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Assessment of butterflies diversity, and distribution in Ghamot National Park, Western Himalaya, Neelum Valley, Pakistan

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Authors' Contribution: **Jahangeer, M.** conducted the field work, **M. S. Awan** designed the study and **R. A. Minhas** conducted the statistical analysis.

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ABSTRACT

Biodiversity measures, species richness and species evenness. Species richness means the number of species present in designated area whereas evenness stands for relative abundance of each species. Butterflies are very important economically. They feed on nectar from flowers by using proboscis. Butterflies act as excellent bioindicator of health of natural ecosystem.The fauna in the study area lacks comprehensive documentation hence there has been no previous assessment of butterfly biodiversity. The study was conducted to estimate species richness, species evenness, and species diversity through a comparative analysis across different habitat types.The Pollard walk method, specifically a butterfly transect count and visual Surveys was used to collect specimen in Ghamot National Park divided into 8 localities. A total of 37 transects covering an area of 12.55 km^2 were established and observed on a monthly basis from June 2020 to July 2021. A collection of 211 specimens was obtained using various standard methods. In order to assess the butterfly population, diversity metrics including the Shannon-Wiener index, Shannon equitability index, Margalef index, and Simpson index were employed. The study documented a total of 539 individuals representing 16 species and 3 butterfly families in 8 different localities with varying habitats. The forest-dominated zones exhibited the highest abundance (n=266; 49.53%) and species richness (n=15; 93.75). Additionally, the forest zone demonstrated the maximum values for the Shannon-Wiener diversity index (3.77) and Simpson index (0.92), while the riparian zone displayed the lowest diversity (3.02) and Simpson index (0.89) among the four selected localities. Therefore, it is recommended that regular monitoring of the study area be undertaken to observe potential fluctuations in butterfly diversity. Continuous surveillance and comparative analysis of data from year to year are essential for identifying any shifts in butterfly populations.

Keywords: Habitat, species, conservation, diversity, AJK wildlife

INTRODUCTION Butterflies have long been symbolized by beauty and grace and are widely recognized for their diurnal behavior, vibrant colors, varied shapes, and graceful flight patterns, captivating the and interest of observers. Butterflies are very important economically. They feed on nectar from flowers by using proboscis. Some take nourishment from pollen (Gilbert, 1972). Butterflies act as excellent bioindicator of health of natural ecosystems due to their sensitivity on microclimate and light level. Caterpillars of sweet potato butterflies feed on sweet potato leaves. Heavy attacks during dry season can result in complete defoliation of crop (Bashaasha *et al.*, 1995). Papiliodemoleus, the citrus caterpillar is pest of citrus and curry leaf *Murrayakoenigii* plantation (Malik, 1970). The young nursery plants 1-2 feet high are preferred by citrus caterpillars and they are capable to defoliate nursery plants completely (Yunus and Munir, 1972; Thakre and Borle, 1974; Matsumoto and Noerdjito, 1996; Narayanamma *et al.*, 2001). Butterflies have specific habitat requirement depending upon their feeding and reproduction requirements, loss of which may cause local extinction. Thus the conservation value of a habitat could be assessed by the presence of various species of Butterflies in an area. Thriving in almost every habitat with flowering plants, butterflies are found at different altitudes, excluding extreme Polar Regions and snow-covered mountainous terrains. The comprehensive examination of butterflies has its roots in the 18th century, and as of 1998, a documented total of 19,238 species worldwide has been recorded. This number is dynamic, as the discovery of new species remains an ongoing occurrence (Roberts, 2001). Biological diversity, commonly known as biodiversity, is a crucial component in the realms of science, society, economy, education, culture, aesthetics, and recreation within the animal kingdom (Kempton and Taylor, 1976; Kempton and Wedderburn, 1978; Kempton, 1979; Magurran, 1988). It encompasses the variety and numerical composition of species. The link between diversity and niche stability over time (Mcintosh, 1967) suggests that a greater number of niches support higher diversity (Begon *et al.*, 1986; Magurran, 1988). Generally, homogeneous environments tend to foster lower diversity, whereas diverse environments and contribute to greater diversity (Begon *et al.*, 1986; Magurran, 1988).

