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Research Article

Butterfly diversity and abundance in a sub-tropical wetland environment of Shyamlatal, Western Himalaya

Aman Verma* **and Manoj Kumar Arya**

Insect Biodiversity Laboratory, Department of Zoology, D.S.B. Campus, Kumaun University, Nainital - 263002, Uttarakhand, India

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ABSTRACT

Shyamlatal, a natural rain-fed wetland located at an elevation of 1300m in Champawat District, owes its prime conservation value in the Himalayan state of Uttarakhand, India. Because there is a scarcity of data on bio-resources that are critical to ecological functioning, the present study documented the species composition and seasonal patterns in richness and abundance of butterflies for their future management and conservation in a wetland environment of the Shyamlatal. A record of 64 species and 45 genera under six butterfly families was made from the catchment area of watershed and surrounding forests surveyed during 2016 to 2018. Nymphalidae with 28 species over 45.84% of the total individuals was the most dominant taxonomic group of butterflies. Species on conservation priority were rare (17.18% species), habitat specific (18.75% species), legally protected (7.81% species) and endemic (20.31% species) butterflies of the Himalaya. The overall species richness and diversity of butterflies varied across seasons and the high similarity in butterfly composition was observed during summer and autumn. Results provided baseline information on the importance of mosaic of vegetation in sustaining rich butterfly diversity around the wetland, which must be managed and conserved for maintaining ecological health and integrity of the region. The results also revealed that human activities have negative consequences on butterfly diversity in the study area.

Key words: endemic, hill garden, Himalaya, mixed forest, seasonal index, wetland

INTRODUCTION

Wetland ecosystems formed at the juncture of terrestrial and aquatic habitats support the multitude of biota and have a high nature conservation value in safeguarding the human welfare (Xu *et al*., 2019). It has been estimated that approximately 7% of the Earth's surface area is covered by wetlands on conservation priorities, delivering an average of 45% of the global natural productivity and ecosystem services (MEA, 2005; Barbier, 2007). However, the human activities in combination with natural factors are causing worldwide decline and deterioration of wetlands at a rapid pace (Davidson, 2014). The recent spate of human encroachment on wetlands is adversely affecting their unique and complex biotic composition including insects, and posing a threat to the wetland environment (Wettstein and Schmid, 1999; Mensah *et al*., 2018). Therefore, empirical studies on bio-resources including insect diversity are important for formulating wetland restoration and conservation policies.

Butterflies (Lepidoptera: Papilionoidea) due to their strong intricate links in the food web are an important component of biodiversity in natural ecosystems (Bonebrake *et al*., 2010). The adult forms provide pollination service which is crucial for the ecological functioning (Tiple *et al*., 2006), whereas larval forms enact as primary consumers and prey to the organisms at higher trophic level, rendering dual roles of butterflies as pollinators and energy transferors (Bonebrake *et al*., 2010). Butterflies are excellent indicators to assess the ecological state and biotope quality of an environment (Launer and Murphy, 1994; Sharma *et al*., 2020), including the wetland ecosystems (Subedi *et al*., 2020; An and Choi, 2021). Many species are habitat specific and show extreme vulnerability towards habitat deterioration including changes in microclimate, vegetation structure and co-occurrence of vegetation types at a local scale (Bonebrake *et al*., 2010; Sharma *et al*., 2020). In addition to habitat types, seasonal conditions also act as key driving forces in determining the spatio-temporal patterns of butterfly species richness and diversity (Kunte, 1997; Sengupta *et al*., 2014; Sharmila *et al*., 2020). The seasonal rhythms in temperature and rainfall strongly influence the similarity and diversity of resident butterfly communities (Grøtan *et al*., 2012, 2014).

Butterflies due to short life spans, host plant specialization and restricted dispersal capability show extreme sensitivity towards fractional variation in environmental conditions and disturbance in their habitats (Kocher and Williams, 2000; Bonebrake *et al*., 2010), thus requiring robust and effective strategies for their management and conservation (Chettri *et al*., 2018; Sharma *et al*., 2020). In the last 40 years, there has been a dramatic decline of about 35% in butterfly abundance across the globe (Dirzo *et al*., 2014), and due to anthropogenic drivers of defaunation many species (about 40%) may face extinction in the next few decades

**Corresponding Author's E-mail: amanzoology187@gmail.com*

(Sánchez-Bayo and Wyckhuys, 2019). In this scenario, studies related to diversity, ecology and habitat suitability are extremely necessary for effective and proper conservation of butterflies (Sharma *et al*., 2020). Wetlands provide unique environment for those species of butterflies with narrow habitat requirements (Severns *et al*., 2006; Kyerematen *et al*., 2018), and hence have become the key areas for improving and maintaining existing levels of biodiversity (Gucel *et al*., 2012). Habitat and host plant associations render several butterflies to have strong ecological and evolutionary relationships with the wetland environment (Shuey, 1985; Subedi *et al*., 2020). Many indigenous plants around wetland serve as larval and nectar food resource for butterflies (Ansari *et al*., 2015; An and Choi, 2021). Wetlands butterflies often exist in a fine balance between the benefits of ample moisture required for good quality host plants and the high costs of egg mortality on plants inundated during seasonal flooding (Severns *et al*., 2006). Wetland butterflies also show extreme sensitivity towards non-scientific restoration and management practices (Aschehoug *et al*., 2015; Sivakoff *et al*., 2016). Therefore, any disturbance or damage to such native habitats could result in a rapid loss and extinction of butterflies (van Swaay *et al*., 2006).

Globally, the wetlands are valued as important wildlife habitats and centers of rich biodiversity (Xu *et al*., 2019). Uttarakhand, a mountainous state located in the Western Himalayan Region (2B bio-geographic zone of the Indian Himalaya) due to its ranges in topographic and climatic features is a cradle of rich bio-resources, and hosts around 508 species of butterflies (Sondhi and Kunte, 2018). On an average, 1.95% (1,039sq km) of its total geographical area is covered by wetlands (about 116 wetlands) in the form of lakes, marshes, ponds, swampy grasslands, peat bogs, streams and rivers. Of these, about 42 wetlands occurring in different elevational zones of the Kumaon and Garhwal Himalayan Divisions of Uttarakhand are under tremendous pressure from human encroachment and developmental activities, agriculture intensification, grazing, siltation, alien species invasion, eutrophication and pollution, hence need immediate conservation interventions (WoU, 2012). Among them, Shyamlatal, a natural rain-fed watershed in the Western Himalaya, is one of the three wetlands identified and prioritized for its conservation in Champawat District by the concerted efforts of the WWF-India and the Forest Department of Uttarakhand (WoU, 2012). The wetland is surrounded by sub-tropical to temperate type of vegetation and support a mosaic of environmentally sensitive habitats with human settlements. The conservation of the Shyamlatal Wetland is important as it plays a key valuable role in regulation and modification of microclimatic conditions, contributes towards retention of nutrients and helps in recharge of groundwater (WoU, 2012). The wetland also provides a crucial habitat for wildlife in the fragile Himalayan ecosystem (WoU, 2012). In this regard, scientific management and preservation of native species of butterflies will aid in the conservation of biodiversity and wetland environment. As many butterflies serve as ‘flagship taxa’ in biodiversity conservation (New, 2011), any initiative of habitat restoration and management for butterfly conservation will protect several other floral and faunal species including the ecological functioning of an area (Bonebrake *et al*., 2010; Subedi *et al*., 2020). However, till date no comprehensive attempts have been made to understand and document the bio-resources important for the functioning and maintenance of the wetland environment at Shyamlatal.

Published data on butterfly fauna from the Shyamlatal Wetland is entirely lacking. Butterflies due to their extreme ecological and scientific significance have been extensively documented from various protected and non-protected forest ecosystems of the Eastern Himalaya (Borang *et al*., 2008; Singh *et al*., 2011; Gogoi, 2012, 2013; Kunte *et al*., 2012; Majumder *et al*., 2012; Acharya and Vijayan, 2015; Chettri, 2015; Singh *et al*., 2015; Sondhi and Kunte, 2016; Dewan *et al*., 2019; Konwar and Bortamuly, 2021) and the Western Himalaya (Thakur *et al*., 2002; Singh and Bhandari, 2003, 2006; Uniyal, 2007; Kittur *et al*., 2006; Joshi, 2007; Joshi and Arya, 2007; Bhardwaj and Uniyal, 2009, 2011; Singh, 2009; Bhardwaj *et al*., 2012; Singh and Sondhi, 2016; Sondhi *et al*., 2017, 2020; Arya *et al*., 2020a,b); however, such comprehensive systematic accounts of butterfly fauna around wetlands are almost scarce (Mehta *et al*., 2002; Smetacek, 2012; Tewari and Rawat, 2013). Therefore, it is of enhanced importance to document the bio-resources from such non-target areas of conservation other than nature reserves which is a key requirement for biodiversity preservation at a regional scale (Chowdhury and Soren, 2011; Sharma *et al*., 2020).

