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***Research Article** (Open Access)*

DIVERSITY OF ORDER LEPIDOPTERA (BUTTERFLIES) IN ANAND, GUJARAT

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ABSTRACT
Butterflies are the most fascinating than most other invertebrates existing in animal kingdom. They have been referred to as 'Flagship' and 'honorary birds'. They are valuable in terms of pollination, apart from this they are important food chain components of birds, reptiles, spiders, and predatory insects; they are also the good indicators of environmental quality and the habitat where they are being found. Biological diversity is the base for upholding the ecosystems and the functional aspects of the species that provide goods and services for human well-being. They are highly temperature sensitive organisms with specific nutritional requirement. Species abundance reaches the peak in the months during August to November. A decline in species abundance was observed in the months of December to January and continued up to the end of May. We found total of 52 species of butterflies. Out of which, 6 species from family Papilionidae, 15 species from family Nymphalidae, 17 species from family Pieridae, 13 species from family Lycaenidae and 1 species from family Hesperidae. At genus level we encountered 3 genus of family Papilionidae, 7 genus of family Pieridae, 9 genus of family Nymphilidae, 13 genus of family Lycanidae and 1 genus of family Hesperidae.

***Keywords:** Biodiversity, Puddling, Temperature, Richness and Abundance*

INTRODUCTION
The butterflies are beautiful part of nature that belongs to order Lepidoptera. They form important exhibits in Zoos and Natural History Museums since ages. Lepidoptera (Butterflies and moths) are the second largest order of phylum arthropoda that can be easily identified and helps to measure the biodiversity (Tiple and Khurad, (2009), Kremen (1992)). Butterflies are mostly nectoriferous that feed up on plants but also fed up on other sources too. Butterflies and their caterpillars are dependent on specific host plants for food, thus the diversity of butterflies indirectly reflects overall plant diversity especially that of shrubs and herbs in the given area. Vegetation type plays an important role in diversity patterns of butterfly community (Sayeswara, 2018). Once the caterpillar become adult and fully matured, they metamorpholigically transform into a winged creature that roam out in the warmth of sun, unlike moths which roam out during night or evening dusk. The adult butterflies are fed by other organisms like lizards, birds and few mammals as food (Maini and Shukla, 2015). They are important part of ecosystem contributing to pollination in plants forming a food chain and more complex food web. A change in environmental condition can bring about huge changes in its number as well as the species. Due to urbanization at global level and decrease in the greenery, most of the organisms and their numbers are shrinking enormously (Nair *et. al*, 2014). Butterflies are facing big threat that can ultimately effects the existing living organisms on earth. There are total 16,823 species recorded from all over the world, from these 1501 species of butterflies are recorded in India, which is about 8.74% of total butterfly species of world and constitute 65% of total Indian fauna (Gaonkar, 1996). The diversity of butterfly is high in the tropics compared to temperate regions of the world. Their habitat ranges from Arctic to the immense deserts of the world. The butterflies are divided into two super families' viz., Papilionoidea which constitutes 11,100 species and Hesperioidea that constitutes 3,650 species in the world (Scott, 2001). In

