Diversity of Butterfly Fauna in Potohar Plateau, Pakistan

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ABSTRACT

An investigation was carried out to study the diversity of butterfly fauna at the 53 selected locales of Potohar Plateau, Pakistan during July 2017 to September, 2019. During this study, 32 species of butterflies were identified out of 1117 specimens that belong to 22 genera, 11 subfamilies and four families. Pieridae was the dominant family contributing 70.64% (n=789) individuals followed by Nymphalidae family 26.14% (n=292) and Papilionidae and Lycaenidae family with 1.61% (n=18) individuals respectively being the least. Nymphalidae was the dominant family with 50% (n=11) genera, followed by Pieridae with 31.82% (n=7) genera, Lycaenidae with 13.63% (n=3) genera and Papilionidae with 4.55% (n=1) genera. Whereas, in case of species composition, Nymphalidae was the most dominant family with 43.75% (n=14) species followed by family Pieridae 40.62% (n=13) species, family Lycaenidae 9.37% (n=3) species and family Papilionidae with 6.25% (n=2) species. *Catopsilia pyranthae* was the most abundant species with 18.89% (n=211) individuals followed by *Danaus chrysippus* with 14.5% (n=162) and *Catopsilia pomona* with 12.26% (n=137) individuals. The abundance of butterflies fluctuated over the months and April, 2019, was the most active month (n=123) and the butterflies were in least proportion (n=6) in July, 2019. As a whole, Shannon-Wiener diversity index (H) was found 2.585 in Potohar Plateau. Maximum Shannon-Wiener diversity index (H) was found in Islamabad, capital territory, with 2.657 H value while it was lowest in district Attock with 2.327 H value and moderate in district Jhelum, district Chakwal and district Rawalpindi with 2.581 H, 2.42 H and 2.415 H respectively. This study shows that butterfly species are threatened due to the introduction of invasive species, new to this area and increased predator population. The species richness, evenness and abundance were found to be normal in the study area.

INTRODUCTION

Biodiversity is a key factor for the survival of mankind on earth. So, the most challenging question for our planet is conservation of biodiversity. Insects contribute more than half (53%) of the known extant animal species of the world (Aslam, 2013; Iqbal *et al.*, 2016). Lepidoptera is more diverse and second largest order of class Insecta (Benton, 1995; Iqbal *et al.*, 2016). In the world, around 19000 species of butterflies are found (Gangotia and Kumar, 2018), whereas in Pakistan, 436 species of butterflies have been reported (Tshikolovets and Pagès, 2016).

Taxonomically butterflies are well study group (Jaboury, 2002; Gangotia and Kumar, 2018). Butterflies are good indicator of environmental changes because they are highly sensitive to changes in weather conditions, temperature, atmosphere and habitats (Iqbal *et al.*, 2016; Paramanandham *et al.*, 2021). In flowering plants, sexual reproduction is performed by pollinating agents like butterflies. Further, butterflies are one of the important components of food chains of the predatory insects, spiders, amphibians, reptiles and birds (Evangeline and Santhi, 2017; Paramanandham *et al.*, 2021).

The pace of disappearance of native butterflies is much faster due to certain factors like environmental pollution, exploitation of food resources, rapid increase in human population, drastic changes in climatic conditions and unscientific management and their population may further decrease in future (Gangotia and Kumar, 2018). It is noteworthy that if once the diversity of butterflies or any other insect species is lost, it would be permanent damage to ecosystem and it cannot be recreated or sustained (Gangotia and Kumar, 2018). So, sincere efforts are needed to conserve the biodiversity and studies concerning to it are essential for the sustainable development of ecosystem. Thus, it is more encouraging that butterflies are being studied as project of biodiversity study and bio conservation Programme (Gangotia and Kumar, 2018).

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Therefore, an attempt has been made to study the diversity and distribution of butterfly fauna in Potohar Plateau, Pakistan during 2017-2019. So, the main objective of this research was to collect, identify and calculate diversity, species richness and evenness of butterfly fauna of the study area.

MATERIALS AND METHODS

Study area

The Potohar Plateau in Pakistan is located between 32.5°N to 34.0°N north latitude and 72°E to 74°E east longitude (Chaudhary and Rasul, 2004; Shah *et al*., 2017; Khanam *et al*., 2017a, b). It is situated at the junction of oriental region and Palearctic region. In Pakistan, it is located in northern side of Punjab province, and western side of Azad Kashmir and Jammu Kashmir along the foothills of Himalaya (Shah *et al*., 2017). It covers 28488.9 Km² area (Chaudhary and Rasul, 2004). It is rain fed area. It is comprised of four districts of Punjab province; Jhelum, Chakwal, Rawalpindi and Attock and Islamabad Capital Territory (ICT) of Pakistan (Khanam *et al*., 2017a, b).
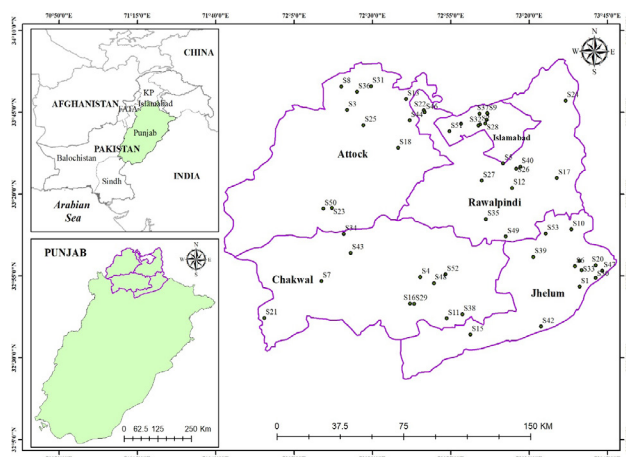

Fig. 1. Study sites in Potohar Plateau, Pakistan during July 2017 to September 2019.