Studies on butterflies are important from the standpoint of understanding their diversity, ecology and multiple functional roles in an ecosystem as well as in exploring the impact of disturbance and land use changes on them (Bhardwaj *et al*., 2012; Sharma *et al*., 2020). Moreover, monitoring and quantification of butterflies across seasons and habitats have strong implications in their systematic conservation planning (Bonebrake *et al*., 2010; Sharmila *et al*., 2020). Given the lack of sufficient information on taxonomic composition and diversity of butterflies, the present study aimed to quantify the species richness and abundance of butterflies from the wetland environment of the Shyamlatal which is prioritized for its conservation in the state Uttarakhand. Also, the purpose of this study was to highlight the importance of wetland habitat in sustaining butterfly diversity which should be preserved effectively and managed scientifically in the current face of biome and biodiversity crises.

MATERIALS AND METHODS

Study area

Butterfly surveys were conducted within 5km radius of the Shyamlatal Wetland, located in Champawat District of Kumaon Himalayan Division, Uttarakhand (Figure 1). Geographically, the area lies between 29°09’34.80” N latitude and 80°07’23.10” E longitude at an elevational range of 1200-1500m above sea level in the Boom Range of the Champawat Forest Division. Shyamlatal is a compound of two hindi words ‘*Shyam*’ (dark) and ‘*Tal*’ (lake), related to dark muddy color of the lake surrounded by moderately dense forested hills in a sub-tropical environment (Figure 2). It is renowned for its own cultural, religious and spiritual importance, and is revered for the Vivekanand Ashram (hermitage), established in 1915 by one of the disciple of the great spiritual saint, Swami Vivekanand. The wetland is a recreational spot and occupies a total geographical area of 3.34ha with several submerged and

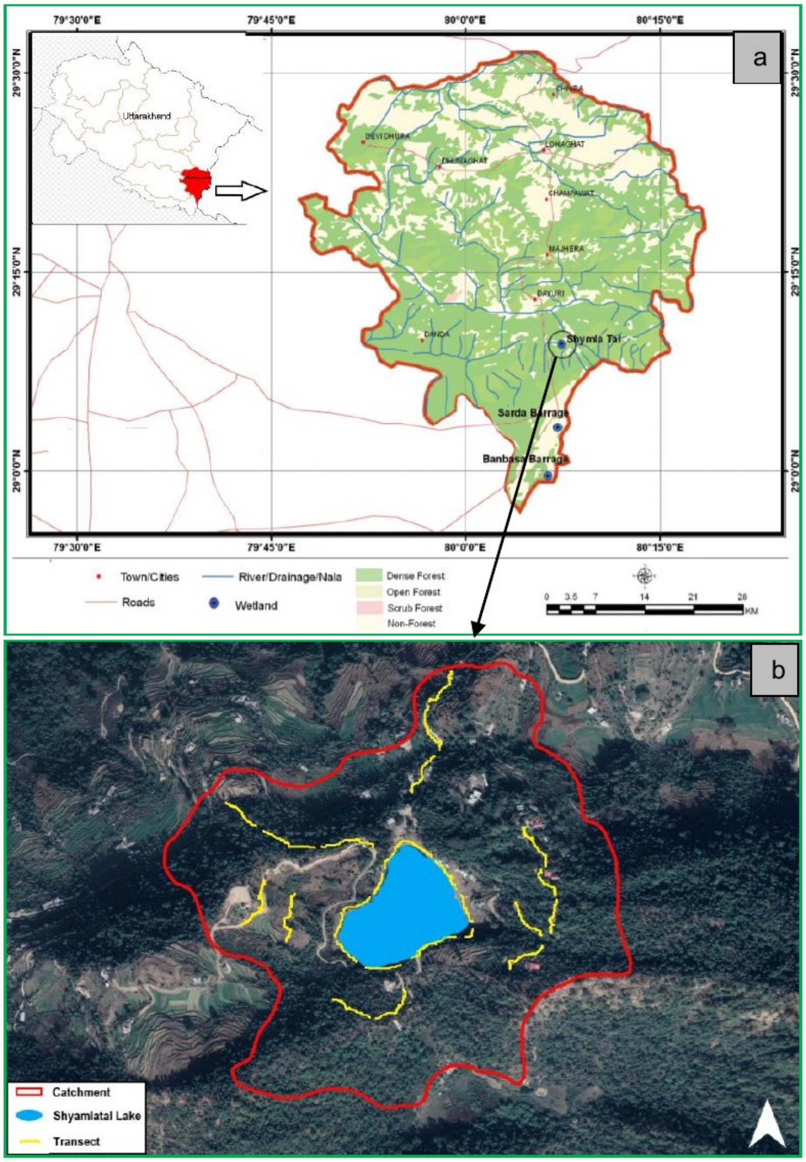

Figure 1. Geographical location of study area: (a) Shyamlatal Wetland (29°09'34.80" N latitude and 80°07'23.10" E longitude) and (b) study transects (indicated in yellow lines) in Champawat District of state Uttarakhand, India (Map data: (a) WoU, 2012; (b) Google Earth, 2020)

emergent plants (WoU, 2012). The surrounding densely forested mountains are distinguished by varieties of vegetation *viz*. Lower Shiwalik Chir Pine Forest, Upper Himalayan Chir Pine Forest and Lower Himalayan Banj Oak Forest (Champion and Seth, 1968), besides cultivated lands and human settlements. The study area experiences sub-tropical to warm temperate type of climate, and receives an annual rainfall of less than 1,100mm mainly from the south-west monsoons during mid June to mid September (WoU, 2012). The temperature ranges from a maximum of 33°C in June to a minimum of 4°C in January, and the relative humidity remains 80-87% during July-August while 40-44% during March-April. The climatic data was collected using digital thermo-hygrometer during the study period.

The study area is covered by a variety of habitats consisting diverse life supporting amenities for butterflies. The major floral vegetation around the banks of wetland include several grasses and plant species such as *Pinus roxburghii*, *Grevillea robusta*, *Quercus leucotrichophora*, *Ficus palmata*, *Ficus nemoralis*, *Flacourtia indica*, *Euphorbia pulcherrima*, *Coriaria nepalensis*, *Ageratina adenophora*, *Murraya koenigii*, *Ageratum conyzoides*, *Lantana camara*, *Cirsium wallichii*, *Agrimonia pilosa*, *Bidens pilosa*, *Gynura nepalensis*, *Tridax procumbens*, *Colebrookea oppositifolia*, *Justicia adhatoda*, *Artemisia nilagirica*, *Callicarpa arborea*, *Datura stramonium* and others. The hermitage lying

Figure 2. An image of Shyamlatal Wetland located in a sub-tropical environment of Western Himalaya

uphill in the east of Shyamlatal Lake is represented by lush green garden with many fruit trees and ornamental plants amidst chir pine (*Pinus roxburghii*) and oak (*Quercus leucotrichophora*) forests. The northern and western sides of the lake are predominantly covered with terraced lands for cultivation of agricultural crops, human habitation and a few patches of forest vegetation. The southern portion is covered with mixed forests and consists plants like *Pinus roxburghii*, *Quercus floribunda*, *Quercus leucotrichophora*, *Rhododendron arboreum*, *Myrica esculenta*, *Alnus nepalensis*, *Cornus macrophylla*, *Viburnum cotinifolium*, *Boehmeria rugulosa*, *Grewia optiva*, *Berberis asiatica*, *Berberis lycium*, *Rubus ellipticus*, *Rubus biflorus*, *Indigofera heterantha*, *Woodfordia fruticosa*, *Erigeron* spp., *Deutzia staminea*, *Flemingia strobilifera*, *Prinsepia utilis*, *Pyracantha crenulata*, *Urtica dioica*, *Blumea lacera*, *Dicliptera bupleuroides*, *Fragaria nubicola*, *Impatiens sulcata*, *Justicia procumbens*, *Oenothera rosea*, *Oxalis corniculata*, *Pilea scripta*, *Rumex hastatus*, *Viola* spp., *Hedychium spicatum*, *Trifolium repens* and others.