India, the Western Ghats is most diversified area containing a wide variety of species of butterflies due to the typical eco-climatic and geographic features (Gowda *et. al,* 2011). The butterflies are seasonal specific. They are almost absent during rain, but once it stops raining and temperature rises they peep out. In post monsoon their numbers raises in astronomical form. When they are not found in external environment, they are present in caterpillar or pupal form, further to form an adult. The active time period of adult is known as flight period. Good amount of rainfall has been proven excellent for the caterpillars and nectar rich flower source for adults. Considerable quantity of rainfall produces the soil rich in nutrients as well as fertile for plants growth (Gandhi and Kumar, 2016). Appropriate abiotic and biotic factors such as climate condition, temperature and wind exposure, availability of host and larval plants, food and vegetation, topographic features, habitat quality are some of the most important parameters to determine butterfly composition in a community (Harsh *et. al,* 2015). Quantity and availability of host plant elucidates a considerable portion of the inter-site variation in population abundance for species that are dietary and habitat specialists (Curtis *et. al,* 2015). The holometabolous life history of butterflies causes them to be exposed to a wide range of environmental influences, and they are highly sensitive to changes in temperature, humidity, and light levels (Bhatt and Nagar, 2017). Vegetation along with favorable climatic condition with appropriate temperature and humidity is truly essential for the butterfly survival (Sankaranarayanan *et. al*, 2018). In open grassy habitats, the major components of butterfly diet include flower nectar, sap, fruit juices, carrion, scat and wetland moisture (Kumar, 2013). Butterflies are highly vulnerable to least changes in the environment and as a result they are used for bio-monitoring (Acharya and Pal, 2019). It has been reported that a disturbed forest is better place to point a diversity index rather that a natural habitat as that might be highly dependent on change in vegetation very frequently (Sharma and Sharma, 2017). Many butterfly species have exhibited population decline due to hunting, poaching and forest fires due to which, many butterfly species are facing threat in natural ecosystems including some protected areas. Butterflies have a preference specific habitat to avail themselves of available resources for endurance in the forest ecosystem. Habitat destruction, degradation, fragmentation, grazing, forest fires and abundance use of pesticides and weedicides can affect butterfly numbers (Padhye *et. al,* 2006)**.** They show diverse feeding habits, and the varied forest habitats offer suitable sites for breeding, foraging and resting during different stages in their life cycle. The nutritional requirements including need for water, food plants and their chemical constituents in relation to the larval feeding, growth rate and habitat preferences are not uniform among the butterfly species. Seasonal migration of butterfly species and occurrence of few butterflies within a particular forest range help to expose their exclusive life sustaining requirements to complete their life cycle during their visit to such ecosystems (Basavarajappa *et. al,* 2018). Butterflies enable nourishment of ecosystem services as their role in pollination and serves as significant component of food chain. Some butterflies shows migratory behavior. They fly thousands of kilometers in the winter to places having a warmer climate, and then return back in the spring to their original pace of existence (Gupta and Majumdar, 2012). It has been found that any change and intervention in the forest may result into migration or vanishing of species. Additionally the forest restricted species are typically both found only in forests and are very susceptible to microhabitat damage (Joshi and Arya, 2007). Butterflies also show interesting behavioral patterns that involve movements that cause rearrangements of parts of whole body creating different positions in relation to various activities like seeking the partner while perching and while shielding the province. As butterflies are poikilothermic, they need to regulate their body temperature. They take pleasure by basking in the sunlight to increase the body temperature or vacate underside a leaf to lower the same. Most butterflies just spread their wings flat and align themselves for maximum exposure to sunlight (Dover *et. al,* 2011). Butterflies show mud puddling behavior (especially males) where they gather on damp soil or mud in huge numbers. It is a type of social activity where one or more species gathers. The conservation of butterflies is necessary to sustain varied kinds of ecosystem services for human well-being (Saraf and

Jadesh, 2016). Habitat restoration and urban landscaping can help to enhance the population of butterfly by several modifications in the existing environment manually (Gandhi and Kumar, 2015).

OBJECTIVES

a) The main aspect for the present study was planned to observe and recognize the species of butterflies particularly in the months of 2019 and 2020 from April 2019 to March 2020 throughout the year depending upon the temperature, humidity and precipitation (Anand district) for winter, summer and monsoon season.

b) We also focused on analyzing the numbers of different species of butterflies for statistical analysis.

