

Butterfly Fauna (Lepidoptera) Diversity in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan: A Taxonomic Checklist

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Abstract Butterflies are renowned for their elegance and kaleidoscopic palette, and their primary role as pollinators is crucial to the intricate tapestry of floral diversity. An entomological investigation was conducted in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan, over the three years (2014–2017). Specimens were captured using nets, preserved in alcohol-filled bottles, meticulously mounted on Styrofoam, and then identified using taxonomic keys. A total of 3,072 butterflies belong to 5 families (Nymphalidae, Lycaenidae, Papilionidae, Pieridae, and Hesperidae), 26 genera and 36 distinct species namely *Pieris brassicae*, *Pieris canidia*, *Pieris rapae*, *Pontia callidice*, *Pontia daplidice*, *Catopsilia pyranthe*, *Colias erate*, *Colias fieldii*, *Catopsilia Pomona*, *Eurema hecabe*, *Gonepteryx rhamni*, *Eurema laeta*, *Parnassius actius*, *Graphium cloanthus*, *Graphium euryplus mecisteus*, *Papilio clytia*, *Papilio demoleus*, *Papilio machaon*, *Papilio polyctor*, *Atrophaneura polyeuctes*, *Junonia orithya*, *Vanessa cardui*, *Lethe rohria*, *Melanitis leda*, *Argynnis hyperbius*, *Phalanta phalanta*, *Danaus chrysippus*, *Lycaena phoenicurus*, *Heliophorus bakeri*, *Acytolepis puspa*, *Leptotes plinius*, *Tarucus extricates*, *Deudoryx epijarbas*, *Pelopidas agna*, *Carcharodus alceae*, *Taractrocera danna* were collected in Mandi Bahauddin. Notably, the discovery of *Graphium euryplus mecisteus* introduces a new butterfly species previously unrecorded in Pakistan. Family-wise distribution of Lepidoptera indicated Papilionidae as the most prevalent (40%), followed by Nymphalidae (23%), Pieridae (17%), Lycaenidae (13%), and Hesperidae (7%). The significance of locations like the Daphar Plantation, identified as a reserved forest, underscores their crucial role as habitats for these delicate creatures. This study not only deepens our understanding of Mandi Bahauddin's butterfly population but also beckons further exploration and conservation efforts to preserve and comprehend the diverse butterfly fauna that graces the landscapes of Pakistan.

Key words- Systematics, Butterfly fauna, Nymphalidae, Pieridae, Mandi Bahauddin

INTRODUCTION

Understanding biodiversity involves examining biological indicators that highlight the significance of forests and their management within ecosystems (Pearce and Venier, 2006; Maleque *et al.*, 2009). In forest ecosystems, insect

biodiversity primarily takes center stage (Kwon *et al.*, 2013; Lee and Kwon, 2014; Lee *et al.*, 2014). Among insects, butterflies stand out as exceptional indicators due to their high population numbers, short generation span, mobility and more sensitivity to changes in environment (Lee and Kwon, 2014; Kwon *et al.*, 2014).

Earth hosts an estimated 1.4 million species, with insects accounting for 53% of this total (Bibi *et al.*, 2022). More than 19,000 butterfly species have been listed worldwide. Only 11% of butterfly species constitute the order Lepidoptera (Khan *et al.*, 2016). Pakistan, specifically, has reported more than 5,000 insect species, including 400 species of moths and butterflies (Khan *et al.*, 2007). Butterflies are known for their grace and beauty, serving as both environmental indicators and possessing significant aesthetic and commercial value. They form the second biggest order within the class Insecta, exhibiting specific habitat preferences based on their feeding and reproductive requirements (Aslam, 2009; Akhtar *et al.*, 2015).