OBJECTIVES: The fauna in the study area lacks comprehensive documentation hence there has been no previous assessment of butterfly biodiversity. This baseline study represents the first effort to evaluate the diversity of butterfly fauna in the Ghamot National Park. The objectives are to estimate species richness, species evenness, and species diversity through a comparative analysis across different habitat types.

MATERIALS AND METHODS: Study area: Ghamot National Park (GNP) is situated in the upper Neelum Valley, approximately 170 kilometers north of Muzaffarabad, the capital of Azad Jammu and Kashmir. Initially established as a game reserve in 1982 and later upgraded as National Park in 2004, GNP comprised on block compartments no. 16 and 17 of Sharda Forest division. The total covered area of this park is 27,271 hectares (67,388 acres), mainly consisting of highlands pinched by fast-flowing cold ravines. GNP is located at 35° 24' N and 73° 57' E, encompassing elevations ranging from 2430 to 4950 meters above sea level. Positioned adjacent to Surgan Nullah, the park is about 25 kilometers from Sharda. Access to Ghamot National Park involves traversing a seven-kilometer paved road leading to a small town Surgan that serves as an entry point to the Surgan Valley. From Surgan village, an additional 16 to 18 kilometers of drivable terrain leads to Ghamot village, a small settlement situated along the park's boundary (Jahangeer *et al.*, 2023; Jahangeer *et al.*, 2024)(figure 1).

The research area encompasses mountainous terrain characterized by sheer and irregular topography, fragile geology, and a climate marked by snowfall and rainfall. It is nestled within deep valleys and high ridges, featuring slopes that are exceptionally steep, reaching up to 100% incline at numerous sites and extending for hundreds of meters. The region experiences common occurrences of landslides and glacier slides due to loose rocks, steep slopes, inadequate land use practices, diminished vegetation, and substantial rainfall. Dotted throughout the area are 25 freshwater springs, and it is traversed by four perennial streams, Hula Bhaik, Sora, Kali Jander, and Saralfed by cold and clear water originating from the melting snow on mountain peaks. These streams converge to form Surgan Nullah, and upon reaching the union council Sharda, it joins the Neelum River (Anwar and Aziz, 2008; Jahangeer *et al.*, 2023).

Data collection: Following the methodology outlined by Sevilleja *et al.* (2019), the butterfly transect counts method was used to collect specimens and Visual Surveys was also conducted in the study area. Zonation of study area was done before conducting study survey; Zonation was done on the basis of topographic feature, vegetation characteristics, elevation, aspect and slope of study area. The Study area was stratified into five different zones i.e. forest zone, (FZ, elevation ranges between 2400-3300m), scrubland zone (SLZ, 2800, 3200m), high alpine pasture zone (APZ, 3400-4400m), riparian zone (RZ, 2400-3600m) and agricultural crop land zone (ACZ, 2300-2700m) (figure 1). These five zones were further divided into eight different localities, all localities in same zone had same vegetation characteristics but with different elevation, slop and aspect. Eeach featuring transects approximately 1 km in length (500x2 m in width). These transects were further subdivided into sections (50x2 m, 125x2 m, 500x2 m) corresponding to various habitats or discrete components within a site (table 1). The transects were systematically walked once a week, with observers tallying the