METHODOLOGY

2.1 Study area

The Anand district is well known for industrialization but additionally this area has vegetation in great abundance. The farmers basically grow tobacco, rice, chilly, millet, mustard and banana throughout the year depending upon the season. The average rainfall in this district is 670 – 690 mm in monsoon. The temperature ranges from 12°C to 45°C on the basis of season. There are total 8 tehsil including Anand itself. The area occupied by Anand district is 3204 km^2. All the tehsil were reared for observation of butterfly in wild. The 8 different tehsil were Anklav 22.2120°N, 73.0136°E, Sojitra 22.3228°N, 72.4319°E, Anand 22.3311°N, 72.5224°E, Borsad 22.2416°N, 72.5418°E, Umreth 22.4206°N, 73.6576°E, Khambhat 22.1843°N, 72.3729°E, Tarapur 22.2529°N, 72.5411°E and Petlad 22.2828°N, 72.4815°E. All 8 tehsil co-ordinates were reared with a range of 5 kilometer area for observation of butterflies.

2.2 Photography

The field rearing was done according to the day light and length. There are some butterflies that are easily observed in early sun rise while majority of the others are found during whole day. We have captured the photographs using Nikon 3500 DSLR camera in the wild. There were several species whose photographs were not taken but they have been found and identified in wild are also included in the list given in the table.

2.3 Collection

We had collected some of the species according to list published by IUCN. The threatened or endangered species were not collected rather only photographs were taken. The collection of samples was done with the help of net and few were done with bare hands directly. After collecting them we have preserved them in specimen bottles in a dry form. Later on pictures were taken for those samples again so that if further verification is required then we can do that to have perfect identification.

2.4 Identification

To identify the samples or species we used ZSI KEY that actually helped us to identify the species properly.

2.5 Statistical analysis

This analysis is totally random on the basis of normal counts during field work at various sites for a particular species depending upon the pictures and observations. Average, Shannon-wiener diversity index and evenness of the species is noted in order to observe the diversity in Anand district. The mean of samples for all the species have been calculated in table: 2. The Shannon Diversity Index (H) is a way to measure the diversity of species in a community. Species evenness is also calculated to know the species distribution throughout the community. Table: 3 contain data for Shannon-weiner diversity index and species evenness for the observed samples.

$H = \sum[(pi) \times \ln(pi)]$
where pi = proportion of total sample represented by species i,
S = number of species,
H_{max}= ln (S) = maximum diversity possible
E = Evenness = H/H_{max}

Fig: 3 *Belenois aurota* (Pioneer white)

Fig: 4 *Castalius rosimon* (Common pierrot)

Fig: 8 *Tarucus nara* (Rounded pierrot)

Fig: 6 *Junonia lemonias* (Lemon pansy)

Fig: 9 *Delias eucharis* (Indian jezebel)

Fig: 10 *Papilio demoleus* (Lime butterfly)

RESULT

Different locations of all tehsils from the district of Anand were reared for finding the types of butterfly from field. The types of locations that were under investigation are residential, agricultural pastures,

wilder places as well as the urban area. There were total of 52 species of butterflies were observed. According to the list in table: 1, there are 6 species that belongs to family Papilionidae, 15 species belongs to family Nymphalidae, 17 species belongs to family Pieridae, 13 species belongs to family Lycaenidae and 1 species from family Hesperidae were observed. Additionally, we encountered 3 genus of family Papilionidae, 7 genus of family Pieridae, 9 genus of family Nymphilidae, 13 genus of family Lycanidae and 1 genus of family Hesperidae. The presence and abundance of butterflies score the significance of the plant resources available in these locations. The survival ratio and their appearance depict the diversified plant locality. The highest Shannon-Weiner diversity value calculated is 2.78 while the Evenness Index value is 0.99. The value of diversity index indicates higher level of species diversity and shows certain ascent of disparity in the species evenness. The samples collected or observed in the field were demonstrated to check the diversity (Table: 2). During December 2019 to March 2020 (winter) season (Graph: 1) the population of butterfly is moderate while in the months from April 2019 to July 2019 (summer) (Graph: 2) the number reduces and again it increases in August 2019 to November 2019 (monsoon) season (Graph: 3) for all the families of Lepidoptera individually. In (Graph: 4) total data for