Collection, identification and preservation of specimens

The butterfly samples were collected from 53 sites of the agro-eco system of all districts; Jhelum, Chakwal, Rawalpindi and Attock of Potohar, Punjab, Pakistan during June 2017 to September 2019 on fortnightly basis (Fig. 1, Supplementary Table I). The collected specimens were labeled with collection place and date (Iqbal *et al*., 2016). The specimens were named after identification by using the Keys (Abbas *et al*., 2002; Perveen and Ahmad, 2012; Perveen and Haroon, 2016) and confirmed by the literature (Roberts, 2001; Tshikolovets and Pagès, 2016) under the

guidance of experts. The photographs of the identified specimens were captured by a professional digital camera.

Data analysis

The information on families, genera and species composition, species richness and relative abundance were tabulated from the collected specimens of butterflies of the study area. Further, density, relative density, relative frequency and cumulative frequency, species diversity, Shannon-Wiener diversity index, simpson index, species evenness index (E), species richness index (d), Margalef's index, Menhinick's index and equitability-J were calculated by the MS excel software, 2007 and past 3 software programme.

RESULTS AND DISCUSSION

During the current studies, a total of 1117 individuals of butterflies belonging to 22 genera and 32 species within four families were recorded.

Among the four families, Nymphalidae was the dominant family with 50% (n=11) genera, followed by Pieridae with 31.82% (n=7) genera, Lycaenidae with 13.63% (n=3) genera and Papilionidae with 4.55% (n=1) genera. In terms of number and percentage of species composition, family Nymphalidae was found to be dominant with 43.75% (n=14) species followed by family Pieridae 40.62% (n=13) species, family Lycaenidae 9.37% (n=3) species and family Papilionidae with 6.25% (n=2) species (Table I). Members of the family Nymphalidae were always dominant in the tropical region because most of them are polyphagous in nature; consequently, they were able to survive in all the habitats. Additionally, many species of this family are strong active fliers that might help them in searching for resources in large areas (Chakravarthy *et al*., 1997; Krishna *et al*., 2008; Elanchezhyan *et al*., 2017). A high proportion of nymphalid butterfly species indicated high host plant richness (Bora and Meitei, 2014; Elanchezhyan *et al*., 2017).

Table I. Butterflies collected during July, 2017 to September, 2019 from Potohar Plateau, Pakistan.

S.	Family	Number with percentage (%)		
		Genus	**Species**	**Individuals**
1	Papilionidae	1(4.55%)	2(6.25%)	18(1.61%)
2	Pieridae	7(31.82%)	13(40.62%)	789(70.64%)
3	Lycaenidae	3(13.63%)	3(9.37%)	18(1.61%)
4	Nymphalidae	11(50%)	14(43.75%)	292(26.14%)
	∑=4	∑=22(100%)	∑=32(100%)	∑=1117(100%)

Table II. Sampling of butterfly specimens with frequency (F1), relative frequency (RF=F3) and cumulative frequency (CF=F4) from Potohar Plateau, Pakistan during July, 2017 to September, 2019.

S. No.	Name of butterflies	F1	RF= F3	CF= F4
	Family: Papilionidae			
1	*Papilio polytes*	3	0.008	0.008
2	*Papilio demoleus*	13	0.035	0.043
	Family: Pieridae			
3	*Pieris canidia*	29	0.077	0.120
4	*Pieris brassicae*	23	0.061	0.181
5	*Pontia daplidice*	9	0.024	0.205
6	*Belenois aurota*	19	0.051	0.256
7	*Colotis etridae*	6	0.016	0.272
8	*Colotis calais*	1	0.003	0.275
9	*Colias eratae*	6	0.016	0.291
10	*Colias fieldii*	11	0.029	0.320
11	*Catopsilia crocalae*	7	0.019	0.339
12	*Catopsilia pomona*	42	0.112	0.451
13	*Catopsilia florella*	5	0.013	0.464
14	*Catopsilia pyranthae*	43	0.115	0.579
15	*Eurema hecabe*	39	0.104	0.683
	Family: Lycaenidae			
16	*Tarucus theophrastus*	1	0.003	0.686
17	*Zizeeria maha*	1	0.003	0.689
18	*Euchrysops cnejus*	2	0.005	0.694
	Family: Nymphalidae			
19	*Danaus chrysippus*	46	0.123	0.817
20	*Tirumala limniace*	2	0.005	0.822
21	*Ypthima nareda*	1	0.003	0.825
22	*Ypthima asterope*	4	0.011	0.836
23	*Melanitis leda*	3	0.008	0.844
24	*Hipparchia parisatis*	1	0.003	0.847
25	*Polyura agraria*	2	0.005	0.852
26	*Ariadne merione*	21	0.056	0.908
27	*Neptis sappho*	2	0.005	0.913
28	*Vanessa cardui*	2	0.005	0.918
29	*Junonia orithya*	14	0.037	0.955
30	*Junonia hierta*	3	0.008	0.963
31	*Junonia almana*	12	0.032	0.995
32	*Phalanta phalantha*	2	0.005	1.000
	Total	**375**	**1**	**2.000**

In terms of number and percentage of collected individual specimen composition (Table I), family Pieridae was found to be dominant with 70.64% (n=789)

individuals, family Nymphalidae 26.14% (n=292) individuals and family Papilionidae and Lycaenidae with 1.61% (n=18) individuals (Table I).