number of butterflies within a predefined area measuring 5 m in width, 5 m in height, and 5 m ahead of the observer's position throughout the butterfly season. Monthly visits to all localities were carried out monthly from June 2020 to the conclusion of July 2021. However from October 2020 to March 2021, surveys were not conducted due to substantial snowfall, rendering the area inaccessible. A total of 211 specimens were collected using pitfall traps, light traps, sweep nets, and hand-picking methods (Faiz *et al.*, 2018; Ahsan *et al.*, 2019) (figure 2). The captured species were retrieved using hand nets and killed and stuffed in a cyanide bottle containing moist cotton swabs soaked in formalin to maintain humidity and minimize physical damage. Subsequently, these specimens were pinned and placed on spreading boards before being transferred to identification boxes. Each specimen was labeled with essential information, including the capture location, date of collection, family name, scientific name, collector's name, and source. Employing both national and international references, the specimens were identified at the species level (Shin and Park, 2001; Faiz *et al.*, 2018; Ahsan *et al.*, 2019).

Statistical analysis: Shannon-Wiener index, Shannon equitability, Margalef index, and Simpson index were used to determine butterfly diversity following Khan *et al.*, (2004). The shannon-Weaver diversity index was further described mathematically in the following words;

$H = \sum [pi\text{-}In\ (pi)]$

$H' = \frac{n \log n - \sum_i^k fi \log fi}{n}$ (Diversity)

$H' max = log k$ (Maximum Diversity)

$J' = \frac{H'}{H' max}$ (Evenness)

$D = 1 - J'$ (Dominance)

Where;
H = the Shannon diversity index.
Pi = fraction of the entire population made-up of species *i*,
S = number of species encountered
∑= sum from species

The local conservation status (LCS) was evaluated based on the abundance of specimens using following formula;

$$LCS = {}^{\Sigma ns}/_{\Sigma NS}\, x\ 100$$

Where;
ns= the individual count of the same species in all localities,
NS= the number of individuals of all species in all localities
(Abundance was converted into percentage, "AP"). Following Jahangeer *et al.* (2023), the local conservation status was classified into four categories: Class Abundant "A," Class Common "C," Class Becoming Rarer "BR," and Class Rare "R.

RESULTS: A total of 539 individuals belonged to 16 species and 3 families, were documented across 8 localities exhibiting diverse habitats. The Nymphalidae family demonstrated the highest species percentage (n=7, 43.75%), followed by Pieridae (n=6, 37.5%) and Papilionidae (n=3; 18.75%). Among these, *Colias erate* was recorded as the most prevalent species, accounting for the highest abundance (n=60; 11.13%) (figure 4). The highest abundance was recorded in the forest-dominated habitats, i.e. FZLI (n=91; 16.53%) followed by FZL5 (n=102; 18.92%), and FZL2 (n=73; 13.54%). Conversely, the agricultural land habitat recorded the lowest abundance (n=32; 5.56%). Furthermore, species richness was highest in the forest habitat (n=15; 93.75%), whereas the riparian zone exhibited the lowest abundance (n=8; 50%) (figure 3). The maximum value of Shannon diversity (3.77) and Simpson (0.92) was recorded in the forest zone (FZL5) while the least diversity (3.02) and Simpson (0.89) was recorded in the riparian zone (RZL2). The highest value of evenness (1.01) was recorded in the forest zone (RZL2). However, lowest value was recorded in the alpine pasture zone (APZL1) (table 2). Within the Ghamot National Park, 03 species were classified as abundant (A), while 06 were as common. However, three species were categorized as common, and one species, *Catopsila crocale*, was identified as rare (R) in the park. Notably, fourteen out of the sixteen species were designated as least concern (LC), while 02 species (*Papilio bianor* and *A. shyperbius*) were not assessed according to the IUCN Red List (2020) (table 3).