Sampling and identification of butterflies

For the visually estimated butterfly surveys, the study area was explored throughout four major seasonal durations *viz*. summer (March-May), monsoon (June-August), autumn (September-November) and winter (December-February), during two consecutive days in each month from August 2016 to July 2018. Twenty permanent transects (N = 20), each of 300m in length were laid in a stratified and random manner across four habitats (N = 5 each) *viz*. wetland periphery, hill garden in the hermitage, cultivation land and mixed forest available in the study area (Figure 1b). The consecutive transects in a habitat were spaced 50m apart from each other. Modified Pollard Walk Protocols were adopted for butterfly samplings in each transect (Pollard, 1977; Pollard and Yates, 1993). Individuals of adult butterflies were recorded and counted around an imaginary 5m radius while walking with a slow, constant pace in each permanent transect. Ten transects (N = 10) were covered in each sampling day, mostly during cloudless and sunny weather conditions between 08.00 to 14.00 hours in order to spot maximum butterflies (Subedi et al., 2020). The identification of butterflies was done in the field based on morphological and behavioral descriptions with reference to Evans (1932), Wynter-Blyth (1957), Haribal (1992), Kumar (2008), Kehimkar (2016), Singh (2017), Sondhi and Kunte (2018), followed by photography using DSLR Canon 750D. The food resources and disturbances affecting butterflies were also recorded during the study period. Plant species were identified with the help of taxonomists and using published information (Polunin and Stainton, 2005).

Data analysis

The taxonomic classification of butterflies was followed using Kehimkar (2016), Sondhi and Kunte (2018). The relative abundance (RA) of each individual species was calculated as a percentage by considering the total counts of each species in relation to the entire individuals counted during the study period. Such obtained values were examined under four categories *viz.* very common (RA > 2.0%), common (RA ≤ 2.0 - > 1.0%), uncommon (RA ≤ 1.0 - > 0.30%) and rare (RA ≤ 0.30%). The total individual counts were log transformed to obtain a Rank abundance plot for representing the distribution pattern of butterfly species in the study area (Magurran, 2004). In order to compare the variations in family-wise butterfly abundance trends, the seasonal index as a measure to interpret the percentage variance of mean number of butterflies in a given month in relation to the overall mean monthly sightings was calculated using the formula given by Mathew and Anto (2007):

$$\text{Seasonal index} = \text{Month} - \text{wise mean} \big/ \text{Overall mean} \times 100$$

where, month-wise mean is the mean number of butterflies for a given family sighted during the study period and overall mean is the mean of all month-wise means.

The extent of similarity in species composition across seasons was determined on the basis of single linkage Bray-Curtis cluster analysis (McAleece, 1998), using the software Bio-diversity Pro (Lambshead et al., 1997). Measures of diversity namely, Shannon's diversity index (H_s), Margalef's richness index (H_m), Simpson's dominance index (D) and Pielou's equitability index (J) were computed using the program PAST 3.04 (Hammer et al., 2001). Individual based rarefaction curves with 95% confidence intervals were constructed for each habitat (Gotelli and Colwell, 2001). A non-metric multi-dimensional scaling (NMDS) plot based on Jaccard similarity index was constructed to determine the interdependence of butterfly assemblages in different habitats of the study area. The rarefaction curves and NMDS plot were constructed by using the program PAST 3.04 (Hammer et al., 2001). Variations in overall butterfly species richness and abundance across seasons and habitats were analyzed by non-parametric one-way ANOVA tests. Pair-wise multiple comparisons based on Tukey's HSD post-hoc tests were performed at the 5% level of significance using the program SPSS.

RESULTS

During the study period (2016-18), a total of 3,246 adult individuals classified into 64 species and 45 genera under six families were recorded from the Shyamlatal Wetland, Western Himalaya (Table 1). Figures 3 to 6 show photographs of the reported butterflies from the study area. Family Nymphalidae consisted the highest number of species (43.75% species), followed by Lycaenidae (15.62% species), Pieridae (14.06% species), Hesperiidae (12.5% species), Papilionidae (10.93% species) and Riodinidae (3.12% species). Nymphalidae was again the most dominant family in terms of abundance (45.84% individuals), followed by Pieridae (26.61% individuals), Lycaenidae (11.12% individuals), Papilionidae (9.61% individuals), Hesperiidae (3.51% individuals) and Riodinidae (3.29% individuals).

The obtained plot of Rank abundance resulted in a gentle curve implying a more even distribution pattern of butterfly assemblages during the study period (Figure 7). A total of 20 species were recorded as very common, 17 species were common, 16 species were uncommon and 11 species were rare in distribution in the study area (Table 1). Butterfly species namely, *Pieris brassicae* (L.), *Papilio polytes* L., *Pieris canidia* (L.), *Danaus genutia* (C.), *Euploea core* (C.), *Callerebia hybrida* (B.), *Catopsilia pomona* (F.), *Danaus chrysippus* (L.), *Eurema laeta* (B.), and *Eurema hecabe* (L.) recorded as very common, accounted for 40% of the total individuals. On the other side, rare butterflies

Table 1. List of butterfly species with their seasonal occurrence, habitat preference, conservation status and relative abundance at the Shyamlatal Wetland, Western Himalaya

Sl. No.	Common name	Scientific name	Family	Seasonal occurrence	Habitat preference	Relative abundance	Local status
1.	Large Cabbage White	*Pieris brassicae* (Linnaeus)	Pieridae	S, M, A, W	Wt, Hg, Cl, Mf	5.39	VC
2.	Common Mormon	*Papilio polytes* Linnaeus	Papilionidae	S, M, A, W	Wt, Hg, Cl, Mf	4.83	VC
3.	Indian Cabbage White	*Pieris canidia* (Linnaeus)	Pieridae	S, M, A	Wt, Hg, Cl, Mf	4.65	VC
4.	Striped Tiger	*Danaus genutia* (Cramer)	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	3.85	VC
5.	Common Crow	*Euploea core* (Cramer)*#	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	3.78	VC
6.	Hybrid Argus	*Callerebia hybrida* (Butler)•	Nymphalidae	M, A	Wt, Hg, Cl, Mf	3.63	VC
7.	Common Emigrant	*Catopsilia pomona* (Fabricius)	Pieridae	S, M, A, W	Wt, Hg, Cl, Mf	3.63	VC
8.	Plain Tiger	*Danaus chrysippus* (Linnaeus)	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	3.57	VC
9.	Spotless Grass Yellow	*Eurema laeta* (Boisduval)	Pieridae	S, M, A, W	Wt, Hg, Cl, Mf	3.41	VC
10.	Common Grass Yellow	*Eurema hecabe* (Linnaeus)	Pieridae	S, M, A, W	Wt, Hg, Cl, Mf	3.26	VC
11.	Sorrel Sapphire	*Heliophorus sena* (Kollar)•	Lycaenidae	S, M, A, W	Wt, Hg, Cl, Mf	2.95	VC
12.	Himalayan Brimstone	*Gonepteryx nepalensis* Doubleday	Pieridae	S, M, A	Wt, Hg, Cl, Mf	2.46	VC
13.	Common Five Ring	*Ypthima baldus* (Fabricius)	Nymphalidae	S, A	Wt, Hg, Cl, Mf	2.46	VC
14.	Common Hedge Blue	*Acytolepis puspa* (Horsfield)	Lycaenidae	S, M, A, W	Wt, Hg, Mf	2.43	VC
15.	Chocolate Pansy	*Junonia iphita* (Cramer)	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	2.43	VC
16.	Ringed Argus	*Callerebia annada* (Moore)•	Nymphalidae	M, A	Wt, Hg, Cl, Mf	2.37	VC
17.	Pea Blue	*Lampides boeticus* (Linnaeus)*	Lycaenidae	S, M, A	Wt, Hg, Cl, Mf	2.18	VC
18.	Common Sailer	*Neptis hylas* (Linnaeus)•	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	2.18	VC
19.	Indian Tortoiseshell	*Aglais caschmirensis* (Kollar)•	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	2.09	VC
20.	Glassy Tiger	*Parantica aglea* (Stoll)	Nymphalidae	S, M, A	Wt, Hg, Cl, Mf	2.03	VC
21.	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus)	Pieridae	S, M, A	Wt, Hg, Cl, Mf	1.94	C
22.	Yellow Pansy	*Junonia hierta* (Fabricius)#	Nymphalidae	S, M, A, W	Wt, Hg, Mf	1.94	C
23.	Common Punch	*Dodona durga* (Kollar)•	Riodinidae	S, M, A, W	Wt, Hg, Cl, Mf	1.78	C
24.	Common Four Ring	*Ypthima huebneri* Kirby	Nymphalidae	M, A	Wt, Hg, Cl, Mf	1.78	C
25.	Indian Red Admiral	*Vanessa indica* (Herbst)	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	1.72	C
26.	Dark Clouded Yellow	*Colias fieldii* Menetries	Pieridae	S, M, A	Wt, Hg, Mf	1.66	C
27.	Lime Butterfly	*Papilio demoleus* Linnaeus	Papilionidae	S, M, A	Wt, Hg, Cl	1.60	C
28.	Punchinello	*Zemeros flegyas* (Cramer)	Riodinidae	S, M, A	Wt, Hg, Mf	1.50	C
29.	Painted Lady	*Vanessa cardui* (Linnaeus)	Nymphalidae	S, A	Wt, Hg, Cl, Mf	1.29	C
30.	Lemon Pansy	*Junonia lemonias* (Linnaeus)	Nymphalidae	S, M, A, W	Wt, Hg, Cl, Mf	1.17	C
31.	Common Castor	*Ariadne merione* (Cramer)	Nymphalidae	S, M	Wt, Hg	1.13	C
32.	Common Sergeant	*Athyma opalina* (Linnaeus)•	Nymphalidae	S, A	Hg, Mf	1.13	C
33.	Common Blue Bottle	*Graphium sarpedon* (Linnaeus)	Papilionidae	S, M, A	Wt, Mf	1.13	C
34.	Peacock Pansy	*Junonia almana* (Linnaeus)#	Nymphalidae	S, A	Wt, Hg, Cl	1.04	C
35.	Blue Pansy	*Junonia orithya* (Linnaeus)	Nymphalidae	S, M, A	Wt, Hg, Mf	1.04	C
36.	Common Peacock	*Papilio bianor* Boisduval	Papilionidae	M, A	Hg, Mf	1.04	C
37.	Pale Grass Blue	*Pseudozizeeria maha* (Kollar)	Lycaenidae	S, A, W	Wt, Mf	1.01	C
38.	Indian Fritillary	*Argynnis hyperbius* (Linnaeus)	Nymphalidae	S, A	Hg, Mf	0.98	UC
39.	Common Bush Brown	*Mycalesis perseus* (Fabricius)	Nymphalidae	S, A	Wt, Hg, Cl, Mf	0.95	UC
40.	Straight Swift	*Parnara guttatus* (Bremer & Grey)	Hesperiidae	S, M, A, W	Wt, Hg, Cl, Mf	0.95	UC

