by[2,21,22] have recorded the effect of climate change on ecology of butterflies. Microclimate of tropical dry forest, Odisha was reported to affect the butterfly assemblages.[23] Measuring the distribution responses of butterflies which are good indicators, is a wise practical means of assessing the effect of climate change on locally distributed species that make up our wildlife. [24] With this background present study was conducted with the aim to record how the local weather conditions influence the abundance of butterflies across various agro-climatic landscapes of Mysore district. Since, Mysore district has good biodiversity[25] and known for its diversified landscapes[26,27] hosted good number of butterfly species. Published reports on locally available butterfly species is poor and inventorying could help undertake protective measures to restore the existing species midst various agro-climatic landscapes. This type of investigations helps provide base line scientific information to initiate further in-depth research to formulate conservation measures to save the butterfly species and local biodiversity as well.

MATERIALS AND METHODS

Study area: Mysore district lies along the coordinates of 12º18' latitude and 76º12' longitude and altitude of 770 meters above mean sea level.[25] The district is characterized by a tropical monsoon type of climate. The minimum and maximum temperatures fall between 21.4 to 34ºC in April to 16.4 to 28.5ºC in January in Mysore. Average annual rainfall of the district is 850 mm. The seven taluks of Mysore district are Mysore, Hunsur, Periyapatna, Tirumakudal Narsipur, Nanjangud, Krishnarajanagara and Heggadadevankote. The study was conducted across various human-modified and managed habitats of rural and urban areas of Mysore district, Karnataka. Fifteen sites were chosen randomly from each taluk of Mysore district for the present study (Figure 1) during August, 2022 to October, 2023.[26-28]

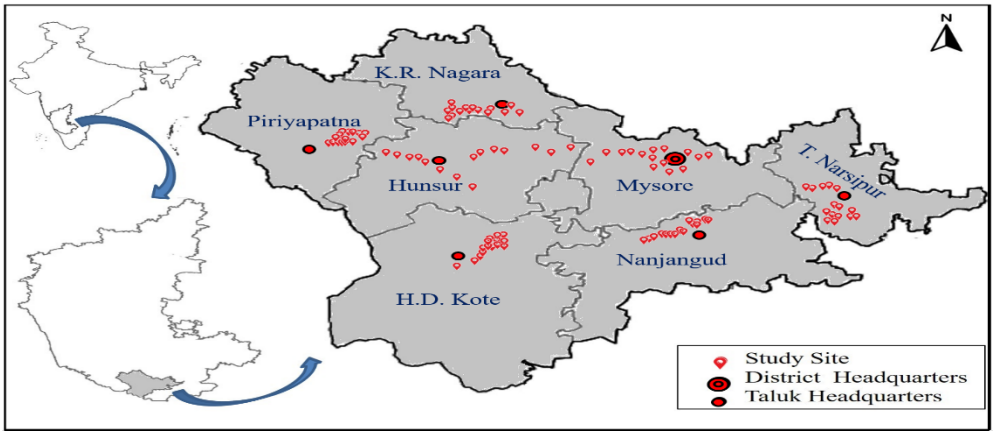

Figure 1: Map showing study sites in Mysore district.

Table 1: Physiographic details, ecological factors, and vegetation of different agro-climatic landscapes of Mysore.