Butterflies, being excellent pollinators due to their long-distance flights, contribute significantly to plant variety pollination. However, certain butterfly species act as serious pests to various fruits and crops (Mal *et al.*, 2014). Their sensitivity to habitat degradation (Perveen and Ahmed, 2012) and climate change (Perveen and Fazal, 2013) underscore their role as key indicators of ecosystem health. A higher population of butterflies often signals a healthier ecosystem (Shi and Luo *et al.*, 2009).

Several entomologists have contributed to understanding the butterfly fauna of Pakistan from different perspectives, such as systematic classification, diversity assessment, and distribution mapping. Bibi *et al.* (2022) explored the abundance and seasonal variation in the population density of butterflies in different areas of the district of Battagram, KPK, Pakistan. Usman *et al.* (2017) compiled a list of butterflies collected from the Takht-e-Nusrati Karak region of Pakistan. Khan and Hanif, 2016 studied the butterfly fauna in Tehsil Choa Saiydan Shah, Punjab. Maalik *et al.* (2013) reported the diversity and abundance of lepidopteran populations from selected crops in the district of Faisalabad, Pakistan. But the butterfly fauna (Lepidoptera) diversity of the Daphar Wildlife Forest Sanctuary remains unexplored. Therefore, this research was designed to explore the distribution and diversity in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan, which is essential for understanding the impacts of deforestation and

climatic changes. Also to create a comprehensive checklist of butterflies by identifying new localities hosting previously unrecorded butterfly species and assessing the status of butterfly species not documented in prior studies.

MATERIAL AND METHODS

Study Site

The selected study area was Daphar wildlife forest sanctuary which is commonly named as Daphar plantation reserved forest. It covers an area of 7135 acres. It is situated at intersection of latitude 32-25'30" degree north, and longitude 73-10'59.98" degree east in Tehsil Malakwal, of district Mandi Bahauddin and is almost 9.6 Km to south course of Pakhowal Railway Station (Figure 1). Mandi Bahauddin typically experiences a subtropical climate. Summers are hot, with temperatures often exceeding 40°C (104°F) during the hottest months of June, July, and August. Winters tend to be cool, with temperatures dropping to around 5-10°C (41-50°F) from December to February. The area usually sees a significant difference between day and night temperatures. Rainfall patterns vary, with most of the precipitation occurring during the monsoon season, from July to September.

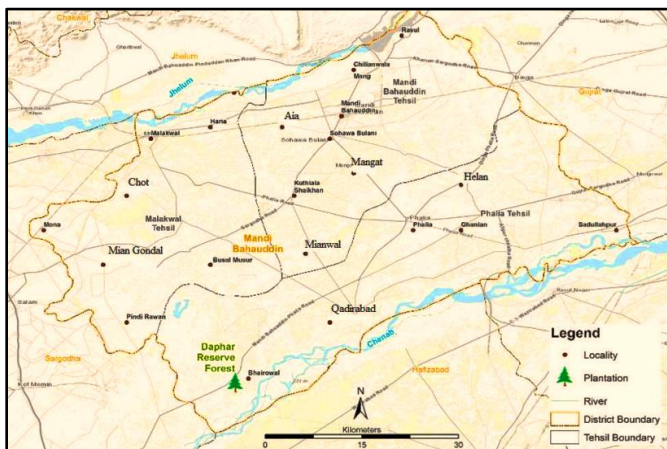


Figure 1: Location of Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan

Collection and Preservation

A total of 3,072 butterfly specimens were collected from Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan, during 2014-2017. Hand-picking techniques and aerial nets were used to collect specimens, which were then placed in jars and chilled for a full 24 hours. Following that, the specimens were pinned and stretched for 24 hours on a stretching board. The specimens were then placed in insect storage boxes. Naphthalene balls were kept in these storage boxes for their protection from ants and other entomophagous species. The strong odor emitted by the naphthalene balls acted as a natural

repellent, helping to ensure the long-term preservation of the specimens.

Identification

Butterfly species were identified, and a taxonomic key was made with the help of available literature and keys (Robert, 2001; Bingham, 1905, 1907; Talbot, 1932, 1939).