Table 1 continued in next page

41.	Spotted Snow Flat	*Tagiades menaka* (Moore)	Hesperiidae	S, A	Wt, Hg	0.92	UC
42.	White Bordered Copper	*Lycaena panava* (Westwood)•	Lycaenidae	S	Hg, Mf	0.77	UC
43.	Bevan's Swift	*Borbo bevani* (Moore)	Hesperiidae	S, A	Wt, Cl	0.73	UC
44.	Common Map	*Cyrestis thyodamas* Boisduval	Nymphalidae	S, M	Wt, Hg, Mf	0.73	UC
45.	Tailed Cupid	*Everes argiades* Chapman*•	Lycaenidae	S, M, A	Hg, Mf	0.73	UC
46.	Common Jester	*Symbrenthia lilaea* (Hewitson)	Nymphalidae	S, M	Wt, Hg, Mf	0.70	UC
47.	Large Hedge Blue	*Celastrina huegelii* (Moore)•	Lycaenidae	S, A	Mf	0.61	UC
48.	Banded Tree-brown	*Lethe confusa* Aurivillius	Nymphalidae	S, M	Wt, Hg, Cl	0.58	UC
49.	Common Tree-brown	*Lethe rohria* (Fabricius)	Nymphalidae	M	Wt, Hg, Mf	0.49	UC
50.	Spangle	*Papilio protenor* Cramer	Papilionidae	S, M	Hg, Mf	0.46	UC
51.	Small Branded Swift	*Pelopidas mathias* (Fabricius)	Hesperiidae	S, M, A	Wt	0.43	UC
52.	Striped Blue Crow	*Euploea mulciber* (Cramer)*	Nymphalidae	S, M	Hg, Mf	0.40	UC
53.	Paris Peacock	*Papilio machaon* Linnaeus*	Papilionidae	S, A	Hg, Mf	0.40	UC
54.	Pale Clouded Yellow	*Colias erate* (Esper)	Pieridae	S	Wt	0.18	R
55.	Restricted Demon	*Notocrypta curvifascia* (Felder & Felder)	Hesperiidae	S, A	Hg	0.18	R
56.	Forget-me-not	*Catochrysops strabo* (Fabricius)	Lycaenidae	S	Hg	0.15	R
57.	Common Leopard	*Phalanta phalantha* (Drury)	Nymphalidae	M	Wt	0.15	R
58.	Common Acacia Blue	*Surendra quercetorum* (Moore)	Lycaenidae	A	Wt	0.15	R
59.	Common Rose	*Pachliopta aristolochiae* (Fabricius)#	Papilionidae	S, A	Wt, Cl	0.12	R
60.	Golden Sapphire	*Heliophorus brahma* (Moore)•	Lycaenidae	S	Wt	0.09	R
61.	Common Evening Brown	*Melanitis leda* (Linnaeus)	Nymphalidae	S	Cl	0.09	R
62.	Himalayan Dart	*Potanthus dara* (Kollar)•	Hesperiidae	M	Mf	0.09	R
63.	Yellow-spot Swift	*Polytremis eltola* (Hewitson)	Hesperiidae	S	Hg	0.09	R
64.	Spotted Small Flat	*Sarangesa purendra* Moore•	Hesperiidae	S	Mf	0.09	R

Note: * represents legally protected species under the Indian Wildlife (Protection) Act (Anonymous, 2006); # indicates 'Least Concerned' species under the Red List of IUCN (2020); • represents endemic species of the Himalaya (Evans, 1932; Wynter-Blyth, 1957; Smetacek, 2012); Seasons – S = Summer, M = Monsoon, A = Autumn, W = Winter; Habitats – Wt = Wetland, Hg = Hill garden, Cl = Cultivated land, Mf = Mixed forest; Local status in the study area as per recorded relative abundance – VC = Very common, C= Common, UC= Uncommon, R = Rare

namely, *Sarangesa purendra* M., *Polytremis eltola* (H.), *Potanthus dara* (K.), *Melanitis leda* (L.), *Heliophorus brahma* (M.), *Pachliopta aristolochiae* (F.), *Surendra quercetorum* (M.), *Phalanta phalantha* (D.), *Catochrysops strabo* (F.), *Notocrypta curvifascia* (F. & F.), and *Colias erate* (E.) constituted 1.38% of the total individuals recorded in the study area.

Figure 8 shows the calculated values of seasonal index which is a measure to provide a better understanding on the temporal changes in the butterfly abundance of different families in the study area. The seasonal index values for the Nymphalids were almost similar in the months of May-August of the study period, highest during September and then declined sharply till the end of January. Butterflies of the family Pieridae were at their highest abundance during April, and then followed a declining pattern until the end of June. The second peak of abundance was observed during August. The seasonal index for the family Lycaenidae showed that the abundance was at its peak during the month of May, and then declined till June. The abundance started building from the onset of the monsoon season and peaked during August, then declined moderately till October. Among the family Papilionidae, the seasonal index was highest during August, and decreased rapidly from mid-October until the end of January. The second peak of abundance was observed in April. The seasonal index for the Riodinidae family showed the nil value in January and was high during September-October. Similarly, the seasonal index for the family Hesperiidae was nil during December-January and peaked during September-October, then declined sharply until November.

The one-way ANOVA analysis showed that the total species richness and abundance of butterflies varied significantly across the four main seasons (Species richness: $F = 17.512$ and $P < 0.005$; Species abundance: $F = 6.431$ and $P < 0.005$). The species richness and abundance was significantly low during winter in comparison to summer, autumn and monsoon seasons (Figure 9).