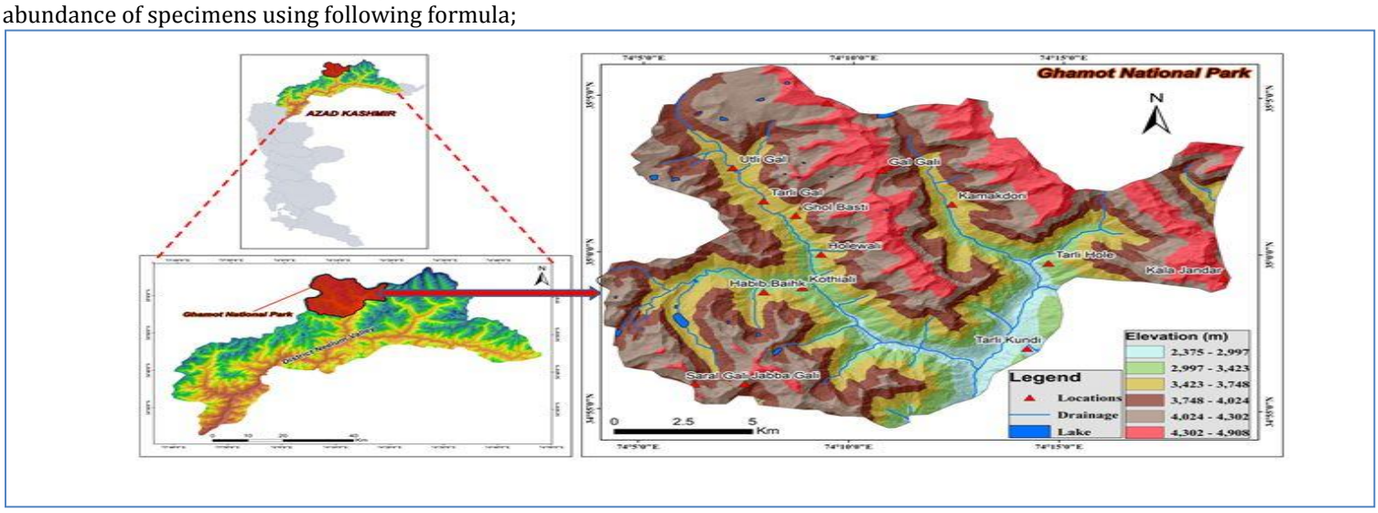

Figure 1: Location map and altitudinal variation of study area

Localities	Elevation	Coordinates		No and size of transect count walk (m)				Area covered(km)	#Specimen collected
		N	E	50X2	125x2	250x2	500x2		
Saral	2510	34°56'28.98	74°12'54.01	2	2	1	-	1.2km	23
Alif Rakh	2750	34°57'06.64	74°13'17.57	-	-	2	1	2km	38
Alihol Bhaik	3025	34°59'50.29	74°14'11.19	1	2	1	1	2.1km	16
Near Kundi village	2590	34°57'31.95	74°13'44.75	2	1	1	-	0.85km	28
Along the Surgan Nullah	2416	34°56'30.55	74°13'01.87	-	1	2	1	2.25km	41
Saral Nar	3225	35°00'00.91	74°08'59.71	1	1	-	1	1.35km	33
Saral Lake	4210	34°03'05.74	74°08'55.70	3	1	1	-	1.05km	11
Saral Bhaik	3450	35°01'29.00	74°07'47.48	5	1	-	1	1.75km	21
				14	**9**	**8**	**6**	**12.55**	**211**

Table 1: Detail of transects Count Pollard walk sampling in Ghamot National Park

Zones	Species (S)	Individuals (N)	Simpson	Shannon (H)	Evenness (J)
FZL1	11	91	0.90	3.35	0.97
FZL2	10	73	0.89	3.27	0.99
FZL5	15	102	0.92	3.77	0.97
SLZL2	12	70	0.90	3.44	0.96
SLZL3	13	74	0.91	3.61	0.98
RZL2	8	38	0.88	3.02	1.01
APZL1	12	59	0.89	3.38	0.94
ACZL1	10	32	0.89	3.29	0.99

Table 2. Recorded diversity indices of butterflies in Ghamot National Park during 2020-21
Key: Forest zone "FZ", scrubland zone "SLZ", riparian zone "RZ", Alpine zone "APZ", Agricultural crop zone "ACZ". localities "L"