The frequency (F1), relative frequency (RF) and cumulative frequency (CF) of different species were also calculated. Among the species, *Danaus chrysippus*, showed the highest ratio of frequency followed by *Catopsilia pyranthae, Catopsilia pomona* and *Eurema hecabe* and lowest ratio of frequency exhibited by *Colotis Calais, Tarucus theophrastus, Zizeeria maha, Ypthima nareda* and *Hipparchia parisatis* (Table II).

Abundance of butterfly fauna

The documented species and their density pattern of butterflies recorded during the study period were shown in the Table III. The relative abundance of dominant, moderate and least abundant species seems to be more or less similar. Dominant species were those which show their relative abundance more than 5%. *Catopsilia pyranthae* Linnaeus, 1758 (Family Pieridae) was recorded as the most abundant species which represented 18.89% (n=211) of the total recorded individuals (n=1117) of the butterflies. *Danaus chrysippus,* Linnaeus, 1758 (Family Nymphalidae) was the second most dominant species (n=162) constituting 14.5% of the total butterflies collected. *Catopsilia pomona,* Fabricius, 1775 (Family Pieridae) was the third most dominant species with 12.26% (n=137); followed by *Pieris canidia,* Sparrman, 1768 (Family Pieridae), *Eurema hecabe*, Linnaeus, 1758 (Family Pieridae) and *Pieris brassicae,* Linnaeus, 1758 (Family Pieridae) with 11.1% (n=124), 10.03% (n=112) and 6.89% (n=77), respectively. Moderate species were those which show their relative abundance (1<5%). So, *Belenois aurota* Moore, 1881 (Family Pieridae) exhibited moderate relative abundance with 4.12% (n=46) followed by *Ariadne merione* Moore, 1884 (Family Nymphalidae), *Colias fieldii* Menetries, 1855 (Family Pieridae), *Junonia orithya* Linnaeus, 1758 (Family Nymphalidae) *Junonia almana* Linnaeus, 1758 (Family Nymphalidae) *Papilio polytes* Linnaeus, 1758 (Family Papilionidae) *Catopsilia crocalae* Fabricius, 1775 (Family Pieridae), *Pontia daplidice* Linnaeus, 1758 (Family Pieridae) and *Ypthima asterope* Klug, 1828 (Family Nymphalidae) with 4.03% (n=45), 2.6 % (n=29), 2.51 % (n=28), 1.97 % (n=22), 1.34 % (n=15), 1.25 % (n=14), 1.16 % (n=13) and 1.07 % (n=12), respectively. While the species with relative abundance (<1%) are categorized as least dominant. So, the least dominant species were *Colotis etridae* Boisduval, 1836 (Family Pieridae), *Euchrysops cnejus* Fabricius, 1798 (Family Lycaenidae), *Catopsilia florella* Fabricius, 1775 (Family Pieridae), *Tarucus theophrastus* Fabricius, 1793 (Family Lycaenidae), *Colias erate* Esper, 1805

Table III. Distribution of density pattern (%) of butterfly fauna in Potohar Plateau, Pakistan during July, 2017 to September, 2019.

Species status	Family/ Name of the species	Distribution of density pattern (%)
Dominant (>5%)	**Family: Pieridae**	
	Catopsilia pyranthae, Linnaeus, 1758	18.89
	Catopsilia pomona, Fabricius, 1775	12.26
	Pieris canidia Sparrman, 1768	11.1
	Eurema hecabe, Linnaeus, 1758	10.03
	Pieris brassicae, Linnaeus, 1758	6.89
	Family: Nymphalidae	
	Danaus chrysippus, Linnaeus, 1758	14.5
Moderate (1-<5%)	**Family: Papilionidae**	
	Papilio demoleus, Linnaeus, 1758	1.34
	Family: Pieridae	
	Belenois aurota, Moore, 1881	4.12
	Colias fieldii, Menetries, 1855	2.6
	Catopsilia crocalae, Fabricius, 1775	1.25
	Pontia daplidice, Linnaeus, 1758	1.16
	Family: Nymphalidae	
	Ariadne merione, Moore, 1884	4.03
	Family: Nymphalidae	
	Junonia orithya, Linnaeus, 1758	2.51
	Junonia almana, Linnaeus, 1758	1.97
	Ypthima asterope, Klug, 1828	1.07
Least dominant (<1%)	**Family: Papilionidae**	
	Papilio polytes, Linnaeus, 1758	0.27
	Family: Pieridae	
	Colotis etridae, Boisduval, 1836	0.9
	Catopsilia florella, Fabricius, 1775	0.72
	Colias erate, Esper, 1805	0.63
	Colotis calais, Cramer, 1775	0.09
	Family: Lycaenidae	
	Euchrysops cnejus, Fabricius, 1798	0.81
	Tarucus Theophrastus, Fab., 1793	0.72
	Zizeera maha, Kollar, 1844	0.09
	Family: Nymphalidae	
	Ypthima nareda, Kollar, 1844	0.54
	Junonia hierta, Fabricius, 1798	0.27
	Melanitis leda, Linnaeus, 1758	0.27
	Tirumala limniace, Moore, 1882	0.18
	Phalanta phalantha, Drury, 1770	0.18
	Polyura agraria, Swinhoe, 1887	0.18
	Neptis sappho, Pallas, 1771	0.18
	Vanessa cardui, Linnaeus, 1758	0.18
	Hipparchia parisatis, Kollar, 1849	0.09