Margalef's richness value during the summer season ($H_m = 8.56$), followed by autumn ($H_m = 7.78$), and monsoon ($H_m = 7.13$), while the least value was obtained in the winter season ($H_m = 4.88$). On the other hand, Shannon's diversity was more or less similar

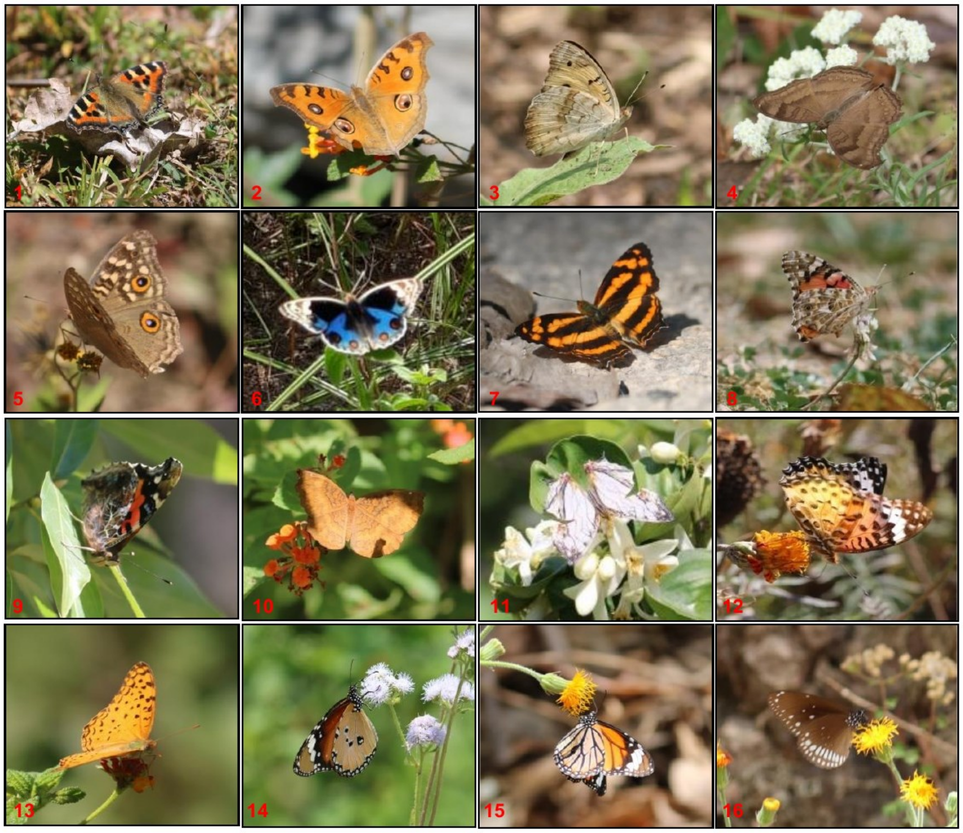

Figure 3. Images of butterflies recorded from the Shyamlatal Wetland, Western Himalaya. Nymphalidae: (1) *Aglais caschmirensis*, (2) *Junonia almana*, (3) *Junonia hierta*, (4) *Junonia iphita*, (5) *Junonia lemonias*, (6) *Junonia orithya*, (7) *Symbrenthia lilaea*, (8) *Vanessa cardui*, (9) *Vanessa indica*, (10) *Ariadne merione*, (11) *Cyrestis thyodamas*, (12) *Argynnis hyperbius*, (13) *Phalanta phalantha*, (14) *Danaus chrysippus*, (15) *Danaus genutia*, (16) *Euploea core*. Photographs by AV

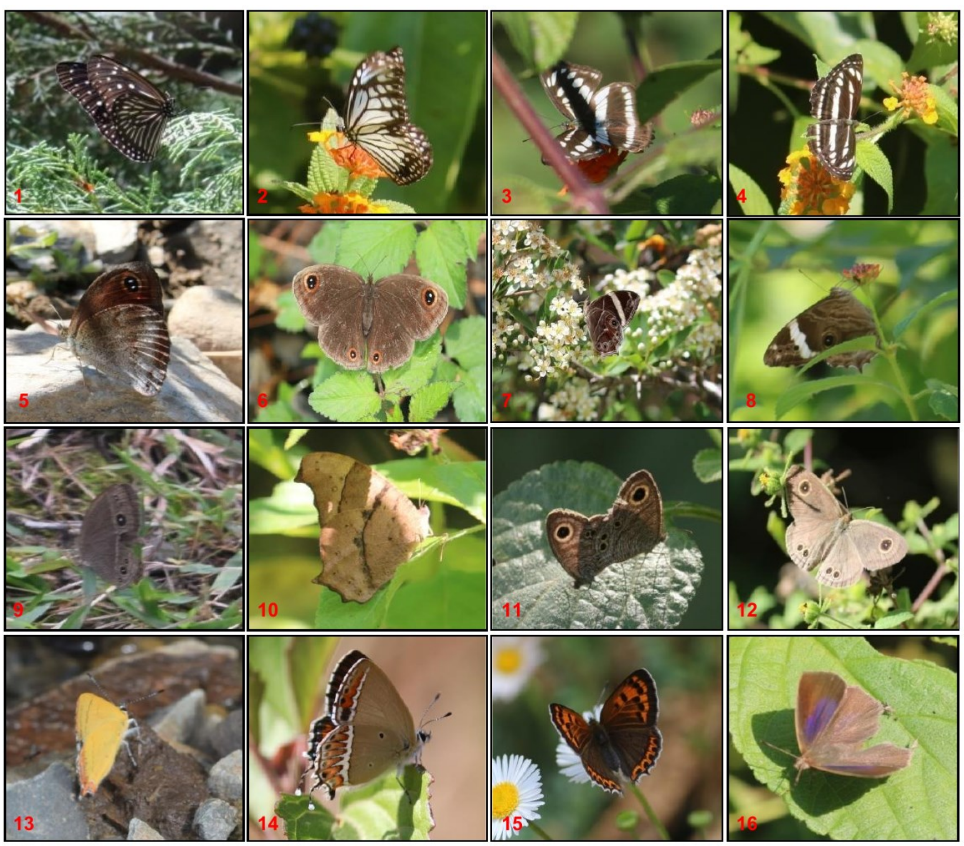

Figure 4. Images of butterflies recorded from the Shyamlatal Wetland, Western Himalaya. Nymphalidae: (1) *Eupolea mulciber*, (2) *Parantica aglea*, (3) *Athyma opalina*, (4) *Neptis hylas*, (5) *Callerebia annada*, (6) *Callerebia hybrida*, (7) *Lethe confusa*, (8) *Lethe rohria*, (9) *Mycalesis perseus*, (10) *Melanitis leda*, (11) *Ypthima baldus*, (12) *Ypthima huebneri*, Lycaenidae: (13) *Heliophorus brahma*, (14) *Heliophorus sena*, (15) *Lycaena panava*, (16) *Surendra quercetorum*. Photographs by AV

Figure 5. Images of butterflies recorded from the Shyamlatal Wetland, Western Himalaya. Lycaenidae: (1) *Acytolepis puspa*, (2) *Catochrysops strabo*, (3) *Celastrina huegelii*, (4) *Everes argiades*, (5) *Lampides boeticus*, (6) *Pseudozizeeria maha*, Pieridae: (7) *Catopsilia pomona*, (8) *Catopsilia pyranthe*, (9) *Colias erate*, (10) *Colias fieldii*, (11) *Eurema hecabe*, (12) *Eurema laeta*, (13) *Gonepteryx nepalensis*, (14) *Pieris brassicae*, (15) *Pieris canidia*, Papilionidae: (16) *Graphium sarpedon*. Photographs by AV

