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Biodiversity Assessment of Butterflies in Kumaun Lesser Himalayan Oak Forest for Promoting Ecotourism at City Nainital

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ABSTRACT

Butterflies have long fascinated humans and portrayed as an important element from ecotourism point of view. In the present study, a foot trail lying in an unprotected temperate forest was assessed based on seasonal data on distribution of butterfly fauna to generate impetus for 'Butterfly Ecotourism' in the city Nainital located in Kumaun Himalaya of Uttarakhand. Field surveys conducted from June, 2017 to April, 2018 downhill up to 5 km in the forest along the walking trail revealed the presence of 42 species of butterflies under six families and six species of the total recorded species protected legally under Indian Wildlife (Protection) Act, 1972. Family Nymphalidae with 17 species of the total recorded species was found dominating in the study area, followed by Pieridae (ten species), Lycaenidae (six species), Papilionidae (four species), Riodinidae (three species) and Hesperidae (two species), respectively. Database relating to seasonal pattern in abundance of butterflies indicates that there was no significant difference of species count in during three periods of observations: spring, rainy and autumn seasons; however abundance of butterflies varied across different seasons. Based on evaluation of diversity indices for different seasons, spring season exhibited maximum butterfly diversity which also coincides with peak tourist influx season in the region. Moreover, 45.23% of the total species were found active in variable abundance throughout the seasons that include species like *Danaus chrysippus* (Linnaeus), *Euploea core* (Cramer), *Junonia iphita* (Cramer), *Vanessa indica* (Herbst), *Catopsilia pomona* (Fabricius), *Heliophorus sena* (Kollar), *Papilio polytes* Linnaeus, *Dodona durga* (Kollar) and others. The overall findings are important providing baseline data for studying temporal changes in butterfly community over time, besides can also be used for drawing immediate attention of managers and planners towards promoting education, research, conservation and ecotourism at the Nainital city.

Key words: *Butterfly trail, Lake City, Rare species, Seasonality, Sustainable development*

INTRODUCTION

Posed by global environmental challenges such as climate change, pollution, natural resource depletion, deforestation, ocean acidification and others, modern nature conservationists especially in developing countries acknowledge the concept of 'Ecotourism' as a potential and effective means of balancing conservation objectives with human development in a sustainable manner (Shoo and Songorwa, 2013). Ecotourism as a form of participatory conservation strategy serves environmental

friendly tourism with socio-economic benefits to the local community while conserving natural resources (Cheung, 2015; Eshun *et al*., 2016). Amongst all insects, butterflies are considered as planet's most majestic creature with brilliantly colored and exquisitely patterned wings, and have always been most fascinating to human kind from the time memorial (Singh, 2017). With relatively well known ecology, butterflies form a crucial aspect of the ecosystems, acting as a strong pollinator, a food source for predators at various levels (Tiple *et al*., 2006) and indicative of general environmental attributes such as conservation value (Ehrlich and Murphy, 1987; Brown *et al*., 2000); disturbances (Kocher and Williams, 2000), environmental health and quality (Kunte, 2000; Sawchik *et al*., 2005); climate change (Hellmann, 2002; Hill *et al*., 2002) and as surrogate taxa for assessing conservation threats to other biodiversity groups (Thomas, 2005; Hayes *et al*., 2009). Butterflies play critical roles at the nexus between environmental science and environmental action (Fleishman and Murphy, 2009) and are often used as flagship species in conservation programs (New, 2011). In more recent, they are rendered as an efficient tourism product in nature based tourism as well as for destination development (Kurnianto *et al*., 2016; Ismail *et al*., 2018). Butterflies, because of their great diversity and aesthetic beauty, represent a natural resource that can be managed in different ways (Lopez-Collado *et al*., 2016). The development of butterfly zones for *in situ* conservation protect not only the butterfly diversity and entire habitat for wide range of native plants and insects but also serve to promote environmental education, research, restoration goals and butterfly ecotourism (Mathew and Anto, 2007; Cutting, 2012, Revathy and Mathew, 2014, Hamdin *et al*., 2015; Sanwal *et al*., 2017).

The state of Uttarakhand located in Lesser Himalayan Domain of Indian Himalayan region is endowed with magnificently diverse landscapes, marvelous range of biodiversity, enough religious and cultural tourist potential (Ahmed, 2013; Choudhuri, 2016; Monga *et al*., 2016). The state presents a large variety of habitats for several charismatic vertebrate fauna and is home to at least 500 species of butterflies (Sondhi and Kunte, 2018). In addition, butterflies of the Kumaun region have been studied systematically, since 1880's. In the most pioneering studies by Doherty (1886), a total of 271 species of butterflies have been recorded from the Kumaun region. Hannyngton (1910-11) made a detailed survey of butterflies and recorded about 378 species including many endemic ones from the Kumaun region. Subsequently, several studies have been conducted by various workers to explore the butterfly diversity at different locations in the Kumaun Himalaya (Smetacek, 2002, 2004; Joshi and Arya,