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			Localities #of species observed/specimen collected								AP	Status	
Family	**Species**	**Common Name**	**FZL1**	**FZL2**	**FZL5**	**SLZL2**	**SLZL3**	**RZL2**	**APZL1**	**ACZL1**	**(%)**	**LCS**	**IUCN**
Pieridae	*Colias erate*	Pale Clouded Yellow	6	9	12	10	9	6	8	0	11.13	A	LC
	Colias fieldii	Dark clouded yellow	4	3	0	6	0	8	13	4	7.05	C	LC
	Colias electo	Clouded yellow	8	11	5	3	2	0	8	4	7.61	C	LC
	Catopsilia crocale	Lemon emigrant	0	0	2	0	3	0	3	2	1.86	R	LC
	Pontia daplidice	Bath white	2	0	2	0	6	2	3	2	3.15	BR	LC
	P. brassicae	Cabbage butterfly	4	3	7	2	0	4	0	0	3.71	BR	LC
Nymphalidae	*Fabriciana kamala*	Kamala fritillary	12	6	4	8	7	4	0	0	7.61	C	LC
	Phalanta phalantha	common leopard or spotted rustic	0	0	4	0	5	0	3	2	2.60	R	LC
	Aglais urticae	Small tortoiseshell	0	0	4	3	2	0	2	0	2.04	R	LC
	Argynnis kamala	Common Silverstripe	11	10	8	7	6	0	1	2	8.35	C	LC
	Vanessa cardui	Painted lady	0	0	2	3	5	3	2	1	2.97	R	LC
	Argynnis hyperbius	Indian fritillary	13	10	8	3	5	4	3	2	8.91	C	NE
	Danaus chrysippus	Plain tiger (Butterfly)	6	5	11	12	10	0	4	7	10.2	A	LC
Papilionidae	*Papilio machaon*	Old World swallowtail	0	0	14	2	2	0	0	0	3.34	BR	LC
	Papilio polyctor	Common peacock	9	11	8	11	0	7	9	6	11.3	A	LC
	Papilio bianor	Common peacock	16	5	11	0	12	0	0	0	8.16	C	NE

Table 3. Recorded diversity, abundance, and richness and conservation status of butterflies in Ghamot National Park during 2020-21.
Key: Forest zone "FZ", scrubland zone "SLZ", riparian zone "RZ", Alpine zone "APZ", Agricultural crop zone "ACZ", localities "L" number "1-3", Abundance percentage "AP", Local conservation status "LCS"; Abundant "A", common "C", becoming rare "BR" and International union for conservation of nature "IUCN", not elevated "NE", least concern "LC".

Figure 2: Specimen's collection in Ghomat National Park. Transect with 8 section in and around the study area (A) and Butterflies Specimens collection in Saral Locality (B).