(Family Pieridae), *Ypthima nareda* Kollar, 1844 (Family Nymphalidae), *Papilio polytes* Linnaeus, 1758 (Family Papilionidae), *Junonia hierta* Fabricius, 1798 (Family Nymphalidae), *Melanitis leda* Linnaeus, 1758 (Family Nymphalidae), *Tirumala limniace* Moore, 1882 (Family Nymphalidae), *Phalanta phalantha* Drury, 1770 (Family Nymphalidae), *Polyura agraria* Swinhoe, 1887 (Family Nymphalidae), *Neptis sappho* Pallas, 1771 (Family Nymphalidae), *Vanessa cardui* Linnaeus, 1758 (Family Nymphalidae), *Colotis calais* Cramer, 1775 (Family Pieridae), *Zizeera maha* Kollar, 1844 (Family; Lycaenidae) and *Hipparchia parisatis* Kollar, 1849 (Family Nymphalidae) with relative abundance 0.9 % (n=10), 0.81 % (n=9), 0.72 % (n=8), 0.63 % (n=7), 0.54 % (n=6), 0.27 % (n=3), 0.27 % (n=3), 0.27 % (n=3), 0.18 % (n=2), 0.18 % (n=2), 0.18 % (n=2), 0.18 % (n=2), 0.18 % (n=2), 0.09 % (n=1), 0.09 % (n=1) and 0.09 % (n=1), respectively (Tables III, IV).

Moreover, district wise abundance and relative abundance of butterflies during July 2017 to September 2019 in Potohar Plateau, Pakistan was also recorded as shown in Tables III and IV. Maximum abundance was found in district Jhelum with 23.90% (n=267) butterfly specimens followed by Islamabad, capital territory, with 21.39% (n=239) specimens, minimum abundance was shown in district Attock with 16.83% (n=188) and moderate abundance of butterfly specimens were observed in district Chakwal with 19.16% (n=214) and district Attock with 18.71% (n= 209) specimens, respectively (Table IV, Fig. 2).
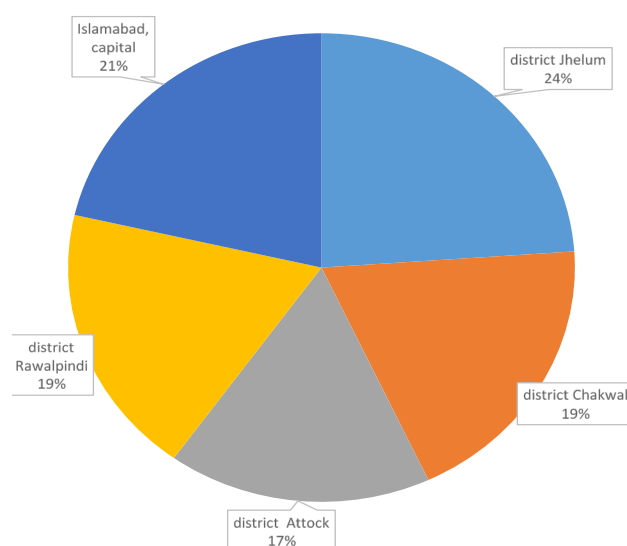

Fig. 2. District wise relative abundance (RA) of butterfly specimens in Potohar Plateau, Pakistan during July 2017 to September 2019.

Table IV. Rank list along with the relative abundance of taxa in different districts of Potohar Plateau, Pakistan during July 2017 to September, 2019.