2007; Tyagi *et al*., 2011; Smetacek, 2011, 2012; Arya *et al*., 2014, 2016a, 2016b; Sondhi, 2017; Farooq and Arya, 2018; Verma and Arya, 2018). The Himalayan state of Uttarakhand promotes ecotourism in protected areas, apart from eco-parks created for ecotourism in Kumaun and Garhwal regions (Kala, 2013), however such integrated planning of conservation is most awaited in regions other than protected areas, important from the standpoints of sustainable tourism development. Furthermore, policies and strategies adopted for *ex situ* and *in situ* conservation of butterflies in form of gardens and parks are presently being practiced and much encouraged in Dehradun and Nainital districts of state Uttarakhand (Meena and Dayakrishna, 2017; Sanwal *et al*., 2017; Sondhi and Kunte, 2018). Nainital located in Kumaun Himalaya is a prime example of Lake Township that has been severely impacted by human activities like increased urbanization and logarithmic tourist influx into the watershed has affected the ecology of fragile areas to a great extent (Shah *et al*., 2009). Ensued from this scenario, areas rich for butterfly diversity should be identified and can be prioritized for *in situ* conservation through setting up butterfly parks or trails in the catchment area of city Nainital which will also aid in developing sustainable form of ecotourism in areas other than wildlife parks. In context of this, a foot trail located in the temperate forest adjacent to city Nainital has been evaluated for its potency to prioritize it for development of 'Butterfly Trail' as a part of promoting conservation and ecotourism in the region. Ideally, the value of a tourist brochure of wilderness area would be greatly enhanced if the best season for sighting a particular faunal group is recommended (Borkar and Komarpant, 2004). Keeping this in view, a preliminary checklist on butterfly diversity available in the forest trail with their seasonal patterns was prepared during the present study.

MATERIAL AND METHODS

Study site

Deriving its name from goddess Naina Devi, Nainital (also known as Lake City) is one of the most pristine hill stations set up in early 19^{th} century during British Era and is renowned worldwide for its picturesque natural lake flanked by steep hills covered with mixed oak-conifer forests. The salubrious climate and rich cultural heritage attracts thousands of tourists throughout the year in Lake City (Tamta, 2016). The city is located at an altitude of 1938 m a. s. l. at the level of lake, stretched between 29°21' to 29°24' N latitudes and 79°25' to 79°29' E longitudes in Kumaun Lesser Himalayan domain of state Uttarakhand, India (Fig. 1). The region experiences temperate and wet monsoon type of climate (Singh and Singh, 1992) with average monthly temperature varying from 15°C to 30°C during hot

summer and from 2°C to 16°C in cold winter. The average annual rainfall around the catchment area is about 1200 mm. The whole year could be divisible into three major seasons- warm and dry summer season, warm and moist rainy season and cold and snowy winter season. Present study was undertaken during June, 2017 to April, 2018 in forest surrounding the foot trail that starts from 'Birla Chungi' nearby Birla Vidyamandir School located on the ridge named Sher-ka-Danda and ends with a low lying valley of the village Ratighat. The present forest trail located at an elevation of about 400 meters above from lake in the city is covered with temperate type of vegetation which gradually merges into subtropical pine forest with decreasing altitude towards the village. A perennial stream on the verge of drying flows adjacent to the forest trail which has its own recreational use, and architecture like small bridges built on the stream from British Era are structural elements in the study area. In the present study, the foot trail which was traversed up to 5 km downhill from 'Birla Chungi' is dominated with oak mixed forest. The floral diversity along the walking trail includes various species of trees, shrubs, herbs, grasses, ferns and others which are congenial for butterflies (Table 1). The present study site is characterized as unprotected and moderately disturbed forest and activities like collection of minor and major forest products by local villagers, dumping of trash and litter along the walking trail, grazing by animals, visitations by local people and tourists for amusement and observing nature are frequent in the study area (Fig. 2).

Fig. 1. Map showing the location of present study site at city Nainital

Butterfly census and data analysis: Sampling of butterflies in forest along the walking trail was conducted bi-weekly following Pollard Walk Technique (Pollard, 1979 and Pollard and Yates, 1993). The butterflies were counted around a radius of 5 m while traversing the trail slowly at a uniform pace mainly during 7.00 to 15.00 hours of a day. Using direct sightings or photographic evidences, butterflies were identified in the field with reference to butterfly identification literature (Haribal, 1992; Kumar, 2008; Kehimkar, 2014; Singh, 2017; Sondhi and Kunte, 2018). None of the butterfly was either caught or killed in the

field. Status of butterflies was evaluated as per the number of sightings in the study area and were categorized as very common (more than 100 sightings), common (41-100 sightings), uncommon (11-40 sightings) and rare (1-10 sightings). Seasonal fluctuation in community assemblage of butterflies was studied quantitatively in three different seasons *viz.* rainy (June to August), autumn (September to November) and spring (February to April) and using the software program PAST (2005), various measures of diversity indices (dominance, Shannon diversity and evenness) were worked out in order to understand seasonal diversity of butterflies.

RESULTS AND DISCUSSION

Studies related to abundance and diversity of insects and other invertebrates add key building blocks to the wildlife value of a site (Hopwood, 2013). A total count of 1669 individuals of butterflies belonging to 42 species and 30 genera under six families was made in the present study (Table 2 and Fig. 3). Among recorded butterfly families, Nymphalidae was the most species rich consisting 17 species followed by Pieridae (10 species), Lycaenidae (six species), Papilionidae (four species), Riodinidae (three species) and Hesperidae (two species), respectively. Abundance of butterflies varied significantly among different families. Family Nymphalidae was dominant again with 45.29% of total individuals, followed by Pieridae (31.04%), Lycaenidae (11.20%), Papilionidae (8.33%), Hesperidae (2.09%) and Riodinidae (2.04%), respectively (Fig. 4). The polyphagous feeding behavior exhibited by larvae of species belonging to family Nymphalidae and Pieridae might be responsible for such abundance of butterflies in the study area. The members of Asteraceae were mostly found to be used by butterflies as nectar food plants along the foot trail. Moreover, predominance of butterflies of family Nymphalidae in the study area is in line with the findings that have also been reported earlier at different locations in city Nainital (Arya *et al*., 2014, 2016a; Garia *et al*., 2016; Meena and Dayakrishna, 2017). In comparison, Arya *et al.* (2014) documented 27 species of butterflies majority of which belonged to family Nymphalidae and Pieridae from academic institutions like D.S.B. Campus and Administrative Block of Kumaun University, Nainital. Arya *et al.* (2016a) recorded 37 species of butterflies from temperate forests located in the city Nainital with majority of species belonged to family Nymphalidae (20 species) and Pieridae (nine species). Garia *et al.* (2016) reported 37 species of butterflies from Naina Devi Himalayan Bird Conservation Reserve located at Kilbury forest which is 13 km north of Nainital. More recently, Meena and Dayakrishna (2017) prepared a list of 29 species of butterflies from the campus of Bharat Ratna Pt. Govind Ballabh Pant High