Fig: 16 *Graphium doson* (Common jay)

Fig: 18 *Colotis etrida* (Little orange tip)

Fig: 26 *Danaus chrysippus* (Plain tiger)

Fig: 27 *Hypolimnas misippus* (Danaid eggfly)

the year 2019 with all three seasons viz. winter, summer and monsoon gives the information of frequency of butterflies existing for five families. Additionally there are some species that are very common, common, rare and very rare. Occurrence of very common and common species is highly visible and also its number is truly high. Consequently that shows high diversity for a particular area. High diversity helps to know about species richness and its relative abundance for order Lepidoptera and its families. Species evenness is clearly visible for eight varied locations ranging from 0.87 to 0.99. Species evenness is greater it equates to less variation in abundances of the species present, and to lesser species diversity.

The value of evenness is varies less compare to other indices (Graph: 5) which depicts stability of species in a given community The Hmax differs for all the species of butterflies. H_{max} indicates about number of different species of butterflies in a family observed in all eight locations. It is highest (Graph: 6) for family Pieridae (2.7725) while it is moderate for family Papilionidae (1.7917) and lowest for family Hesperidae (0). The numbers in table: 3 represent the information about H, H_{max} and evenness (E) for all the families of Lepidoptera for different locations.

Table: 1 List and number of butterflies observed in field

Family	Scientific name	Common name	December 2019 – March 2020	April 2019 – July 2019	August 2019 – November 2019
Papilionidae (06)	*Graphium agamemnon agamemnon* (Linnaeus, 1758)	Tailed jay	18	5	26
	Graphium doson eleius (Fruhstorfer, 1907)	Common jay	25	5	30
	Graphium nomius nomius (Esper, 1799)	Spot swordtail	19	1	20
	Papilio demoleus demoleus (Linnaeus, 1758)	Lime swallowtail	26	16	30
	Papilio polytes romulus (Cramer, 1775)	Common Mormon	21	7	26
	Pachliopta aristolochiae aristolochiae (Fabricius, 1775)	Indian Common rose	14	5	19
Pieridae (17)	*Belenois aurota aurota* (Fabricius, 1793)	Pioneer	31	24	39
	Catopsilia pomona pomona (Fabricius, 1775)	Oreintal Lemon emigrant	38	29	42
	Catopsilia pyranthe pyranthe (Linnaeus, 1758)	Oriental Mottled emigrant	47	35	52
	Cepora nerissa nerissa (Fabricius, 1775)	Chinese Common gull	30	18	40
	Cepora nerissa phryne (Fabricius, 1775)	Dakhan common gull	23	20	30
	Cepora nerissa lichenosa (Moore, 1877)	Andaman common gull	27	13	34
	Colotis amata amata (Fabricius, 1775)	Desert small salmon arab	21	12	29
	Colotis amata modesta (Butler, 1876)	Modest small salmon arab	20	10	25
	Colotis aurora (Cramer, 1780)	Plain orange-tip	34	18	40
	Colotis danae danae (Fabricius, 1775)	Indian crimson tip	30	15	31
	Colotis danae dulcis (Butler, 1876)	Kathiyawar crimson-tip	36	19	36
	Colotis etrida etrida (Boisduval,	Little orange-tip	30	21	45