S. No.	Name of butterflies	Jhelum	Chakwal	Attock	Rawalpindi	Islamabad	Overall	Rank
	Family: Papilionidae							
1	*Papilio polytes*	0.00	0.93	0.00	0.00	0.42	0.27	22
2	*Papilio demoleus*	1.87	0.93	1.06	1.44	1.26	1.34	12
	Family: Pieridae							
3	*Pieris canidia*	8.99	9.35	14.36	12.92	10.88	11.1	4
4	*Pieris brassicae*	5.62	6.54	5.85	8.61	7.95	6.89	6
5	*Pontia daplidice*	1.12	0.00	1.60	1.44	1.67	1.16	14
6	*Belenois aurota*	4.49	4.21	3.19	5.26	3.35	4.12	7
7	*Colotis etridae*	1.87	0.00	0.00	0.00	2.09	0.9	16
8	*Colotis calais*	0.00	0.00	0.00	0.00	0.42	0.09	31
9	*Colias eratae*	0.75	0.00	1.06	0.00	1.26	0.63	20
10	*Colias fieldii*	4.49	2.34	1.06	0.96	3.35	2.6	9
11	*Catopsilia crocalae*	1.50	0.00	1.60	0.48	2.51	1.25	13
12	*Catopsilia pomona*	11.61	14.02	13.30	12.92	10.04	12.26	3
13	*Catopsilia florella*	1.87	0.00	0.53	0.96	0.00	0.72	18
14	*Catopsilia pyranthae*	19.10	21.50	19.15	16.75	17.99	18.89	1
15	*Eurema hecabe*	9.74	8.41	13.83	10.05	8.79	10.03	5
	Family: Lycaenidae							
16	*Tarucus theophrastus*	0.00	3.74	0.00	0.00	0.00	0.72	19
17	*Zizeeria maha*	0.00	0.00	0.00	0.00	0.42	0.09	30
18	*Euchrysops cnejus*	0.00	3.74	0.00	0.00	0.42	0.81	17
	Family: Nymphalidae							
19	*Danaus chrysippus*	13.86	13.55	14.36	16.75	14.23	14.5	2
20	*Tirumala limniace*	0.00	0.00	0.00	0.48	0.42	0.18	25
21	*Ypthima nareda*	1.87	0.00	0.00	0.00	0.42	0.54	21
22	*Ypthima asterope*	0.00	0.00	0.53	3.35	1.67	1.07	15
23	*Melanitis leda*	0.00	0.00	0.00	0.48	0.84	0.27	24
24	*Hipparchia parisatis*	0.00	0.47	0.00	0.00	0.00	0.09	32
25	*Polyura agraria*	0.00	0.00	0.00	0.00	0.84	0.18	27
26	*Ariadne merione*	5.24	4.67	3.19	2.87	3.77	4.03	8
27	*Neptis sappho*	0.00	0.47	0.00	0.48	0.00	0.18	28
28	*Vanessa cardui*	0.37	0.00	0.00	0.48	0.00	0.18	29
29	*Junonia orithya*	2.25	2.80	2.66	1.91	2.93	2.51	10
30	*Junonia hierta*	0.75	0.00	0.00	0.00	0.42	0.27	23
31	*Junonia almana*	1.87	2.34	2.66	1.44	1.67	1.97	11
32	*Phalanta phalantha*	0.75	0.00	0.00	0.00	0.00	0.18	26

The abundance of butterfly fauna was calculated over the month and year wise basis. It was seen that there was less abundance and diversity in 1st year (from July 2017 to June 2018) that 349 specimens belonging to 15 species were recorded (Table V and Fig. 3A). While in 2nd year (from July 2018 to September 2019), 768 individuals belonging to 32 species were recorded that may be due to host plant and climatic conditions of the study area (Table VI and Fig. 3B). Further, as a whole, the abundance of butterfly fauna was fluctuated over the months in the whole study period and study area. April, 2019, was the most active month (n=123) and the butterflies were in

Table V. Month wise distribution of butterflies during 1st year (from July 2017 to June 2018) in Potohar Plateau, Pakistan.

S. No.	Name of butterflies	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	March 18	Apr-18	May-18	Jun-18	Total
1	*Pieris canidia*	0	0	0	1	1	8	9	11	19	17	7	6	79
2	*Pieris brassicae*	0	0	1	4	4	4	4	0	1	0	0	0	18
3	*Pontia daplidice*	0	0	0	0	0	0	0	0	3	2	0	0	5
4	*Belenois aurota*	0	3	0	0	4	5	0	0	2	0	2	2	18
5	*Colotis etridae*	0	0	1	0	3	0	0	0	0	0	0	0	4
6	*Colias eratae*	1	0	0	0	0	0	0	0	0	2	0	0	3
7	*Colias fieldii*	9	3	0	0	0	0	0	0	0	0	0	0	12
8	*Catopsilia crocalae*	4	3	4	0	0	0	0	0	0	0	0	0	11
9	*Catopsilia pomona*	0	3	3	4	3	2	2	5	1	0	4	2	29
10	*Catopsilia florella*	0	0	1	0	0	0	0	0	0	0	0	0	1
11	*Catopsilia pyranthae*	3	5	12	16	17	12	7	0	0	0	0	0	72
12	*Eurema hecabe*	0	3	3	3	3	0	3	0	0	0	2	1	18
13	*Danaus chrysippus*	5	5	0	0	4	5	0	3	14	14	7	9	66
14	*Tirumala limniace*	0	0	0	0	0	0	0	0	0	1	0	0	1
15	*Ariadne merione*	2	0	1	2	4	3	0	0	0	0	0	0	12
	Total species	24	25	26	30	43	39	25	19	40	36	22	20	349

Table VI. Month wise distribution of butterflies during 2ond year (from July 2018 to September 2019) in Potohar Plateau, Pakistan.

S. No.	Name of butterflies	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Total
1	*Papilio polytes*	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	3
2	*Papilio demoleus*	0	3	2	2	0	0	0	0	2	3	1	1	0	0	1	15
3	*Pieris canidia*	0	0	0	0	5	12	10	6	2	8	2	0	0	0	0	45
4	*Pieris brassicae*	0	0	2	2	6	13	11	11	0	9	5	0	0	0	0	59
5	*Pontia daplidice*	0	0	1	3	0	0	0	0	2	2	0	0	0	0	0	13
6	*Belenois aurota*	0	1	0	0	4	5	0	2	0	11	5	0	0	0	0	28
7	*Colotis etridae*	0	1	1	0	0	0	0	1	0	0	0	0	0	0	3	6
8	*Colotis calais*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9	*Colias eratae*	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	4
10	*Colias fieldii*	4	2	3	2	1	0	0	3	0	2	0	0	0	0	0	17
11	*Catopsilia crocalae*	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3
12	*Catopsilia pomona*	5	18	7	9	6	11	6	8	9	18	6	5	0	0	0	108
13	*Catopsilia florella*	0	0	1	0	0	0	0	2	0	3	0	1	0	0	0	7
14	*Catopsilia pyranthae*	6	9	12	18	14	14	16	10	12	13	5	3	2	3	2	139
15	*Eurema hecabe*	6	6	9	10	7	10	6	8	4	19	5	4	0	0	0	94
16	*Tarucus theophrastus*	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	8
17	*Zizeeria maha*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
18	*Euchrysops cnejus*	0	8	0	0	0	0	0	1	0	0	0	0	0	0	0	9
19	*Danaus chrysippus*	4	11	8	10	6	4	6	6	9	11	4	4	3	6	4	96
20	*Tirumala limniace*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