Sl. No.	Agro-climatic landscape	Physiographic details		Ecological factors					Vegetation
		Longitude	Latitude	Altitude (MSL)	Temperature (ºC)	RH (%)	Rainfall (mm)	Wind flow (Km/hr)	
1	At the vicinity of aquatic habitat	12º10'48 N to 12º20'19"N	76º08'47"E to 76º53'17"E	650 to 844	24.9 to 38.8	10.0 to 69.0	0.0 to 8.66	3.0 to 17.0	Aquatic habitats include maintained as well as abandoned lakes, ponds and canals. Wild trees, herbs and shrubs characterize the rural aquatic habitats. Whereas, the urban lake environment is a human modified habitat developed to provide recreation to visitors. This habitat is bordered by trees like *Albizia* sp., *Polyalthia longifolia*, *Acacia*, *Tamrindus indica*, *Senna* and other wild trees. Grass, *Tridax prucumbens*, *Asystasia gangetica*, *Sida* sp., *Plumbago zeylanica*, *Alternanthera sessilis* and other wild herbs and shrubs which constitute the ground vegetation in all the aquatic habitats. Interestingly, vegetation is less disturbed in this habitat.
2	Urban Park (Human modified habitat)	12º18'04"N to 12º19'13"N	76º36'48"E to 76º39'42"E	736 to 778	26.5 to 34.2	31.0 to 66.6	0.33 to 5.44	2.0 to 11.0	Public parks are modified landscape established for recreation to people who visits often in cities. This habitat is well maintained with grass lawn and ornamental herbs, shrubs and trees. The presence of weeds like *Indigofera* sp., *Tridax procumbens*, *Alternanthera sessilis* and *Euphorbia hirta* attract many butterflies. Different species of few Poaceae members serve as host plants for many butterflies. Mowing is commonly conducted in parks this activity create disturbance in parks which is done as part of maintenance.
3	Residential area	12º18'13"N to 12º18'17"N	76º35'01"E to 76º35'04"E	768 to 808	28.8 to 34.5	29.5 to 47.9	0.0	7.6 to 20.1	It is newly established residential plots characterized by fragmented plots with weeds, houses with few ornamental plants in small garden area. Weeds and grasses covered in the plot that attracts few butterfly species. It is a modified landscape for establishing residences. Burning, removal of vegetations are the major threats observed in this habitat.
4	Institutional Campus (Human maintained habitat)	12º18'32"N to 12º18'56"N	76º37'04"E to 76º37'25"E	771 to 784	25.2 to 37.1	25.0 to 67.0	0.66	3.2 to 9.5	Institutional campuses with many wild trees, herbs and shrubs serving as host and nectar plants of butterflies. Ornamental plants like *Hamelia patens*, *Plumbago auriculata*, *Ixora* sp. and others also attract butterflies in large number. Comparatively, this area is calm and least disturbed site within a city. Mowing is done occasionally as a part of lawn management. Trimming of shrubs destroys the early stages of butterflies namely: egg, larva and pupa-staged butterfly species.

5	Road verge	12º06'35"N to 12º25'27"N	76º07'58"E to 76º53'09"E	651 to 849	23.8 to 37.4	10.0 to 79.0	0.0 to 8.66	4.0 to 17.0	It is a modified landscape characterized by weeds, grasses weedy vegetation on the road verges. *Senna* sp. is commonly found in large number on the verges. Ground vegetation comprises of grasses, *Parthenium*, *Alternanthera sessilis*, *Indigoferra* sp. and other wild herbs, shrubs and trees. Occasionally clearing of vegetation and burning of weeds and grassy vegetation is observed. Mostly, it is least disturbed with thick vegetation and serving as breeding ground for many butterfly species.
6	Cultivable land for agriculture	12º03'01"N to12º23'28"N	76º07'13"E to 76º53'58"E	642 to 861	25.2 to 37.9	10.0 to 72.0	0.0 to 8.66	4.0 to 20.0	Main crops are cultivated in this habitat. Hyacinth beans, finger millet, paddy, maize, sugarcane, coconut, areca palm, banana and some vegetables are grown in this landscape. Hedge of most cultivated lands are characterized by the growth of plants which include grass, *Euphorbia heterophylla*, *Mimosa pudica*, *Parthenium hysterophorus*, *Sida* sp., *Merremia aegyptia*, *Bidens pilosa* and others. The periphery of lands is bordered by trees like *Senna* sp., *Delonix regia*, *Acacia* sp, etc. Vegetation removal, pesticide application and burning are common threats observed in this habitat.
7	Nursery (Ornamental plants and fruit yielding plants)	12º18'41"N to12º19'58"N	76º15'33"E to 76º37'40"E	761 to 804	26.7 to 36.9	22.0 to 62.0	0.33 to 8.0	4.0 to 11.0	It is a modified established habitat in urban area. Many ornamental plant species like *Dianthes*, *Bougainvillea*, *Kalanchoe*, *Cycas*, *Ocimum*, *Hibiscus*, *Nerium*, *Ixora*, *Rosa*, *Mangifera indica*, *Citrus*, *Artocarpus hetetophyllus*, *Manilkara zapota*. Ornamentals are grown. These plant species extend forage (e.g. nectar) to butterflies. Many plants serve as host plants; provide platform/shelter to lay eggs. Wild herbs and grasses are also grown midst among nursery plants in less number. Clearing of weeds, trimming certain plants in such areas reduces butterfly visits.
8	Weedy vegetation (Uncultivable land)	12º05'23"N to12º24'54"N	76º17'54"E to 76º29'26"E	701 to 800	27.1 to 35.5	32.0 to 65.0	0.0 to 0.33	4.0 to 14.0	Weeds like *Lantana camara*, *Senna occidentalis*, *Ipomoea obscura*, *Solanum* sp., *Boerrhavia diffusa*, grasses and other wild herbs and shrubs represent the weedy vegetation. Many butterfly species are attracted to this habitat. The locally grown weedy vegetation help allow to conduct breeding activities by several butterfly species which serves them with breeding resources. This habitat is undisturbed. Burning and vegetation removal is observed commonly occurring in this habitat.