	1836)				
	Delias eucharis (Drury, 1773)	Indian Jezebel	28	15	32
	Eurema hecabe hecabe (Linnaeus, 1758)	Oriental Common grass yellow	37	23	43
	Eurema laeta laeta (Boisduval, 1836)	Indian Spotless grass yellow	39	29	45
	Ixias marianne (Cramer, 1779)	White orange-tip	40	31	36
	Ixias pyrene sesia (Linnaeus, 1764)	Dakhan Yellow orange-tip	35	24	34
Nymphilidae (15)	*Danaus chrysippus chrysippus* (Linnaeus, 1758)	Plain tiger	35	25	32
	Danaus genutia genutia (Cramer, 1779)	Striped tiger	18	10	22
	Euploea core core (Cramer, 1780)	Common crow	10	5	15
	Euploea klugii kollari (C. & R. Felder, 1865)	King crow	9	3	7
	Hypolimnas bolina jacintha (Drury, 1773)	Great eggfly	24	17	20
	Hypolimnas misippus (Linnaeus, 1764)	Danaid eggfly	39	26	43
	Junonia almana almana (Linnaeus, 1758)	Peacock pansy	16	9	20
	Junonia hierta hierta (Fabricius, 1798)	Yellow pansy	23	16	25
	Junonia iphita iphita (Cramer, 1779)	Chocolate pansy	25	15	19
	Junonia lemonias lemonias (Linnaeus, 1758)	Lemon pansy	26	14	21
	Melanitis leda leda (Linnaeus, 1758)	Common evening brown	22	10	32
	Mycalesis perseus tabitha (Fabricius, 1793)	Common bushbrown	20	12	25
	Phalanta phalantha phalantha (Drury, 1773)	Common leopard	3	0	2
	Tirumala limniace exoticus (Gmélin, 1790)	Blue tiger	3	1	1
	Ypthima baldus madrasa (Evans, 1923)	Common five-ring	12	8	8
Lycaenidae (13)	*Azanus jesous gamra* (Lederer, 1855)	African babul blue	16	19	10
	Azanus ubaldus (Stoll, 1782)	Bright babul blue	25	30	20
	Castalius rosimon rosimon	Common Pierrot	23	22	16

	(Fabricius, 1775)				
	Catochrysops strabo strabo (Fabricius, 1793)	Forget-me-not	23	19	14
	Chilades lajus lajus (Stoll, 1780)	Lime blue	15	10	9
	Chilades parrhasius parrhasius (Fabricius, 1793)	Small Cupid	16	10	11
	Euchrysops cnejus cnejus (Fabricius, 1798)	Gram blue	12	7	9
	Freyeria putli (Kollar, 1844)	Oriental grass jewel	11	8	8
	Luthrodes pandava pandava (Horsfield, 1829)	Plains Cupid	19	13	11
	Pseudozizeeria maha maha (Kollar, 1844)	Pale grass blue	4	11	11
	Rapala iarbus iarbus (Fabricius, 1787)	Common red flash	9	4	2
	Rapala manea schistacea (Moore, 1879)	Slate flash	2	1	5
	Tarucus nara (Moore, 1881)	Rounded pierrot	5	3	9
Hesperidae (01)	*Pelopidas mathias mathias* (Fabricius, 1798)	Dark small branded swift	4	1	10

Table: 2 Number of samples obtained from field from April 2019 to March 2020

Family	December 2019 – March 2020	April 2019 – July 2019	August 2019 – November 2019	Total
Papilionidae	123 ± 0.9506	39 ± 0.8439	151 ± 1.1072	289 ± 0.9672
Pieridae	591 ± 1.4520	356 ± 1.2469	633 ± 1.3468	1535 ± 1.3486
Nymphilidae	285 ± 1.5628	171 ± 1.1620	592 ± 1.6070	750 ± 1.4439
Lycaenidae	180 ± 1.1598	157 ± 1.1643	135 ± 0.8158	472 ± 1.0333
Hesperidae	4 ± 0	1 ± 0	10 ± 0	15 ± 0