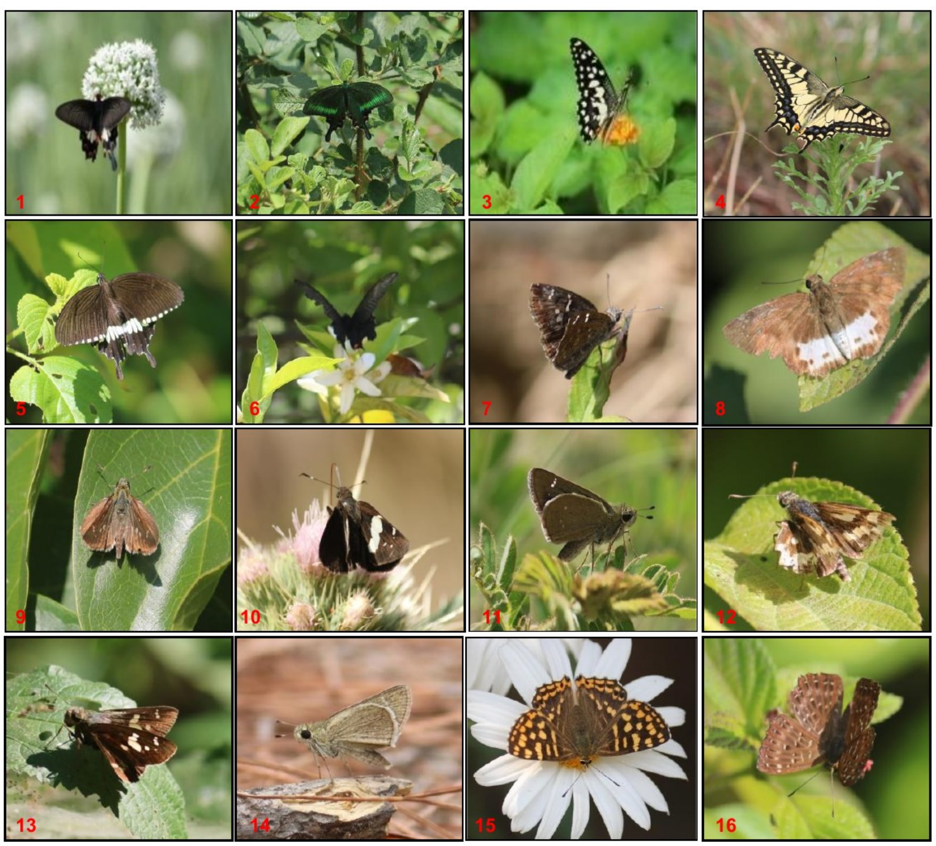

Figure 6. Images of butterflies recorded from the Shyamlatal Wetland, Western Himalaya. Papilionidae: (1) *Pachliopta aristolochiae*, (2) *Papilio bianor*, (3) *Papilio demoleus*, (4) *Papilio machaon*, (5) *Papilio polytes*, (6) *Papilio protenor*, Hesperiidae: (7) *Sarangesa purendra*, (8) *Tagiades menaka*, (9) *Borbo bevani*, (10) *Notocrypta curvifascia*, (11) *Parnara guttatus*, (12) *Potanthus dara*, (13) *Polytremis eltola*, (14) *Pelopidas mathias*, Riodinidae: (15) *Dodona durga*, (16) *Zemeros flegyas*. Photographs by AV

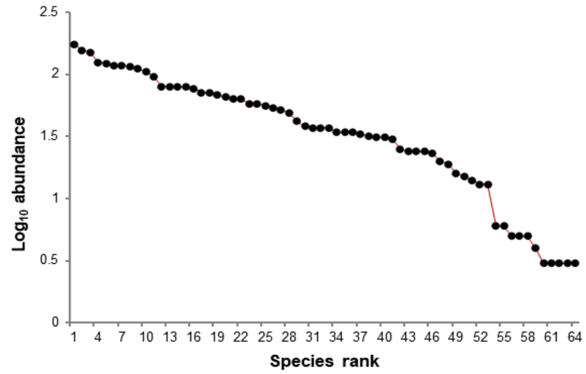

Figure 7. Rank abundance curve of butterfly species recorded in the study area during 2016-18. Species rank corresponds with the numbers of butterfly species listed in Table 1

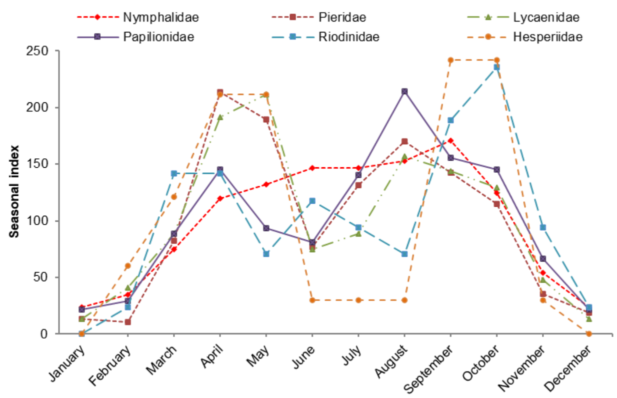

Figure 8. Calculated values of seasonal index for different butterfly families in the study area during 2016-18

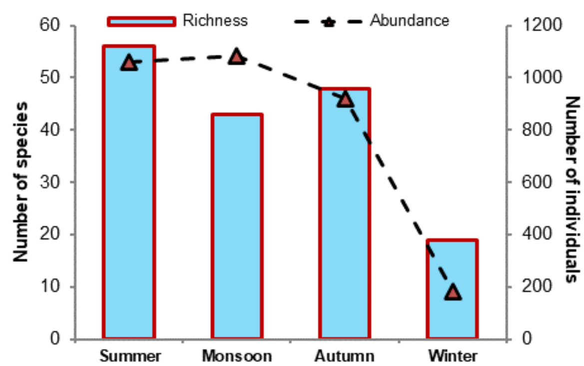

Figure 9. Total species richness and abundance of butterflies recorded across seasons in the study area

during the summer, autumn and monsoon seasons (H_s = 3.73, 3.68 and 3.62; respectively) while the lowest value was observed in the winter season (H_s = 2.89).

The single linkage cluster analysis depicted that the percentage similarity of butterfly assemblages was highest in summer and autumn (82.69%), forming a single cluster with the monsoon season at 74.72% (Figure 10). Butterfly assemblages in winter were highly dissimilar and showed similarity linkage at 58.06%.

The individual rarefaction curves were asymptotic, showing sufficient sampling efforts to differentiate butterfly assemblages each habitat (Figure 11). The

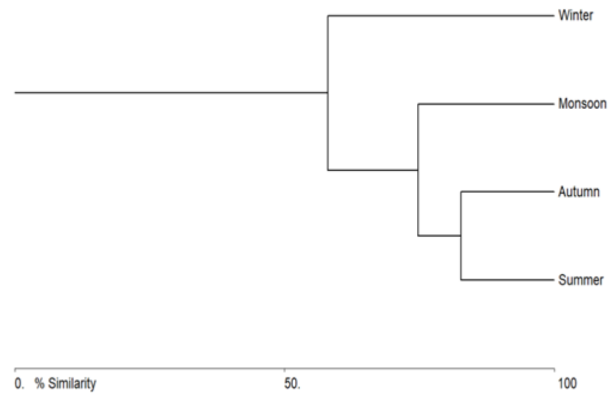

Figure 10. Dendrogram showing similarity of butterfly assemblages across seasons in the present study based on single linkage Bray-Curtis cluster analysis. Distance between nodes of clusters represents dissimilarity of butterfly assemblages

overlapping curves between hill garden, wetland and mixed forest indicated no significant difference of species richness in these habitats. The overall species richness in cultivation land was significantly low than in the other habitats (ANOVA: F = 5.280 and P = 0.008), while the abundance of butterflies showed insignificant differences (ANOVA: F = 2.483 and P = 0.090). Figure 12 shows the pattern of species richness and abundance of butterflies recorded in different habitats of the study area.