Survey of butterflies was carried out from 8:00 am to 17:30 pm to record butterflies during their active period. Each study site was visited once in rainy, winter and summer seasons. Butterfly abundance was recorded using various methods namely: all out search method as per,[26-31] variable width line transects method[32] and Point count method.[33] Date, time, temperature and humidity were recorded at the beginning of each site survey as per.[34] A digital thermo-hygrometer was used to record the temperature and humidity.[35] Wind speed data was obtained using the website www.timeanddate.com. Site-wise rainfall data was collected from https://chrsdata.eng.uci.edu. Photographic documentation of butterflies across different landscapes were made using Canon SX430 IS camera. Further, the identification of butterflies was made using field guides as per.[36,37] Correlation was calculated using Microsoft excel office 2019 and.[38]

RESULTS

Table 2 shows the abundance of butterflies belonging to five families namely: Nymphalidae, Pieridae, Lycaenidae, Hesperiidae and Papilionidae recorded from different agro-climatic landscapes at Mysore district namely: vicinity of aquatic habitat, urban park (human modified habitat, residential area, institutional campus (human-maintained habitat), road verge, cultivable land for agriculture, nursery (ornamental plants and fruit yielding plants) and weedy vegetation (uncultivable land). Abundance of butterflies was high at cultivable land for agriculture (789), followed by park (488), road verge (338), aquatic habitat (287), institutional campus (277), nursery (118), residential area (89) and weedy vegetation (86). Familywise butterfly population at distinct agro-climatic landscapes were not significant (F=1.173) (Table 2).

Table 3 shows the correlation values of ecological factors namely temperature, relative humidity, wind flow and rainfall with butterfly abundance at different agro-climatic landscapes of Mysore district. Temperature and butterfly abundance showed negative correlation at the vicinity of aquatic habitat, residential area, institutional campus and nursery. Positive correlation was observed at urban park, road verge, cultivable land for agriculture and weedy vegetation. Correlation coefficient was significant at institutional campus (r=-0.54, t=-2.32) (Table 3). Relative humidity and butterfly abundance were negatively correlated at urban park, road verge, cultivable land for agriculture, weedy vegetation and positively correlated at the vicinity of aquatic habitat, residential area, institutional campus and nursery. Correlation coefficient was significant at institutional campus (r=0.51, t=2.16) (Table 3). Positive correlation was observed for wind speed and butterfly abundance at the vicinity of aquatic habitat, urban park, residential area, institutional campus, road verge, cultivable land for agriculture, nursery and negative correlation was observed at weedy vegetation. Correlation coefficient was significant at the vicinity of aquatic habitat, road verge and cultivable land for agriculture (r=0.67, 0.55 and 0.31) (t=2.59, 2.91 and 2.34) (Table 3). Rainfall and butterfly abundance showed positive correlation at the vicinity of aquatic habitat, urban park, residential area, institutional campus and negative correlation at road verge, cultivable land for agriculture, nursery and weedy vegetation. Correlation coefficient was not significant at none of the agro-climatic landscapes (Table 3).

DISCUSSION

During the present investigation, significant correlation (r=-0.54, t=-2.32) was observed between temperature and butterfly abundance at institutional campuses of Mysore district. Similarly, significant correlation (r=0.51, t=2.16) existed between relative humidity and butterfly abundance at institutional campuses of Mysore district. However, at most of the agro-climatic landscapes, there

Table 2: Family wise butterflies' population at different agro-climatic landscapes of Mysore.