Table continued on next page...............

| S. No.	Name of butterflies	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Total
21	*Ypthima nareda*	0	0	0	1	0	0	0	0	0	2	0	0	0	0	3	6
22	*Ypthima asterope*	6	2	1	2	0	0	0	0	0	1	0	0	0	0	0	12
23	*Melanitis leda*	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	3
24	*Hipparchia parisatis*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25	*Polyura agraria*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
26	*Ariadne merione*	1	4	4	7	0	0	0	0	0	8	2	0	1	2	4	33
27	*Neptis sappho*	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2
28	*Vanessa cardui*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2
29	*Junonia orithya*	2	2	2	5	5	0	0	1	2	5	3	0	0	0	1	28
30	*Junonia hierta*	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3
31	*Junonia almana*	0	4	3	4	2	0	0	1	3	5	0	0	0	0	0	22
32	*Phalanta phalantha*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2
	Total species	34	87	62	81	57	69	55	60	46	123	39	18	6	12	19	768
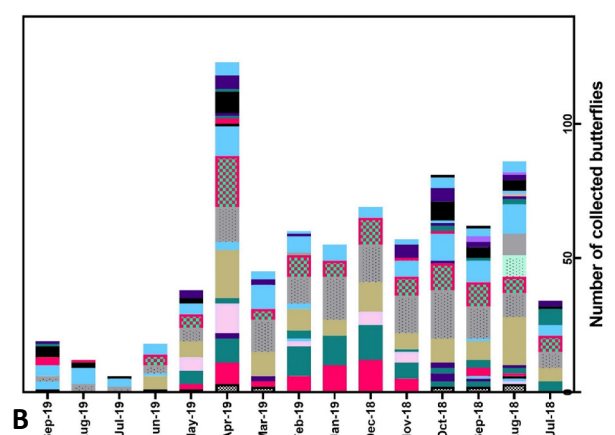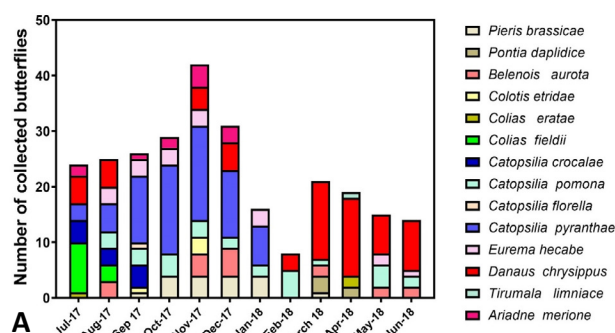
Fig. 3. Month wise distribution of butterflies during 1st year (from July 2017 to June 2018) (A), and 2nd year (from July 2018 to September 2019) (B) in Potohar Plateau, Pakistan.

least proportion in July, 2019 (n=6). The highest peak in the spring month, April was due to high abundance of the members of the family Pieridae representing a higher number of individuals (n=85) followed by the members of family Nymphalidae (n=35) and family Papilionidae (n=3). In the present study, more number of adult butterflies was observed during the period of spring season because during this season, Potohar Plateau, receives sufficient humidity, moisture and temperature and these factors are vital to both butterflies as well as their host plants. Butterfly population was rapidly declined during the period from May to July. Usually, in Potohar plateau, these months are very hot and dry. In addition to this, other factors such as poor nectar butterfly host plants, dry vegetation and scarcity of water results in less abundance of butterfly fauna and lower survival ability of most species. Seasonal fluctuations of butterfly fauna are often influenced by environmental factors like photoperiod, temperature, humidity, and rainfall, vegetation cover such as herbs, shrubs and trees and availability of food resources (Anu et al., 2009; Shanthi et al., 2009; Tiple and Khurad, 2009; Elanchezhyan et al., 2017).

Diversity indices of butterfly fauna

The calculated values of different diversity indices are given in Table VII. In the study area, 32 species were reported. It was clear from the results that Islamabad, capital territory, has more species richness (more number of species were 26) than in the other four localities; district Jhelum, district Rawalpindi, district Chakwal and district Attock (number of species were 21, 20, 17 and 17, respectively).

As a whole in the study area, dominance, D was found (0.108). It was seen that Dominance_ D was found highest in district Attock (0.123), while it was lowest in

Table VII. The alpha diversity indices of butterfly specimens from different localities of 4 districts and Islamabad, capital along overall, Potohar Plateau, Pakistan during July 2017 to September 2019.