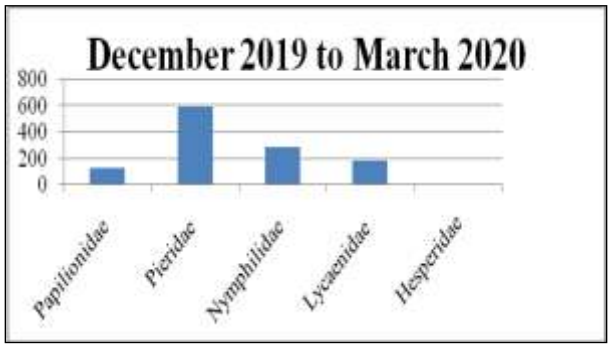
Table: 3 Diversity values with H, H_{max} and species evenness for different families

Family	L1	L2	L3	L4	L5	L6	L7	L8	Parameters
	1.6349	1.6931	1.7533	1.6649	1.5678	1.6762	1.6529	1.7144	**H**
Papilionidae	1.7917	1.7917	1.7917	1.7917	1.7917	1.7917	1.7917	1.7917	**H_{max}**
	0.9124	0.9449	0.9785	0.9292	0.8750	0.9355	0.9225	0.9568	**E**
	2.7984	2.7918	2.7999	2.7743	2.7697	2.8074	2.7994	2.8016	**H**
Pieridae	2.8332	2.8332	2.8332	2.8332	2.8332	2.8332	2.8332	2.8332	**H_{max}**
	0.9877	0.9854	0.9882	0.9792	0.9776	0.9908	0.9880	0.9888	**E**
	2.5327	2.4042	2.4701	2.4384	2.4300	2.5104	2.4881	2.5832	**H**
Nymphilidae	2.7080	2.7080	2.7080	2.7080	2.7080	2.7080	2.7080	2.7080	**H_{max}**

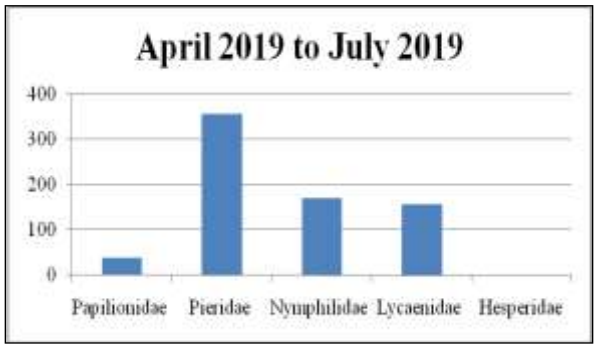
	0.9352	0.8878	0.9121	0.9004	0.8973	0.9270	0.9188	0.9539	**E**
	2.2446	2.0841	2.0878	2.2152	2.1723	2.1306	2.2231	2.2345	**H**
Lycaenidae	2.5649	2.5649	2.5649	2.5649	2.5649	2.5649	2.5649	2.5649	**H_{max}**
	0.9403	0.8855	0.9155	0.9376	0.9291	0.9450	0.9529	0.9634	**E**
	0	0	0	0	0	0	0	0	**H**
Hesperidae	0	0	0	0	0	0	0	0	**H_{max}**
	0	0	0	0	0	0	0	0	**E**

(L1 – Anand: 22.3311°N, 72.5224°E, L2 – Anklav: 22.2120°N, 73.0136°E,, L3 – Borsad: 22.2416°N, 72.5418°E , L4 – Umreth: 22.4206°N, 73.6576°E, L5 –Petlad: 22.2828°N, 72.4815°E, L6 – Tarapur: 22.2529°N, 72.5411°E, L7 – Khambhat: 22.1843°N, 72.3729°E, L8 – Sojitra: 22.3228°N, 72.4319°E are the locations from where the numbers of species observed in field.)