Altitude Zoo, Nainital established for *ex situ* conservation of endemic wildlife to Himalayan region. Nymphalidae was again most species rich family with 14 species, followed by Pieridae (seven species), Lycaenidae and Papilionidae (four species each), respectively. Overall, these findings indicate that species richness of butterflies was high in the present study site as compared to areas explored for butterfly diversity in and around Lake City. Based on number of sightings, four species of butterflies namely, *Pieris brassicae* (Linneaus), *Junonia iphita* (Cramer), *Aglais cashmiriensis* (Kollar) and *Papilio polytes* (Linneaus) were recorded as fairly common which accounted 30.85% of total individuals recorded in the present study. Similarly, 17 species (40.47% of the total species) were recorded as common, most of which belonged to family Nymphalidae and Pieridae, while 15 species of butterflies such as *Symbrenthia lilaea* (Hewitson), *Vanessa cardui* (Linnaeus), *Libythea lepita* Moore, *Ypthima nikea* Moore, *Lethe insana* (Kollar), *Danaus genutia* (Cramer), *Argyreus hyperbius* (Linnaeus) of family Nymphalidae and *Colias erate* (Esper), *Eurema brigitta* (Stoll) of family Pieridae and rest belonging to the other families were recorded as uncommon during study period. On the other hand, species of butterflies like *Abisara fylla* (Westwood), *Heliophorus oda* (Hewitson), *Graphium agamemnon* (Linneaus), *Lethe verma* (Kollar) and *Melanitis leda* (Linnaeus) were recorded as least abundant and rare in terms of their local status. Apart from this, six species having protected status under the Indian Wildlife Act namely *Euploea core* (Cramer), *Libythea lepita* Moore, *Melanitis leda* (Linnaeus), *Heliophorus oda* (Hewitson), *Lampides boeticus* (Linnaeus) and *Everes argiades diporides* Chapman were also recorded.

Seasonal conditions are considered to be the major factor in determining spatial and temporal distribution of butterflies and other insects (Kunte, 1999; Ramya *et al*., 2017). Fig. 5 shows the number of species with individuals of butterflies arranged family wise across spring, rainy and autumn seasons of the study period. The figure indicates that there was no significant difference in species count however, abundance of butterflies belonging to different families was found to be varied across different seasons. The individual abundance of families Pieridae, Lycaenidae and Riodinidae was reported maximum for the spring season, followed by rainy and autumn seasons, whereas members of families Nymphalidae and Hesperidae were found abundant during rainy season, followed by spring and autumn seasons. On the other hand, abundance of butterflies belonging to family Papilionidae was recorded maximum during autumn season and least in rainy season. Of the total butterfly species, eight species were

seasonal (based on flight periods) i.e. they were recorded in specific seasons. The butterfly species such as *Libythea lepita* Moore, *Melanitis leda* (Linnaeus) belonging to family Nymphalidae, *Heliophorus oda* (Hewitson) of family Lycaenidae, *Graphium agamemnon* (Linnaeus) of family Papilionidae and *Dodona dipoea* Hewitson, *Abisara fylla* (Westwood) of family Riodinidae were recorded during spring season in the present study. Species of family Nymphalidae *Lethe verma* (Kollar) was recorded during rainy season, whereas *Lampides boeticus* (Linnaeus) of family Lycaenidae was found with flight period during the autumn season. The species such as *Callerebia scanda* (Kollar), *Symbrenthia lilaea* (Hewitson), *Vanessa cardui* (Linnaeus), *Eurema brigitta* (Stoll), *Aporia agathon* (Gray), *Notocrypta curvifascia* and *Tagiades cohaerens cynthia* Evans were found during rainy and spring seasons. On the other hand, species of butterflies such as *Danaus genutia* (Cramer), *Colias erate* (Esper), *Byasa polyeuctes* (Doubleday) and *Papilio protenor* Cramer were recorded during autumn and spring seasons, whereas species such as *Argyreus hyperbius* (Linnaeus), *Lethe insana* (Kollar), *Ypthima nikea* Moore and *Lycaena pavana* (Westwood) were found with flight periods during rainy and autumn seasons. Apart from this, 19 species of butterflies remained active in variable abundance throughout the seasons that include species like *Aglais cashmiriensis* (Kollar), *Danaus chrysippus* (Linnaeus), *Euploea core* (Cramer), *Junonia iphita* (Cramer), *Vanessa indica* (Herbst), *Pieris canidia* (Linnaeus), *Colias fieldii* Menetries, *Catopsilia pomona* (Fabricius), *Heliophorus sena* (Kollar), *Papilio polytes* Linnaeus, *Dodona durga* (Kollar) and few others.