RESULTS

During the study period, a total of 3,072 butterfly individuals were collected from Daphar Forest Sanctuary, Mandi Bahauddin. Upon identification, it was revealed that these butterflies belong to 5 families, 26 genera, and 36 species. A Taxonomic Checklist for Butterfly Fauna Diversity in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan is given in Table 1. The identified families in this study are Nymphalidae, Lycaenidae, Papilionidae, Pieridae, and Hesperidae. Figure 4 depicts the diversity of butterfly families in percentages. The highest percentage of species (40%) was exhibited by the family Papilionidae, followed by Nymphalidae representing 23%. Pieridae accounted for 17% of the species, followed by Lycaenidae at 13% and Hesperidae at 7% (Papilionidae > Nymphalidae > Pieridae > Lycaenidae > Hesperidae).

Graphium euryplus mecisteus has been reported for the first time in Pakistan. *Papilio demoleus* was the most abundant species, comprising 7.78% (n= 237) of the total count, followed by *Papilio machaon* at 5.53% (n= 170), and then *Graphium euryplus mecisteus* at 5.46% (n= 168). *Papilio clytia* and *Argynnis hyperbius* shared the same percentage of 4.94% (n= 152), followed by *Parnassius actius* at 4.65% (n= 143). *Junonia orithya* accounted for 4.62% (n= 142), *Papilio polyctor* for 4.42% (n= 136), and *Atrophaneura polyeuctes* for 3.80% (n= 117). *Graphium cloanthus* constituted 3.51% (n= 108), *Phalanta phalanta* 3.12% (n= 96), and *Acytrolepis puspa* 3.09% (n= 95). *Vanessa cardui* and *Carcharodus alceae* accounted for 3.15% and 3.02%, respectively, with 97 and 93 individuals each. *Lethe rohria* represented 2.63% (n= 81), *Pelopidas agna* represented 2.57% (n= 79), and *Heliophorus bakeri* represented 2.40% (n= 74).

Melanitis leda and *Tarucus extricates* were at 2.34% (n= 72 each), followed by *Danaus chrysippus* at 2.21% (n= 68). *Leptotes plinius* made up 2.14% (n= 66), *Colias fieldii* 2.05% (n= 63), *Pontia daplidice* 1.92% (n= 59), and *Catopsilia pomona* was also at 1.92% (n= 59). *Eurema hecabe* accounted for 1.69% (n= 52), *Lycaena phoenicurus* for 1.66% (n= 51), and *Eurema laeta* for 1.59% (n= 49). *Catopsilia pyranthe* represented 1.49% (n= 46), *Pieris canidia* 1.46% (n= 45) and *Deudoryx epijarbas* 1.36% (n= 42). *Taractrocera danna* constituted 1.24% (n= 38), *Pontia callidice* 1.17% (n= 36), and *Gonepteryx rhamni* 1.10% (n= 34). *Pieris brassicae* accounted for 1.04% (n= 32), *Colias erate* for 1.00% (n= 31), and *Pieris rapae* for 0.55% (n= 17) as shown in Figure 3.

Table 1: Taxonomic position of collected species from with common name from Mandi Bahauddin, Pakistan