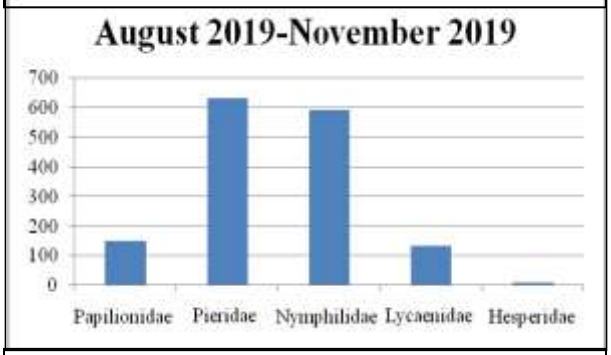
GRAPHS



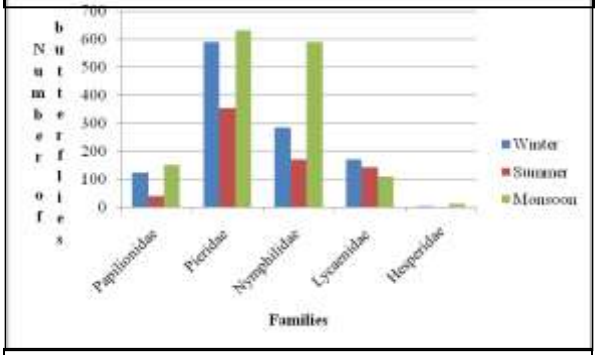
Graph: 1 Comparison of different families for their presence from December 2019 to March 2020



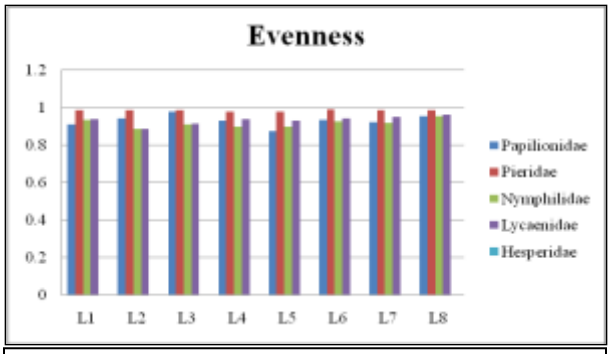
Graph: 2 Comparison of different families for their presence from April 2019 to July 2019



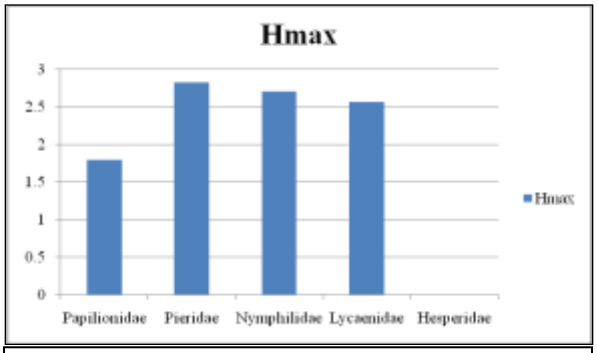
Graph: 3 Comparison of different families for their presence from August 2019 to November 2019



Graph: 4 Comparison of different families for their presence from December 2019 to March 2020



Graph: 5 Comparison of different families for Species evenness for 8 different locations



Graph: 6 Comparison of different families for Hmax

DISCUSSION

According to the observations diversity of butterfly is more where there is huge vegetation. The diversity of vegetation and its number implies the occurrence and existence of butterflies. Diversity of butterfly at a given place defines the key structure of vegetation and floral specification and thus that will show great diversity. The butterflies are temperature sensitive. Variation in temperature can bring about alteration in number of butterflies too. According to the statistical data derived the population of butterfly is at peak during the months of monsoon rather than in the months of winter and summer. This clearly indicates that temperature as well as humidity also brings about drastic change in its number. The diversity index depicts the species diversification in any particular area. The value of Shannon diversity indices (H) ranges from 0 to 2.80 for the species of five different families. More the numerical data near to 1 for species evenness (E) more the diversification. The H_{max} value remains the same for a family though the number varies consequently at all eight locations. These eight locations were having almost common vegetation thus many of the species were found almost everywhere. This study depicts relative abundance of species for different locations and for all five families even though richness of a species is more for a given community.

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