It is thus, evident from these results that different seasons crucially influence the population structure of many species of butterflies. Moreover, seasonal fluctuations faced by different generations may include changes in ambient temperature and light levels, rainfall, differential availability of resting places, periodic supply of nectar and larval host plants, vegetation cover, and a differential set of predators and predation risk (Shobana *et al*., 2012 and Sajjad *et al*., 2012). Phenology of insects, especially life span and the number of generations per year besides their fecundity and host plant range also determine their population fluctuations across the seasons (Sajjad *et al*., 2012). The diversity indices that were calculated have been given in Table 3 depicting information about distribution of butterfly community across different seasons during the study period. Shannon Wiener Diversity index (H') was calculated as 3.486 for overall samplings indicating rich diversity for the sampled area. During the study period, maximum species diversity was recorded during spring season (3.397), followed by rainy (3.387) and autumn (3.258). Such species diversity of butterflies across the

seasons were found to be slight contradictory with observations that have also been recorded earlier in Kumaun Himalaya (Joshi and Arya, 2007; Tyagi *et al*., 2011; Arya *et al*., 2016b; Verma and Arya, 2018). Simpson's Dominance Index ranged from 0.9492 to 0.9599 which is nearer to 1, indicating the dominance of certain species of butterflies as *Aglais cashmiriensis* (Kollar), *Junonia iphita* (Cramer), *Pieris brassicae* (Linnaeus), *Papilio polytes* (Linnaeus), etc. in the forest trail. Moreover, Pielou's Evenness Index (J′) for the butterfly communities is 0.9326 which expresses that species were evenly distributed across the seasons during the study period.

From the past many years due to rapid expansion and increased urbanization augmented by unplanned and non regulated tourism management, several threats like frequent landslides, diminished spring water, forest fires, depleted forest cover and vegetation are disturbing fragile ecological processes in Nainital. These drastic alterations are leading to a decline in the vegetation primarily and ultimately in all forms of fauna through a number of eco-biological components of the complex food web. This necessitates immediate and proper conservation of natural resources while developing sustained and eco-friendly form of tourism. Besides the conservation of biological diversity, the establishment of Butterfly trail would encourage a number of nature lover tourists which in turn would generate economic incentives to local stakeholders. Several native plant species serving as host plants should be afforested to develop better survival and breeding grounds for butterflies in the study area. Such active measures would be helpful in building complementary inventory of insects and other fauna essential for providing ecosystem services in the urban region of Nainital.

Table 1. List of plant species with their families available in the study area

S. No.	Species name	Botanical Family
	Trees	
1.	*Quercus leucotrichophora* A.	Fagaceae
2.	*Quercus floribunda* Lindl. ex A. Camus	Fagaceae
3.	*Cornus macrophylla* Wall.	Cornaceae
4.	*Rhododendron arboreum* Sm.	Ericaceae
5.	*Acer oblongum* Wall. ex DC.	Sapindaceae
6.	*Acer pictum* Thunb.	Sapindaceae
7.	*Acer caesium* Wall. ex Brandis	Sapindaceae
8.	*Betula utilis* D.Don	Betulaceae

9.	*Aesculus indica* (Wall. ex Camb) Hook. F	Hippocastanaceae
10.	*Fraxinus micrantha* L.	Oleaceae
11.	*Litsea umbrosa* Nees.	Lauraceae
12.	*Machilus duthiei* King ex Hook. F.	Lauraceae
13.	*Carpinus viminea* Wall. ex Lindl.	Betulaceae
14.	*Ficus nemoralis* Wall.	Moraceae
15.	*Magnolia grandiflora* L.	Magnoliaceae
	Shrubs	
16.	*Berberis asiatica* Roxb. ex. Dc.	Berberidaceae
17.	*Coriaria nepalensis* Wall.	Coriariaceae
18.	*Pyracantha crenulata* (Don) Roem.	Rosaceae
19.	*Rubus ellipticus* Sm.	Rosaceae
20.	*Virburnum cotinifolium* Don	Caprifoliaceae
21.	*Sarcococca saligana* (D. Don.) Muell.	Buxaceae
22.	*Daphne papyracea* Wall. ex Steud.	Thymelaeaceae
23.	*Rosa macrophylla* Lindl.	Rosaceae
24.	*Urtica dioca* Linn.	Urticaceae
25.	*Reinwardtia indica* Dum.	Linaceae
26.	*Myrsine africana* L.	Myrsinaceae
27.	*Indigofera pulchella* Roxb.	Fabaceae
28.	*Debregeasia longifolia* (Burm. f.) Wedd.	Urticaceae
	Herbs	
29.	*Ainsliaea aptera* DC.	Asteraceae
30.	*Oxalis corniculata* L.	Oxalidaceae
31.	*Euphorbia hirta* L.	Euphorbiaceae
32.	*Bidens pillosa* L.	Asteraceae
33.	*Galium rotundifolium* Linn.	Rubiaceae
34.	*Pilea scripta* (Buch.-Ham. ex D. Don)	Urticaceae
35.	*Geranium wallichianum* D. Don ex Sweet	Geraniaceae
36.	*Artemisia nilagirica* (Clarke) Pamp.	Asteraceae
37.	*Trifolium repens* L.	Fabaceae
38.	*Viola canescens* Wall.	Violaceae
39.	*Erigeron annuus* (L.) Pers.	Asteraceae
40.	*Galium asperifolium* Wall. ex Roxb.	Rubiaceae
41.	*Achyranthes bidentata* Blume	Amaranthaceae
42.	*Anaphalis busua* (Buch.-Ham. ex. D. Don) DC.	Asteraceae
43.	*Bistorta amplexicaulis* (D. Don) Greene	Polygonaceae
44.	*Fragaria indica* Andr.	Rosaceae
45.	*Hedychium spicatum* Buch.-Ham. ex Sm.	Zingiberaceae
46.	*Microstylis wallichii* Lindl.	Orchideaceae