Families	Subfamilies	Scientific name	Common name	Total	Relative abundance (%)		
Pieridae	Pierinae	<i>Pieris brassicae</i> (Linnaeus, 1758)	Large cabbage white	32	1.04		
		<i>Pieris canidia</i> (Linnaeus, 1768)	Asian cabbage white	45	1.46		
		<i>Pieris rapae</i> (Linnaeus, 1758)	Small cabbage white	17	0.55		
		<i>Pontia callidice</i> (Hübner, 1800)	Lofty bath peak white	36	1.17		
		<i>Pontia daplidice</i> (Linnaeus, 1758)	Bath white	59	1.92		
	Coliadinae	<i>Catopsilia pyranthe</i> (Linnaeus, 1758)	Mottled emigrant or white migrant	46	1.49		
		<i>Catopsilia pomona</i> (Fabricius, 1775)	Lemon migrant	59	1.92		
		<i>Colias erate</i> (Esper, 1805)	Pale clouded yellow	31	1.00		
		<i>Colias fieldii</i> (Ménétrières, 1855)	Dark clouded yellow	63	2.05		
		<i>Eurema hecabe</i> (Linnaeus, 1758)	Common grass yellow	52	1.69		
		<i>Eurema laeta</i> (Boisduval, 1836)	Short spotless yellow	49	1.59		
		<i>Gonepteryx rhamni</i> (Linnaeus, 1758)	Common brimstone	34	1.10		
		Papilionidae	Parnassiinae	<i>Parnassius actius</i> (Eversmann, 1843)	Pale keeled Apollo	143	4.65
Papilioninae	<i>Graphium cloanthus</i> (Cramer, 1775)		Glassy bluebottle	108	3.51		
	<i>Graphium euryplus mecisteus</i> (Distant, 1885)		Pale green triangle	168	5.46		
	<i>Papilio clytia</i> (Linnaeus, 1758)		Common mime	152	4.94		
	<i>Papilio demoleus</i> (Linnaeus, 1758)		Lemon lime butterfly	237	7.78		
	<i>Papilio machaon</i> (Linnaeus, 1758)		Yellow swallow tail	170	5.53		
	<i>Papilio polyctor</i> (Boisduval, 1836)		Common peacock	136	4.42		
	<i>Atrophaneura polyeuctes</i> (Reakirt, 1864)		Common windmill	117	3.80		
	Nymphalidae		Nymphalinae	<i>Junonia orithya</i> (Linnaeus, 1764)	Blue pansy	142	4.62
				<i>Vanessa cardui</i> (Linnaeus, 1758)	Painted lady	97	3.15
Satyrinae		<i>Lethe rohria</i> (Fabricius, 1787)	Common tree brown	81	2.63		
		<i>Melanitis leda</i> (Linnaeus, 1758)	Evening brown	72	2.34		
Heliconiinae		<i>Argynnis hyperbius</i> (Linnaeus, 1763)	Tropical fritillary	152	4.94		
		<i>Phalanta phalanta</i> (Drury, 1773)	Common leopard	96	3.12		
Danainae		<i>Danaus chrysippus</i> (Linnaeus, 1758)	Plain tiger	68	2.21		
Lycaenidae		Lycaeninae	<i>Lycaena phoenicurus</i> (Fabricius, 1807)	Baluchi copper	51	1.66	
			<i>Heliophorus bakeri</i> (Geyer, 1832)	Western sapphire	74	2.40	
		Polyommatainae	<i>Acytolepis puspa</i> (Horsfield, 1828)	Common hedge blue	95	3.09	
	<i>Leptotes plinius</i> (Fabricius, 1793)		Zebra blue	66	2.14		
	<i>Tarucus extricates</i> (Butler, 1886)		Striped or pierrot	72	2.34		
	Theclinae	<i>Deudoryx epijarbas</i> (Moore, 1858)	Cornelian	42	1.36		
	Hesperiidae	Hesperinae	<i>Pelopidas agna</i> (Moore, 1866)	Obscure banded swift	79	2.57	
<i>Carcharodus alceae</i> (Esper, 1780)			Plain marbled or mallow skipper	93	3.02		
<i>Taractrocera danna</i>			Himalayan grass dart	38	1.24		