Sl. No.	Study site	Agro-climatic condition							
		Aquatic habitat	Park	Residential area	Road verge	Cultivated land	Institutional campus	Nursery	Weedy vegetation
1	Nymphalidae	62	149	25	73	335	131	25	26
2	Pieridae	157	64	14	193	315	55	25	27
3	Lycaenidae	52	205	45	42	81	70	50	31
4	Hesperiidae	3	13	0	0	11	4	1	0
5	Papilionidae	13	57	5	30	47	17	17	2
	Mean	57.4	97.6	22.3	67.6	157.8	55.4	23.6	21.5
	'F' Value	1.173 NS							

Table 3: Correlation coefficient between butterfly abundance and ecological factors at different agro-climatic landscapes of Mysore.

Sl. No.	Agro-climatic landscape	Butterfly abundance	Ecological conditions							
			Temperature (ºC)	'r' value	Relative humidity (%)	'r' value	Rainfall (mm)	'r' value	Wind flow (Km/hr)	'r' value
1	At the vicinity of aquatic habitat.	28.7	32.8	-0.27 NS	42.3	0.12 NS	3.21	0.06 NS	7.2	0.67*
2	Urban Park (Human modified habitat).	97.6	30.1	0.47 NS	46.7	-0.14 NS	3.37	0.54 NS	7.1	0.28 NS
3	Residential area.	17.8	26.5	-0.58 NS	40.1	0.48 NS	0	0.0 NS	12.3	0.22 NS
4	Institutional Campus (Human maintained habitat).	18.4	32.1	-0.54*	41.3	0.51*	0.66	0.0 NS	6.8	0.28 NS
5	Road verge	15.9	31.9	0.25 NS	46.1	-0.31 NS	2.23	-0.21 NS	7.5	0.55*
6	Cultivable land for agriculture.	14.4	32.8	0.13 NS	43.7	-0.21 NS	8.33	-0.06 NS	7.7	0.31*
7	Nursery (Ornamental plants and fruit yielding plants).	19.6	32.6	-0.66 NS	41.1	0.42 NS	1.94	-0.51 NS	6.9	0.45 NS
8	Weedy vegetation (Uncultivable land).	13.6	32.3	0.18 NS	46.7	-0.28 NS	0.16	-0.72 NS	8.0	-0.72 NS

Note: *Values are significant. NS: Value is not significant.

was no significant correlation existed between rainfall and wind flow with butterfly abundance. Surprisingly, wind flow at the vicinity of aquatic habitat, road verge and cultivable land for agriculture activity, there was an influence on the butterfly abundance and indicated significant correlation (r=0.67, 0.55 and 0.31) (t=2.59, 2.91 and 2.34) respectively. Notwithstanding to rainfall, butterfly abundance correlation was not significant at any of the study sites in Mysore district. In tropical monsoon climate, differences in rainfall pattern is high perhaps that might influence the biology and ecology of butterflies which is evident as variation in adult butterflies abundance. Similar type of observations was made by.[39] As Mysore district has experience a tropical monsoon type climate,[25] variations in rainfall pattern is often along with the temperature and relative humidity. Perhaps, all these factors might have intervened at different stages in the life cycle of butterflies and affected the abundance at different agro-climatic landscapes. Hence, the butterfly's abundance varied considerably between the agro-climatic landscapes in this part of the state.

Several researchers have reported the effect of various physiographic factors influence on butterfly's abundance. The local weather of current and previous year influenced the butterfly abundance,[10] through the growth and development of food plants of butterflies. Perhaps, during the present study the rainfall might have indirectly influenced the butterfly abundance by enabling the growth and development of food plants during the time of need at various agro-climatic landscapes in Mysore district. The mean annual temperature and actual evapotranspiration remained the most important factors determining the butterfly distribution along the elevation gradient of Eastern Himalaya.[40] Influence of annual temperature on butterfly species richness was reported in Britain by.[1] Temperature affects early stages i.e., larval stages and adult butterflies behaviour.[4] Similarly, temperature and relative humidity affected the butterfly community composition and indicated the relationship between the climatic factors and seasonality of butterflies in Mediterranean region[41,42] has recorded high butterfly abundance during September to November when temperature was low and humidity was high compared to March to May. Similarly,[23] has recorded the influence of temperature and relative humidity on butterfly richness in the tropical dry forests of Eastern Ghats[15] has recorded that butterflies were less during low rainfall and high temperature prevailing periods. Thus, variation in rainfall affects the seasonal distribution of butterfly species[3] and rainfall influenced the Papilionid butterfly abundance at the Rani-Garbhanga Reserve Forest, Assam[39] Moreover, butterfly species abundance was positively correlated with the locally prevailed temperature and negatively correlated with the rainfall at Manonmaniam Sundaranar University,