Table 2. Species composition and status of butterflies recorded in and around the forest trail located in city Nainital during June, 2017 to April, 2018

S.No.	Scientific name	Common name	Status	Relative Abundance
Family: Nymphalidae				
1.	*Aglais cashmiriensis* (Kollar)	Indian Tortoiseshell	FC	6.17
2.	*Argyreus hyperbius* (Linnaeus)	Indian Fritillary	UC	2.09
3.	*Callerebia scanda* (Kollar)	Pallid Argus	C	4.13
4.	*Danaus chrysippus* (Linnaeus)	Plain Tiger	C	2.93
5.	*Danaus genutia* (Cramer)	Striped Tiger	UC	1.49
6.	*Euploea core* (Cramer)	Common Indian Crow	C	2.93
7.	*Junonia iphita* (Cramer)	Chocolate Pansy	FC	6.77
8.	*Junonia orithiya* (Linnaeus)	Blue Pansy	C	5.03
9.	*Lethe insana* (Kollar)	Common Forester	UC	1.44
10.	*Lethe verma* (Kollar)	Straight-Banded Treebrown	R	0.42
11.	*Libythea lepita* Moore	Common Beak	UC	1.19
12.	*Melanitis leda* (Linneaus)	Common Evening Brown	R	0.48
13.	*Neptis yerburyi yerburyi* (Butler)	Yerbury's Sailar	C	2.52
14.	*Symbrenthia lilaea* (Hewitson)	Common Jester	UC	1.61
15.	*Vanessa cardui* (Linnaeus)	Painted Lady	UC	2.04
16.	*Vanessa indica* (Herbst)	Indian Red Admiral	C	3.29
17.	*Ypthima nikea* Moore	Moore's Five-Ring	UC	0.72
Family: Pieridae				
18.	*Aporia agathon* (Gray)	Great Blackvein	C	2.87
19.	*Catopsilia pomona* (Fabricius)	Common Emigrant	C	3.17
20.	*Colias erate* (Esper)	Pale Clouded Yellow	UC	1.38
21.	*Colias fieldii* Menetries	Dark Clouded Yellow	C	2.93
22.	*Eurema brigitta* (Stoll)	Small Grass Yellow	UC	1.68
23.	*Eurema hecabe* (Linneaus)	Common Grass Yellow	C	3.53
24.	*Eurema laeta* (Boisduval)	Spotless Grass Yellow	C	3.11
25.	*Gonepteryx rhamni nepalensis* Doubleday	Common Brimstone	C	2.52

26.	*Pieris brassicae* (Linnaeus)	Large Cabbage White	FC	6.83
27.	*Pieris canidia* (Linnaeus)	Indian Cabbage White	C	2.99
Family: Lycaenidae				
28.	*Celastrina huegelii* (Moore)	Large Hedge Blue	C	2.52
29.	*Everes argiades diporides* Chapman	Tailed Cupid	C	2.52
30.	*Heliophorus oda* (Hewitson)	Eastern Blue Sapphire	R	0.29
31.	*Heliophorus sena* (Kollar)	Sorrel Sapphire	C	2.93
32.	*Lampides boeticus* (Linneaus)	Pea Blue	UC	1.44
33.	*Lycaena pavana* (Westwood)	White-Bordered Copper	UC	1.49
Family: Papilionidae				
34.	*Byasa polyeuctes* (Doubleday)	Common Windmill	C	0.78
35.	*Graphium agamemnon* (Linneaus)	Tailed Jay	R	0.42
36.	*Papilio polytes* Linneaus	Common Mormon	FC	6.05
37.	*Papilio protenor* Cramer	Spangle	UC	1.08
Family: Riodinidae				
38.	*Abisara fylla* (Westwood)	Dark Judy	R	0.29
39.	*Dodona dipoea* Hewitson	Lesser Punch	R	0.24
40.	*Dodona durga* (Kollar)	Common Punch	UC	1.49
Family: Hesperidae				
41.	*Notocrypta curvifascia* (Felder &Felder)	Restricted Demon	UC	1.38
42.	*Tagiades cohaerens cynthia* Evans	Evan's Snow Flat	UC	0.72

(Abbreviations used: C= common; FC= fairly common; UC= uncommon; R= rare)

Table 3. Seasonal variation in diversity indices of butterflies observed during the study period

Indices	**Rainy**	**Autumn**	**Spring**	**Total**
Simpson	0.9595	0.9492	0.9599	0.9636
Shannon	3.387	3.258	3.397	3.486
Equitability/Pielou (J')	0.9312	0.9091	0.9339	0.9326