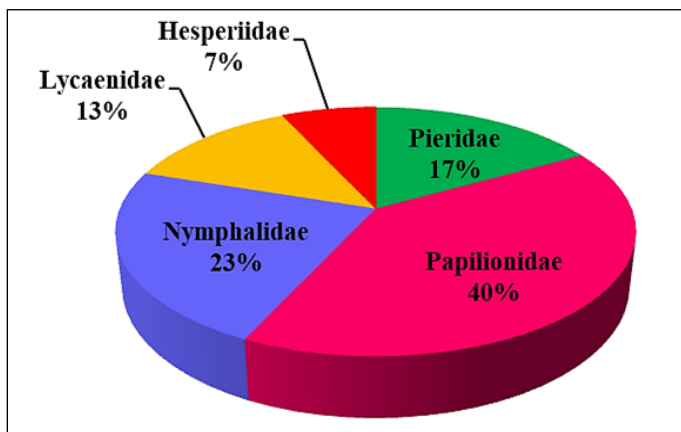


Figure 4: Distribution of Lepidoptera in different species in Mandi Bahauddin, Pakistan

DISCUSSION

The present survey was conducted to explore the biodiversity of butterflies in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan, for duration of three years (2014–2017). A total of 3,072 specimens were collected from the study site. During this research, 36 different species were recognized, belonging to 5 families and 26 genera. This study was a detailed work on the taxonomic position and abundance of butterfly fauna in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan, which has not been previously reported.

The fauna of butterflies from diverse locations in Pakistan has already been recorded. A study was conducted intending to document the butterfly fauna in the district of Charsadda and also to explore its richness by creating a key from August 2014 to May 2015. The reported species belonged to 3 different families, 18 genera, and 23 species. The collected butterflies comprised the families Nymphalidae, 50%, Pieridae, 43%, and Papilionidae, 7% (Khan, 2015). Due to high floral diversity and plantation fodder was most preferred habitat for many insect's fauna as well as for lepidoptera (Patel, 2014).

Insect diversity is greatly inclined by different plant substance because certain plant substances attract the insect and certain restrain those (Greenberg et al., 2001). So in this way feeding habits of phytophagous insects are influenced and ultimately their diversity and occurrence is also affected. The present survey was conducted to explore the biodiversity of butterflies in Daphar Forest Sanctuary, Mandi Bahauddin, Pakistan, for duration of three years (2014–2017). A total of 3,072 specimens were collected from the study site. During this research, 36 different species were recognized, belonging to 5 families and 26 genera. The Papilionidae family had the most species reported. The species' variance might be attributed to seasonal and environmental variations in the research region.

Van-Lien and Yuan (2003) conducted their survey on the species composition, richness, and abundance of the family Papilionidae from different habitats of tropical forests at Tam

Dao National Park. Fitzherbert *et al.* (2006) recorded 90 species of butterflies between Gilgit and Khunjerab. They observed the diversity and distribution of butterfly species and also found the highly distributed and lowest distributed butterfly species.

Sharma *et al.* (2006) studied the collection of butterflies from Punjab's new campus area from June to September. This study was based on the relationship between temperature, humidity, and the population of butterflies. Khan *et al.* (2007) reported 20 butterfly species from Mirpur, 19 butterfly species from Bhimber, and 16 butterfly species from Kotli. Parchem *et al.* (2007) stated that the evolution of wings and adaptive properties of butterflies made them a successful group on Earth. Parveen (2012) explored the butterfly fauna from Kohat (Khyber Pakhtunkhwa), Pakistan, and identified 21 species of 3 families, namely Nymphalidae (33%), Papilionidae (10%), and Pieridae (57%). However, our study showed conflict with this study.