Attributes	Overall Potohar Plateau abundance	District Jhelum	District Chakwal	District Attock	District Rawalpindi	Islamabad, Capital
Taxa_S	32	21	17	17	20	26
Individuals	1117	267	214	188	209	239
Simpson_1-D	0.8952	0.9005	0.8868	0.8775	0.887	0.9044
Shannon_H	2.585	2.581	2.42	2.327	2.415	2.657
Evenness_e^H/S	0.4143	0.6289	0.6617	0.6031	0.5596	0.548
Menhinick	0.9575	1.285	1.162	1.24	1.383	1.682
Margalef	4.417	3.58	2.982	3.056	3.556	4.565
Equitability_J	0.7458	0.8476	0.8542	0.8215	0.8062	0.8154

Islamabad Capital Territory (0.09557) and moderate in district Chakwal (0.1132), district Rawalpindi (0.113) and district Jhelum (0.995).

Simpson index of diversity (1-D) was found highest in Islamabad Capital Territory (0.9044), followed by district Jhelum (0.9005), district Rawalpindi (0.887), district Chakwal (0.8868) and district Attock (0.878), whereas as a whole in Potohar Plateau it was found to be 0.8952.

As a whole, Shannon-Wiener diversity index (H) was found 2.585 in Potohar Plateau. Maximum Shannon-Wiener diversity index (H) was found in Islamabad Capital Territory with 2.657 H value, while it was lowest in district Attock with 2.327 H value and moderate in district Jhelum, district Chakwal and district Rawalpindi with 2.581 H, 2.42 H and 2.415 H, respectively.

The calculated value of Evenness-e H/S index ranged from 0.548 (Islamabad Capital Territory) to 0.6617 (district Chakwal). Brillouin index ranged from 2.181 (district Attock) to 2.486 (Islamabad Capital Territory). Menhinick index ranged from 1.24 (district Attock) to 1.682 (Islamabad Capital Territory). Margalef richness index ranged from 2.982 (district Chakwal) to 4.656 (Islamabad Capital Territory) and Equitability- J index ranged from 0.8062 (district Rawalpindi) to 0.8542 (district Chakwal). All the values obtained from these indices showed that the whole area is rich in butterfly abundance.

Simpson index (D) and Shannon equitability (J) indices revealed that the individuals among species were not evenly distributed during the study period indicating that some species were more abundant than the others. The abundance of the individuals of a species at any given point on a temporal scale is again dependent on various biotic and abiotic environmental factors.

CONCLUSION

The present study demonstrated that 22 genera and 32 species within four families were recorded. Nymphalidae was the most dominant family with 14 species followed by the family Pieridae with 13 species, family Lycaenidae with 3 species and family Papilionidae with 2 species. Maximum butterflies were observed in April 2019 in spring season and least in July 2019 in scorching heat summer season that might be due to the host availability and food preference. During present study, a total of 1117 specimens were collected from 53 selected locales of four districts; district Jhelum, district Chakwal, district Attock, district Rawalpindi and Islamabad, capital territory, of Potohar Plateau, Pakistan. It was seen that district Jhelum showed the highest abundance with 23.90% (n=267) butterfly specimens followed by Islamabad Capital Territory, with 21.39 % (n=239), least abundance was exhibited by district Attock 16.83% (n=188) and moderate abundance of butterfly specimens were observed in district Chakwal with 19.16% (n=214) and district Attock with 18.71% (n= 209) (Table VII). As a whole, Shannon-Wiener diversity index (H) was found 2.585 in Potohar Plateau. Maximum Shannon-Wiener diversity index (H) was found in Islamabad Capital Territory, with 2.657 H value while it was lowest in district Attock with 2.327 H value and moderate in district Jhelum, district Chakwal and district Rawalpindi with 2.581 H, 2.42 H and 2.415 H, respectively.

Whereas, maximum species richness was shown by Islamabad, capital territory that was 26 species, moderate species richness was present in district Jhelum with 21 species, district Rawalpindi with 20 species and least species richness was present in district Chakwal with 17 species and district Attock with also 17 species. The species richness, evenness and abundance were found to be normal in the study area. Furthermore, proper measurement should be taken in attention to minimize the loss of natural habitat as butterfly fauna is dependent upon better environmental conditions.

RECOMMENDATIONS

It is suggested that area under present study should be continuously monitored to observe any changes in the diversity and abundance of butterfly populations because the changes in the diversity can only be observed through continuous monitoring and comparing the data of every year (Khan *et al*., 2007).

It is essential to identify the rare butterfly species and conserve them by establishing butterfly parks and by creating awareness among school, college and university students and common people through social media.

Establishment of butterfly gardens will help to maximize butterfly diversity and abundance in conserving the butterfly species that might otherwise become rare or even disappear.

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IRB approval
The research project has been approved by the Advance Studies and Research Board, University of Gujrat vide letter # ASRB/ZOO/03/11546 dated May 2018.

Ethical statement
All efforts were taken to minimize pain and discomfort to the animal while conducting this research according to the ethical protocol of the University of Gujrat.

Supplementary material
There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20231217050506

Statement of conflict of interest
The authors have declared no conflict of interest.

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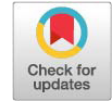
Supplementary Material

Diversity of Butterfly Fauna in Potohar Plateau, Pakistan

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Supplementary Table I. Study sites along its coordinates and altitude during July, 2017 to September, 2019 in Potohar Plateau, Pakistan.