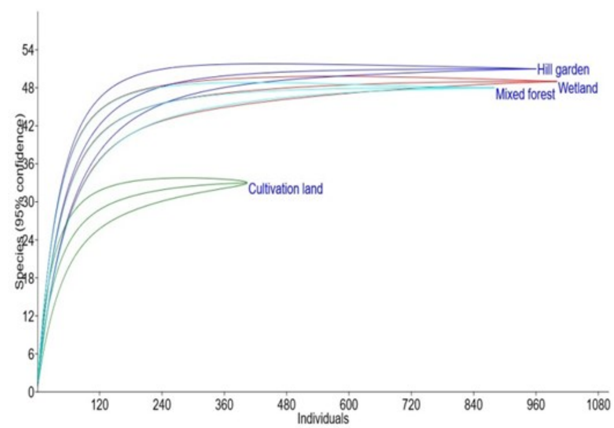

Figure 11. Individual-based rarefaction curves with 95% confidence intervals in different habitats of the study area

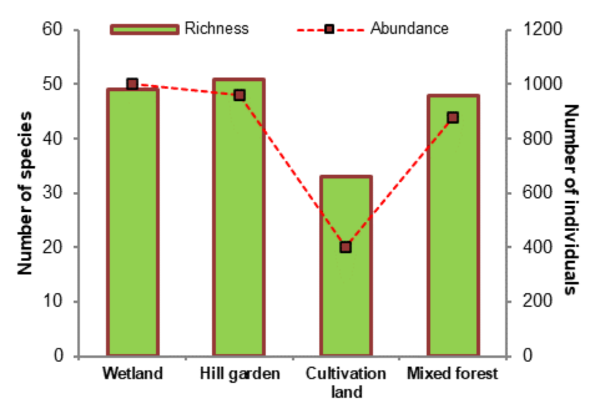

Figure 12. Total species richness and abundance of butterflies recorded in different habitats of the study area

Table 2. Variation in diversity indices of reported butterflies across habitats in the study area during 2016-18

Diversity measures	Wetland	Hill garden	Cultivation land	Mixed forest	Overall
Shannon (H_s)	3.720	3.755	3.090	3.695	3.816
Margalef (H_m)	6.949	7.281	5.332	6.932	7.792
Simpson (D)	0.973	0.973	0.930	0.971	0.973
Pielou's equitability (J)	0.955	0.955	0.883	0.954	0.917

Habitats namely, hill garden, wetland and mixed forest had the highest diversity and richness, while cultivation land showed least values (Table 2). Shannon's diversity (H_s = 3.816), Margalef's richness (H_m = 7.792) and Simpson's dominance (D = 0.973) were high in the study area.

Butterfly species composition in hill garden and mixed forest resembled each other, while wetland showed unique composition (Figure 13). Cultivation land with human settlements showed high dissimilarity of butterfly composition in the study area. Twenty seven species were found across all habitats, while 12 species were habitat specific (Table 1). Species such as *Pelopidas mathias* (F.), *Colias erate* (E.), *Phalanta phalantha* (D.), *Surendra quercetorum* (M.), *Heliophorus brahma* (M.) were unique to the wetland habitat, *Notocrypta curvifascia* (F. & F.), *Catochrysops strabo* (F.), *Polytremis eltola* (H.) were unique to the hill garden, *Celastrina huegelii* (M.), *Potanthus dara* (K.), *Sarangesa purendra* M. were unique to the mixed forest, and *Melanitis leda* (L.) was found unique to the cultivation land in the study area.

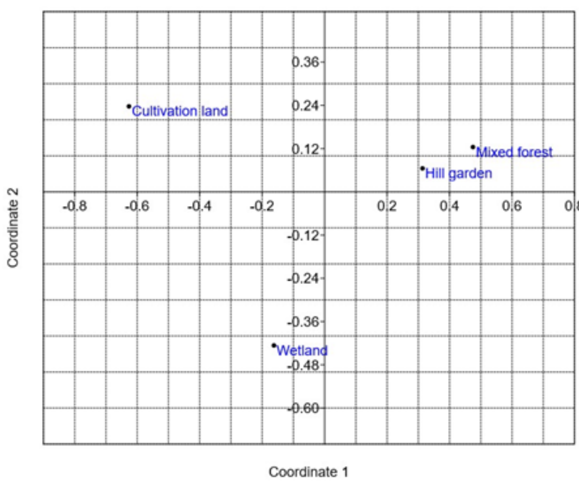

Figure 13. Non-metric multi-dimensional scaling (NMDS) plot based on Jaccard similarity index for butterfly assemblages in different habitats of the study area

Five species are listed under different schedules of the Indian Wildlife (Protection) Act 1972 (Table 1). Species namely, *Everes argiades* C., *Lampides boeticus* (L.), *Papilio machaon* L. are legally protected under Schedule II, whereas *Euploea core* (C.) and *Euploea mulciber* (C.) are legally protected under Schedule IV of the act. As per the IUCN Red list of Threatened Species, none of the reported butterfly is endangered or threatened globally. Thirteen species have their global distribution restricted to the Indian Himalayan Region (Table 1). Of these, four species namely, *Callerebia hybrida* (B.), *Sarangesa purendra* M., *Potanthus dara* (K.) and *Lycaena panava* (W.) are endemic butterflies of the Western Himalaya.

DISCUSSION

Although the Shyamlatal Wetland has recently received the attention of conservation planners and managers, our preliminary investigations emphasize the importance of varied ecological conditions and mosaic of vegetation in sustaining a rich diversity of butterfly fauna in the wetland environment. About 40.62% species that include rare (11 species), habitat specific (12 species), legally protected (5 species) and Himalayan endemic (13 species) are the important species of butterflies from the standpoint of their conservation at the Shyamlatal Wetland. Butterfly richness in the study area accounted for 23.86% of the total known species (243 species) during the years 1951 to 2010 from a nearby dying watershed of Jones Estate in Nainital District of the Kumaon Himalaya (Smetacek, 2012). The reported butterflies namely, *Tagiades menaka* (M.), *Borbo bevani* (M.), *Parnara guttatus* (B. & G.), *Potanthus dara* (K.), *Heliophorus brahma* (M.) and *Surendra quercetorum* (M.) were not present in the provided checklist of species from the Jones Estate in Western Himalaya. Moreover, the asymptotic individual based rarefaction curves provided an indication for addition of more species with increased samplings in the study area. In comparison to studies on butterfly diversity around wetland ecosystems, Subedi et al (2020) recorded 138 butterfly species from the Rupa Wetland of Nepal in the Central Himalaya. Sarath et al (2017) documented 58 species from the Kole Wetlands, a Ramsar Site in Kerala. Ansari et al (2015) documented 53 species from the Surajpur, an urban wetland in Gautam Budh Nagar District of Uttar Pradesh. Murugesan et al (2013) recorded 63 butterfly species from the Oussudu Bird Sanctuary, an urban wetland in Puducherry. Tewari and Rawat (2013) reported 28 species of butterflies from the Jhilmil Jheel Conservation Reserve, a marshy wetland in the Gangetic plains of the Garhwal Himalayan Range, Uttarakhand. Chowdhury and Soren (2011) reported 74 species from the East Calcutta Wetlands, a Ramsar Site in West Bengal. Mehta et al (2002) reported 50 species from the Pong Dam Wetland in Himachal Pradesh, Western Himalaya.

The species richness in the present study area was also high as compared to that of records from different regions of the Himalaya such as Kalatop-Khajjiar Wildlife Sanctuary (49 species reported by Thakur et al., 2002), Motichur Sanctuary of the Rajaji National Park (40 species reported by Joshi, 2007), Pindari area of the Nanda Devi Biosphere Reserve (54 species reported by Joshi and Arya, 2007), Allain-Duhaingain catchment in Kullu (40 species reported by Bhardwaj and Uniyal, 2009), Gangotri National Park (34 species reported by Bhardwaj and Uniyal, 2011), Trishna Wildlife Sanctuary (59 species reported by Majumder et al., 2012), Corbett Tiger Reserve (56 species reported by Arya et al., 2020a) and Binsar Wildlife Sanctuary (46 species reported by Arya et al., 2020b).

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The study area has fairly lower species richness in comparison to known records of 340 species in the Pakke Tiger Reserve of Arunachal Pradesh (Sondhi and Kunte, 2014), 298 species in the Garo Hills of Meghalaya (Kunte et al., 2012), 294 species in the Dibang Valley of Arunachal Pradesh (Gogoi, 2012), 292 species in the Jeypore Reserve Forest of Assam (Gogoi, 2013), 211 species in the Gibbon Wildlife Sanctuary of Assam (Singh et al., 2015), 189 species in the Kangchendzonga Biosphere Reserve of Sikkim (Chettri, 2015), 183 species in the Dehradun Valley of Uttarakhand (Singh and Bhandari, 2003, 2006), 143 species in the Kedarnath Musk Deer Reserve of Uttarakhand (Singh, 2009), 134 species in the Dihang Dibang Biosphere Reserve of Arunachal Pradesh (Borang et al., 2008), 117 species in the Keibul Lamjao National Park of Manipur (Singh et al., 2011), 111 species in the Kitam Bird Sanctuary of Sikkim (Dewan et al., 2019), 79 species in the Tons Valley of Garhwal Himalaya (Bhardwaj et al., 2012), 75 species in the Great Himalayan Conservation Landscape of Himachal Pradesh (Uniyal, 2007) and 70 species in the Simbalwara Wildlife Sanctuary of Himachal Pradesh (Kittur et al., 2006).