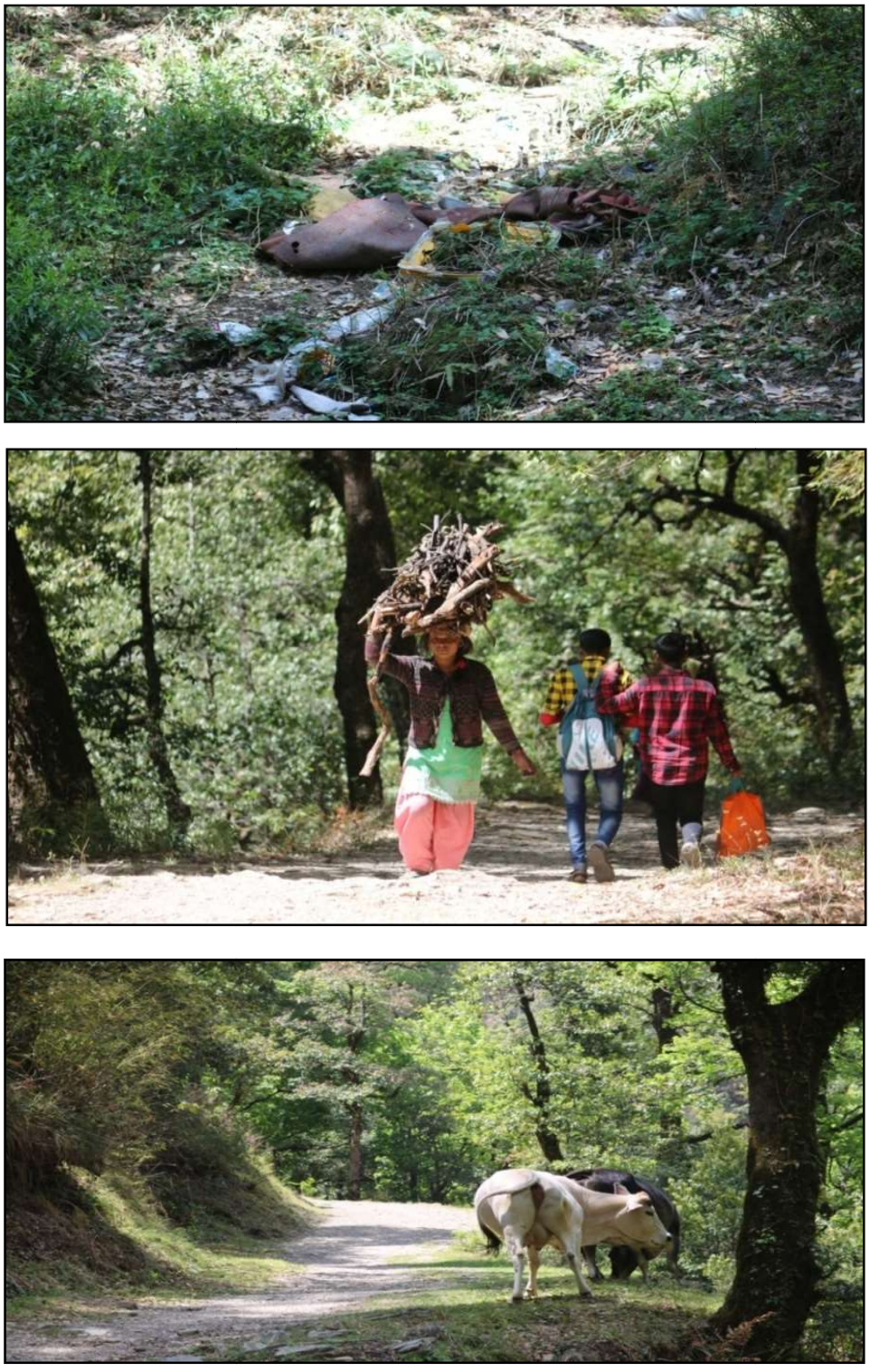

Fig. 2. Images showing observed level of disturbances along foot trail in the study area