A study was conducted on butterflies of Takht-e-Nusrati Karak region of Pakistan in which 17 species from families Nymphalidae, Papilionidae and Pieridae cover 35%, 12%, and 53% of the butterflies were reported. Family Nymphalidae included species *Argynnis hyperbius*, *Cynthia cardui*, *Ariadne merione*, *Junonia orithya*, *Phalanta phalantha* and *Hipparchia parisati*. Family Papilionidae: *Catopsilia pomona*, *Colias croceus*, *Colotis etrida*, *C. protractus*, *Eumera hecab*, *Pieris ajaka*, *P. brassicae*, *P. rapae* and *P. napae* respectively. While Pieridae included *Papilio demoleus* and *P. polytes* only (Usman *et al.* 2017). In our study the species were *Pieris brassicae*, *Pieris canidia*, *Pieris rapae*, *Pontia callidice*, *Pontia daplidice*, *Catopsilia pyranthe*, *Colias erate*, *Colias fieldii*, *Catopsilia pomona*, *Eurema hecabe*, *Gonepteryx rhamni*, *Eurema laeta*, *Parnassius actius*, *Graphium cloanthus*, *Graphium eurypylus mecisteus*, *Papilio clytia*, *Papilio demoleus*, *Papilio machaon*, *Papilio polyctor*, *Atrophaneura polyeuctes*, *Junonia orithya*, *Vanessa cardui*, *Lethe rohria*, *Melanitis leda*, *Argynnis hyperbius*, *Phalanta phalanta*, *Danaus chrysippus*, *Lycaena phoenicurus*, *Heliophorus bakeri*, *Acytolepis puspa*, *Leptotes plinius*, *Tarucus extricates*, *Deudoryx epijarbas*, *Pelopidas agna*, *Carcharodus alceae* and *Taractrocera danna*. In the recorded 36 species *Papilio demoleus* was the most common species of the district Mandi Bahauddin, Pakistan and the most rear specie was *Pieris rapae* during this study.

Another study provided knowledge about the occurrence of different species of butterflies in Sindh. Mal *et al.* (2021) made a checklist of butterflies in Sindh, Pakistan. They collected 67 species of butterflies, having 41 genera and 6 families, from various localities in Sindh. Twenty butterfly species belonging to the two families Nymphalidae and Pieridae were observed by Faiz *et al.* (2015) in Tolipir National Park in Azad Jammu and Kashmir, Pakistan by using the line transect sampling method. Batool and Hussain (2016) reported the distribution and diversity of butterflies in Pakistan. They observed a total of 70 butterfly species, comprising 4397 specimens belonging to 19 families from

various cities in Pakistan, of which Bahawalpur City showed the highest diversity of butterflies. About 232 butterfly individuals belonging to 4 subfamilies, 3 families, 8 genera, and 12 species were collected by Iqbal *et al.* (2016) from Gujrat, Pakistan. They also observed that 78.44% of butterfly species belong to the family Pieridae, 8.18% of species belong to Nymphalidae, and 13.36% of butterfly species belong to the family Danaidae. Khan *et al.* (2016) collected 375 specimens belonging to 7 families, 20 genera, and 24 species of butterflies from the district of Lower Dir (Khyber Pakhtunkhwa), Pakistan.

Conclusion

The comprehensive taxonomic checklist compiled in this study unveils a rich tapestry of butterfly diversity within the Daphar Forest Sanctuary in Mandi Bahauddin, Pakistan. Beyond cataloging species, this research offers a foundational resource for understanding and preserving regional biodiversity. The development of a key and checklist serves as a vital tool not only for current assessments but also for guiding future research endeavors and conservation efforts in similar ecosystems. By shedding light on the intricate network of butterfly species in this specific locale, this study underscores the significance of continued exploration and protection of natural habitats. Furthermore, the findings presented here lay the groundwork for broader studies on ecological patterns, species interactions, and potential impacts of environmental changes, thus contributing to the broader field of biodiversity conservation and management. Ultimately, this research stands as a testament to the invaluable insights gained from studying and safeguarding the delicate yet captivating world of butterfly fauna.

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DECLARATIONS

Statements of consent

The publishing of the manuscript was approved by all authors. Participants in the study gave their informed consent.

Competing interests

The authors have no competing interests to disclose.

Author's contribution

The data collection and examination were spearheaded by Waqas Ahmad Gondal. The conceptual framework stemmed from Aqsa Shehzadi, while the final draft was meticulously organized by Aqsa Shehzadi. Each author played a pivotal role, contributing significantly to the study, and collectively reviewed and endorsed the final draft of this work.

Availability of data

All data are available upon request.

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