Taxonomic composition of butterflies in the study area comprising high species richness of the Nymphalids corroborated with the pattern that has also been recorded from various nature reserves of the Himalaya (Kittur et al., 2006; Joshi, 2007; Uniyal, 2007; Borang et al., 2008; Singh, 2009; Singh et al., 2011; Bhardwaj et al., 2012; Sondhi and Kunte, 2014; Chettri, 2015; Singh et al., 2015; Singh and Sondhi, 2016; Dewan et al., 2019; Arya et al., 2020a,b), and wetland ecosystems in India (Mehta et al., 2002; Smetacek, 2012; Murugesan et al., 2013; Ansari et al., 2015; Sarath et al., 2017) and Nepal (Subedi et al., 2020). The high dominance of the Nymphalids with 43.75% of the total recorded species was might be due to their polyphagous nature and large wingspan rendering them as strong active fliers for maneuvering a number of niches in the habitat (Majumder et al., 2012; Subedi et al., 2020).

The pattern of high diversity, richness and similarity during pre-monsoon (summer) and post-monsoon (autumn) seasons in the study area is in concordance with previous findings on butterfly seasonality from the regions experiencing tropical to sub-tropical type of climate in India (Kunte, 1997; Padhye et al., 2006; Sengupta et al., 2014; Gupta et al., 2019; Arya et al., 2020a; Sharmila et al., 2020; Bhowmik and Chowdhury, 2021). In tropical regions, annual patterns of precipitation have a significant impact on butterfly communities (Valtonen et al., 2013), and the occurrence of dry-wet seasonal cycles influence the host plant dynamics and generate bi-annual rhythms in species diversity and similarity of butterfly communities (Grøtan et al., 2012, 2014). The temporal changes in butterfly diversity and abundance of a region are caused due to seasonal fluctuations in climatic and ecological conditions such as temperature, photoperiod, humidity, precipitation, adequate food resource availability, vegetation cover and presence of natural enemies (Kunte, 1997; Grøtan et al., 2012; Valtonen et al., 2013; Sharmila et al., 2020). In India, the monsoons promote increase in foliage cover and density, and have a profound effect on seasonal occurrence of butterflies (Wynter-Blyth, 1957). The young tender leaves in ample quantity stimulated by high rainfall provide better quality food for larvae and thus result in peak abundance of butterflies during monsoons (Kunte, 1997; Sengupta et al., 2014).

Amongst the sampled habitats, cultivation land showed least richness and high dissimilarity of butterfly species composition in the study area. Reduced vegetation cover, constant human interferences, increased land use for raising agricultural and vegetable crops, and infrastructure development are the responsible factors for the observed low diversity and richness of butterflies in the cultivation land. Butterfly species of the genus *Pieris* which feed on vegetable crops dominated this habitat. On the other hand, the prevalence of complex vegetation with pre-dominance of dense chir pine-oak forests resulted in a high species diversity and similarity of butterflies across hill garden and mixed forest in the study area. These habitats shared many plants which are important larval food resource for a number of butterflies common to the both habitats. Nectar resources that include several ornamental plants such as *Cosmos bipinnatus*, *Anthemis punctata*, *Dahlia pinnata*, *Tagetes erecta*, *Duranta repens*, fruit crops such as *Citrus* spp., *Psidium guajava*, *Prunus persica*, *Pyrus pashia* and wild native plants such as *Viburnum cotinifolium*, *Anaphalis contorta*, *Erigeron* spp., *Pyracantha crenulata*, *Berberis* spp., *Elaeagnus umbellata*, *Trifolium repens*, *Micromeria biflora*, *Salvia leucantha* attracted many butterflies in the lush green hill garden and adjacent mixed forest. These results are similar to those studies reporting more butterflies in forest habitats compared to areas disturbed or altered by human activities (Bhardwaj et al., 2012; Arya et al., 2020a; Bohra and Purkayastha, 2021), while few studies have also reported the converse of this pattern (Chettri, 2015; Mukherjee and Mondal, 2020; Koirala et al., 2020).

Wetland in the forest edge habitat provided more heterogeneous ecological conditions to butterflies in form of unique vegetation, provisioning of basking sites with higher sunshine and grassland area with puddling sites around the periphery of the lake. Several free ranging butterflies frequently visited the wetland in search of grounds required for their feeding, resting, mating and breeding. The availability of diverse essential resources around the periphery of the lake including the high numbers of nectar plants such as *Ageratum conyzoides*, *Ageratina adenophora*, *Cirsium wallichii*, *Lantana camara*, *Tridax procumbens*, *Bidens pilosa*, *Blumea lacera*, *Gynura nepalensis* and *Crassocephalum crepidioides* render the wetland as a prime habitat for butterfly conservation in the study area. The members of the family Hesperiidae mainly feed on grasses, bamboos and other species of Poaceae (Sondhi and Kunte, 2018), which were common around the wetland. The close association of the reported Hesperiids such as *Borbo bevani* (M.), *Parnara guttatus* (B. & G.), *Pelopidas mathias* (F.), *Potanthus dara* (K.) with host plants like *Imperata cylindrica*, *Saccharum* spp., *Sorghum* spp., *Paspalum conjugatum*, *Axonopus compressus*, *Cynodon dactylon*, *Brachiaria reptans* in the grassland around the lake periphery makes them susceptible to minor perturbations in the wetland habitat. The overall findings across habitats in the study area are similar with previous observations from different Himalayan regions suggesting high butterfly diversity associated with landscape heterogeneity (Bhardwaj et al., 2012; Sengupta et al., 2014; Acharya and Vijayan, 2015; Chettri et al., 2018; Mukherjee and Mondal, 2020). Besides high plant species diversity that constitutes a large source of food for larval and adult forms, the connectivity between different habitats and dispersal abilities of individual species are also the factors of great importance in determining the diversity and abundance patterns of butterflies in the study area.

Disturbance around wetlands affects butterfly communities (Cabette et al., 2017; An and Choi, 2021). The agricultural expansion and intensification, increased dependence on forest resources, overgrazing by cattle in grassland and forest around the lake, lopping and logging of forest trees, constructions leading to deforestation, discharge of domestic garbage and waste are among the observed threats to the wetland environment and may cause a shift in relative abundance and diversity of butterflies in the study area. These disturbances are degrading habitat quality and adversely affecting food resources of butterflies which in turn have the potential of accelerating declines in their taxonomic compositions. Loss of wetland area and surrounding forest could be detrimental for the butterflies on the highest conservation priority in the study area. Many butterflies with a narrow range of host specialization and habitat utilization show extreme vulnerability towards changes that affect their host plants (Aschehoug et al., 2015; Sivakoff et al., 2016; Chettri et al., 2018; Sharma et al., 2020). The availability of food plants in non-inundated areas during seasonal flooding is crucial for the conservation of wetland butterflies (Severns et al., 2006). Conservation of butterfly diversity in the study area is extremely important as they are essential component for integrating many ecological functions including hydrologic and geomorphic aspects crucial for the functioning of wetland ecosystems (Nelson, 2007), and as the nectar resource production is related to groundwater levels, detecting changes in butterfly composition could signal a higher potential for their use as indicative taxa for monitoring ecological health of the wetland environment (Smetacek, 2012; An and Choi, 2021). Notably, the Common Peacock Butterfly (*Papilio bianor* B.) which was recorded as a common species can be used as a ‘flagship taxa’ for biodiversity conservation programs in the study area, as the species due to its charismatic appearance and ecological importance was recently designated as the ‘State Butterfly of Uttarakhand’ (Sondhi and Kunte, 2018).

CONCLUSION

Though the study area provides better life supporting necessities to butterfly fauna, declines in environmental quality due to human activities could have negative impacts on their diversity, potentially affecting the butterflies having close associations with their host plants in diverse natural habitats. The occurrence of rich diversity including several rare, habitat specific, legally protected and endemic butterfly species of the Himalaya increased the conservation value and wildlife status of the Shyamlatal Wetland. Such rich butterfly diversity must be protected for ecological integrity, and it is strongly recommended that the study area must be declared as an *in-situ* conservation zone for the preservation of butterfly fauna and wetland environment. The cultivation and management of native food plants around the watershed and in conspicuous locations would help in the proliferation of butterflies and restoration of the natural wetland. The wetland also holds the potential for butterfly eco-tourism, and offers an opportunity for promoting public awareness and conservation programs. Future monitoring and research is required to observe any change in the species composition of butterflies from the Shyamlatal Wetland.

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