Site	Detail of study sites	Latitude	Longitude	Altitude
S1	Sangohi, district Jhelum	32.861663°	73.601565°	224m
S2	Loke Virsa Shakar Parrian, Islamabad, Capital	33.687668°	73.072515°	350m
S3	Attock city, district Attock	33.760359°	72.365081°	357m
S4	Murid village, district Chakwal	32.910508°	72.754254°	534m
S5	Rawat, district Rawalpindi	33.489100°	73.194168°	574m
S6	Rohtas fort Road, tehsil Dina, district Jhelum	32.965638°	73.575757°	309m
S7	Dhok Faqiran, tehsil Tala Gang, district Chakwal	32.890371°	72.228938°	482m
S8	Haji Shah village, tehsil Hazro, district Attock	33.879719°	72.333988°	314m
S9	Noor Pur Shahan, Islamabad, Capital	33.742503°	73.111447°	583m
S10	Lehri village, tehsil Sohawa, district Jhelum	33.153095°	73.557831°	504m
S11	Dalwal, tehsil Choa Saidan Shah, district Chakwal	32.700181°	72.893839°	697m
S12	Mandra, tehsil Gujar Khan, district Rawalpindi	33.364174°	73.242187°	521m
S13	Hassan Abdal City, district Attock	33.815956°	72.678880°	420m
S14	Bari Imam village, Islamabad, Capital	33.745360°	73.110307°	597m
S15	Khewra, tehsil Pinddan Khan, district Jhelum	32.617732°	73.020069°	237m
S16	Chakora village, tehsil Kallar Kahar, district Chakwal	32.787965°	72.713167°	648m
S17	Choha Khalsa, tehsil Kallar Syedan, district Rawalpindi	33.414150°	73.480198°	523m
S18	Fateh Jang city, tehsil Fateh Jang, district Attock	33.568242°	72.635690°	514m
S19	Golra Sharif village, Islamabad, Capital	33.689862°	72.970152°	570m
S20	Kala Gujran village, tehsil and district Jhelum	32.970719°	73.685761°	353m
S21	Lawa, tehsil Lawa, district Chakwal	32.701976°	71.925096°	423m
S22	Wah Cantt, tehsil Rawalpindi, district Rawalpindi	33.759987°	72.772582°	474m
S23	Pindi Gheb city, tehsil Pindi Gheb, district Attock	33.262791°	72.284501°	320m

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Site	Detail of study sites	Latitude	Longitude	Altitude
S24	Kotli Sattian, tehsil Kotli Sattian, district Rawalpindi	33.808317°	73.526932°	146m
S25	Akhori village, tehsil Attock, district Attock	33.683228°	72.451049°	362m
S26	Saagri, tehsil and district Rawalpindi	33.461519°	73.263880°	575m
S27	Jan Waal village, tehsil and district Chakwal	32.945466°	72.879562°	515m
S28	Garden avenue, Shakar Parrian, Islamabad, Pakistan	33.692715°	73.099666°	530m
S29	Chakwal road, Kallar Kahar, district Chakwal	32.773957°	72.721745°	723m
S30	Bagga, tehsil Jhelum, district Jhelum	32.906345°	73.686866°	225m
S31	Musa village, tehsil Hazro, district Attock	33.881399°	72.492623°	323m
S32	Sector H-8, Islamabad, Pakistan	33.681812°	73.063403°	526m
S33	Mallot, tehsil Dina, district Jhelum	32.944763°	73.611962°	255m
S34	Dhok Pathan, tehsil Tala Gang, district Chakwal	33.130170°	72.346822°	315m
S35	Jatli, tehsil Gujar Khan, district Rawalpindi	33.205638°	73.103409°	532m
S36	Kamra city GT Road, tehsil Hassan Abdal, district Attock	33.853225°	72.418007°	330m
S37	Said Pur village, Islamabad, Capital	33.742263°	73.068444°	629m
S38	Choa Saidan Shah city, district Chakwal	32.721565°	72.977791°	630m
S39	Domeli village, tehsil Sohawa, district Jhelum	33.013281°	73.355031°	328m
S40	Shah Bagh, tehsil Kallar Syedan, district Rawalpindi	33.472634°	73.285370°	576m
S41	Rawal lake, Islamabad, Capital	33.711309°	73.106834°	533m
S42	Pind Dadan Khan Road Jalal Pur Sharif, district Jhelum	32.658805°	73.395465°	213m
S43	Kot Sarang, tehsil Tala Gang, district Chakwal	33.033393°	72.383464°	387m
S44	Pind Bahadur Khan, tehsil Fateh Jang, district Attock	33.707649°	72.697341°	486m
S45	Maldev, district Jhelum	32.993911°	73.600233°	272m
S46	Taxila city, district Rawalpindi	33.748989°	72.777477°	504m
S47	Jhelum city Railway Road district Jhelum	32.942726°	73.722114°	231m
S48	Sad Waal village, tehsil and district Chakwal	32.879671°	72.827190°	544m
S49	Mohra Noori, tehsil and district Rawalpindi	33.116654°	73.209045°	507m
S50	Dandi village, tehsil Pindi Gheb, district Attock	33.258789°	72.238431°	333m
S51	Tarnol, Islamabad, Capital	33.651739°	72.909359°	603m
S52	Jabar Pur, tehsil and district Chakwal	32.924387°	72.887900°	514m
S53	Sohawa GT Road, tehsil Sohawa, district Jhelum	33.131883°	73.420928°	449m