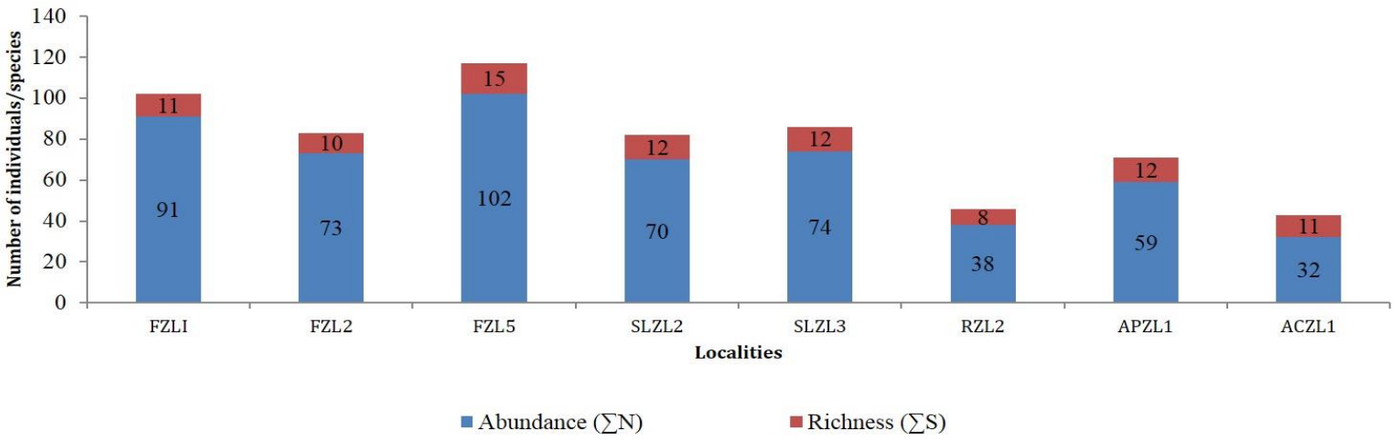

Figure 3: Recorded richness and abundance of butterfly species in Ghamot National Park during 2020-21.

DISCUSSIONS: In current study 16 species and 3 families, were documented across 8 localities exhibiting diverse habitats.The Nymphalidae family demonstrated the highest species percentage (43.75%), followed by Pieridae (37.5%) and Papilionidae (18.75%). Previous studies conducted by khan *et al*., (2015) in azad Kashmir reported Nymphalidae family with higest species richness. Among these, *Colias erate* was recorded as the most prevalent species. Butterfly diversity was evident across all habitat types, with the exception of high alpine pastures and wetlands. Forests and scrublands, however, exhibited higher diversity, as indicated by their higher Shannon-Weiner diversity index. Out of the 16 butterfly species, 11 species thrived predominantly in forest habitats, while five species were prominently present in scrublands, indicating the crucial role of these two habitats in sustaining the local butterfly community. The variation in butterfly diversity among different habitats underscored the pivotal role of heterogeneous vegetation in shaping the diversity and abundance patterns of butterfly species. The relatively lower diversity observed in high alpine pastures could be attributed to the high altitude or the significant impact of avian predation in open pasture environments. These findings support previous studies by Khan *et al.* (2000), highlighting the higher diversity in forest habitats compared to other habitats in the

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Azad kashmir region. Furthermore, Ramesh *et al.* (2012) indicated that the structural composition of habitat types correlated with insect species diversity in India. The availability of diverse vegetation, access to host plants, and the presence of attractive flowering plants were crucial factors promoting the richness and abundance of butterfly species (Akhtar *et al.*, 2015). Additionally, the scarcity of vegetation in hilly and sandy areas might contribute to the comparatively lower diversity observed in these regions. The lower butterfly diversity in agricultural land, riparian zones, and alpine pasture habitats, possibly due to human-induced activities, further underscores the impact of anthropogenic actions on local butterfly diversity (Ramesh *et al.*, 2012). The study also revealed that diversity was particularly higher around the Surgan freshwater stream and other lotic water habitats in comparison to lentic water habitats such as ponds, and swamps. These findings contrast with the observations of Seidu *et al.* (2020), who noted a dominance of isopterans in lentic ecosystems and a prevalence of zygopterans in lotic ecosystems. These findings align with previous observations made by Mehmood *et al.* (2019) and Ahsan *et al.* (2019), all of whom reported Nymphalidae as a dominant family in terms of species richness in the AJK region.

CONCLUSIONS In conclusion, the genotype Sulltan and hybrid (K54TMS × Agatti 84) were found to only absorb a minimal quantity of the metals (Cr and Pb) both separately and in combination. This suggests that they should be used in breeding programs going forward to increase the genotypes' resistance to heavy metal absorption. Also, the genotypes with high GCA values can be utilized to create synthetic varieties with high yields due to the existence of additive gene activity whereas the crosses which shown highest SCA value can be used for future breeding program for the development of hybrids for desired traits.

CONFLICT OF INTEREST: All the authors mentioned in this paper declared that they have no conflict of interest regarding this paper.

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