Vanessa indica *Lethe verma* *Lethe insana*

Aporia agathon *Neptis yerburyi yerburyi* *Vanessa cardui*

Callerebia scanda *Ypthima nikea* *Libythea lepita*

Junonia iphita *Melanitis leda* *Symbrenthia lilea*

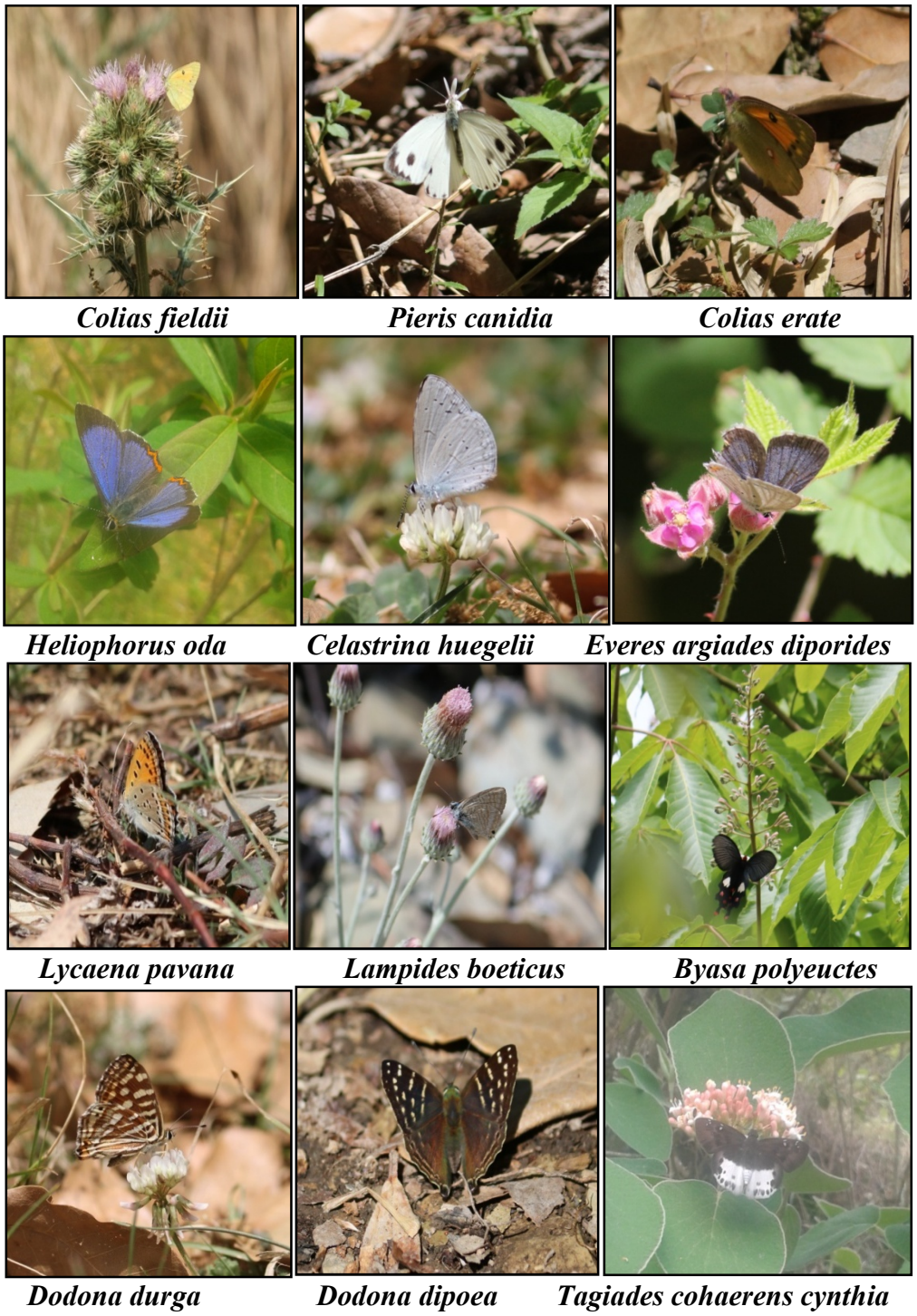

Fig. 3. Some of the observed species of butterflies during the study period

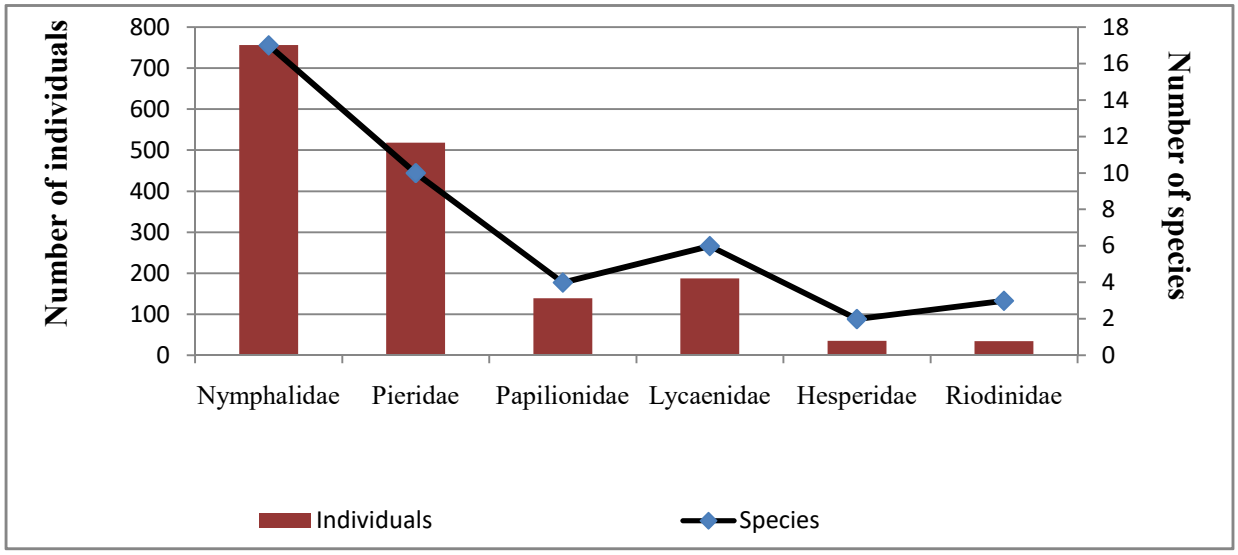

Fig. 4. Variation in total number of species and individuals of different families of butterflies recorded from the forest trail