Alwarkurichi, Tamil Nadu.[20] Further, butterfly species abundance was positively correlated with warm summer temperature and low rainfall in Britain.[43] Furthermore, sub-normal temperature affected the population of *Maculinea alcon* in Italy.[44] All these observations clearly demonstrated that butterflies are sensitive to the changing environmental conditions, their abundance and distribution is directly correlated with the locally available temperature, relative humidity and rainfall pattern. Notwithstanding to rainfall, temperature and relative humidity are directly depended on the rainfall pattern and these factors prevalence is region and season specific. Accordingly, food plants availability for butterflies might have differed, as many species depends on food plants during different stages of their life cycle at different agro-climatic landscapes. Our observations stand in accordance with the investigations carried out by.[3,4,15,20,21,23,39,41-44] During the present investigation it was observed that the butterfly abundance and the ecological factors showed positive and negative correlations differently at various habitat types. This observation is in line with.[45] Too high temperature and low rainfall affected the butterfly abundance by reducing the food plant availability. Post monsoon period was found to favour high butterfly abundance due to the presence of ideal climatic condition and availability of resources which ensure butterfly species survival. Similar results were reported from Nagpur city, central India where monsoon to winter period favoured large number of butterfly species.[46] Northern Western Ghats also showed increase in butterfly species richness during post-monsoon period.[47] Variations in relation between butterfly abundance and ecological factors observed at different agro-climatic landscapes may be due to the effect of habitat factors like the prevalence of vegetation and its diversity, anthropogenic disturbances such as burning of vegetation, clearing of vegetation for agricultural activities or as a part of habitat management and mowing amidst human modified habitats which negatively affects butterflies abundance and distribution. So, conclusions made in the investigations of,[46,48] who have recorded the effect of habitat factors and anthropogenic activities on butterflies which matches with the inference of the present study. Thus, butterfly abundance showed significant positive correlation with temperature,[21] humidity[23,41] and negative correlation with rainfall.[3,20,39] Climate change and urbanisation might lead to extirpation of butterfly species.[49] Seeking optimal microhabitats and appropriate basking postures are some strategies adopted by butterflies to cope up with climate change.[22] In response to variation of locally prevailed environmental factors, butterfly species abundance and distribution accordingly differed at various agro-climatic landscapes. So, present study provided the base-line scientific information on the existing butterfly species midst agro-climatic landscapes of Mysore district and can be used for formulating the conservative measures to implement landscape specific suitable methods to protect the butterfly fauna and in turn help protect the local biodiversity.

CONCLUSION

Ecological factors like temperature, relative humidity, wind flow and rainfall are important determinants affecting butterfly species composition and abundance. Butterfly ecology is dependent on optimum temperature and relative humidity. Rainfall affects butterfly's species composition indirectly by influencing the vegetation diversity needed for maintaining abundance and diversity. Butterflies have evolved some strategies like basking to maintain the body temperature but long-term local climate change threatens their survival. Hence, local climate restoration is essential to protect the locally existed butterfly's population.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

SUMMARY

Butterflies belong to five families such as Nymphalidae, Pieridae, Lycaenidae, Hesperiidae and Papilionidae were resided at eight habitats namely: the vicinity of aquatic habitat, urban park, road verge, cultivable land, nursery and weedy vegetation midst agro-climatic landscapes. Surprisingly, the cultivable land and park hosted highest abundance of butterflies compared to other habitats. However, at residential area and weedy vegetation the butterfly abundance was poor. During the present study, correlation coefficient between temperature, relative humidity, wind flow and rainfall with butterfly abundance at different habitats indicated interesting results. As the

prevailed ecological factors are uneven at these habitats and varied considerably, obviously didn't affect butterfly abundance evenly at these habitats' midst agro-climatic landscapes. Thus, butterfly abundance is habitat specific and it is influenced by prevailed ecological factors which are habitat specific.

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