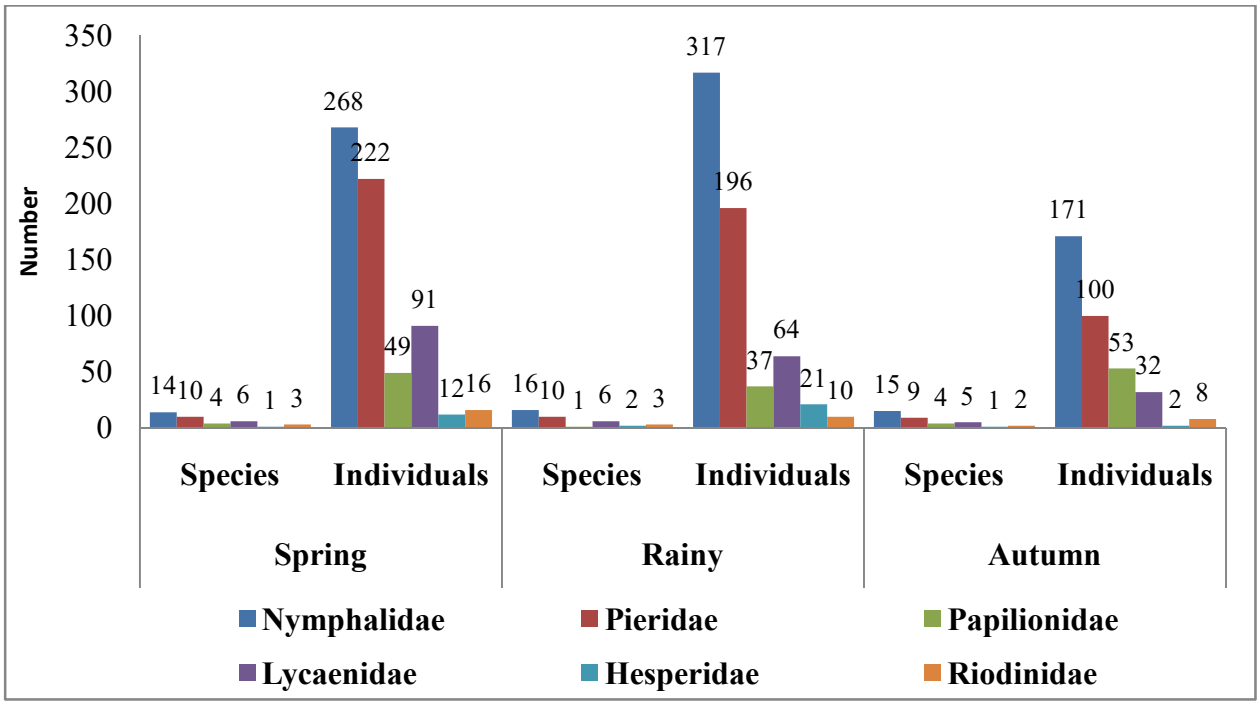

Fig. 5. Family wise seasonal variation of butterflies in terms of number of species and individuals recorded from the forest trail

CONCLUSION

Based on observations of the present study, it is suggested that temperate forest around the foot trail linking urban city Nainital to rural Ratighat is rich for butterfly community when compared to the various areas assessed earlier at times for butterfly diversity at city Nainital, thus establishment of biodiversity offsets such as Butterfly 'Trail' or 'Park' within a timeframe would be the most significant way forward to promote *in situ* conservation of butterflies. High species richness throughout the seasons, with peak abundance of butterflies during spring that also coincides with tourism season of the region is a good indicator for potential of this forest trail for promoting butterfly ecotourism in city Nainital. The creation of butterfly offsets will further help to create awareness in masses about the conservation of biodiversity and natural resources by synchronizing these valuable assets with the livelihood of local community.

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REFERENCES

Ahmed, N. 2013. Sustainable tourism development in Uttarakhand region of India. *Int. J. Mgt. Soc. Sci. Res.*, **2**(4): 106-111.

Arya, M. K., Dayakrishna and Chaudhary, R. 2014. Species richness and diversity of butterflies in and around Kumaun University, Nainital, Uttarakhand, India. *J. Ent. Zool. Studies*, **2**(3): 153-159.

Arya, M. K., Dayakrishna and Tamta, P. 2016a. Local status, distribution and diversity of butterflies (Lepidoptera: Rhopalocera) in a temperate forest ecosystem in the Kumaun Himalayas, India. p. 121-133. In: *Trends in Biodiversity: Floral, Faunal and Ecological Aspects*, Narendra Publishing House, Delhi, India.

Arya, M. K., Tamta, P. and Dayakrishna 2016b. Species composition, distribution and diversity of butterflies along altitudinal gradients in Binsar Wildlife Sanctuary, Kumaun Himalaya, Uttarakhand, India. In M.K. Arya, P.K. Bharati and R. Joshi (eds.), Discovery Publishing House, 11 pp.

Borkar, M. R. and Komarpant, N. 2004. Diversity, abundance and habitat associations of butterfly species in Bondla Wildlife Sanctuary of Goa, India. *Zoo's Print Journal,* **19**(10): 1648-1653.

Brown, K. S. and Freitas, A. V. L. 2000. Atlantic forest butterflies: indicators for landscape conservation. *Biotropica*, **32**: 934-956.

Cheung, H. 2015. Ecotourism as a multidisciplinary conservation appr-oach in Africa. *Therya*, **6**(1): 31-41.

Choudhuri, S. 2016. The relevance of tourism industry in Uttarakhand. *J. Adv. Bus. Mgt.*, **2**(4): 194-207.

Cutting, B.T. 2012. *An evaluation of Butterfly Garden as restoration tools using the Monarch Butterfly Danaus plexippus*. M. Sc. Thesis submitted to the Faculty of the University of Delaware. 34 pp.

Doherty, W. 1886. A list of butterflies in Kumaun. *J. Asiat. Soc. Beng.*, **55**(2): 103-140.

Ehrlich, P. R. and Murphy, D. D. 1987. Conservation lessons from long term studies of checkerspot butterflies. *Cons. Biol.*, **1**: 122-131.

Eshun, G., Adjei, P. O. and Segbefia, A. Y. 2016. Beyond business as usual: implication of tourist experiences for ecotourism development. *African Journal of Hospitality, Tourism and Leisure*, **5**(2): 1-26.

Farooq, F. and Arya, M.K. 2018. Butterflies diversity in the temperate fruit tree orchards of Kumaun Himalaya, Uttarakhand, India. *J. Ent. Zool. Studies,* **6**(2): 2946-2953.

Fleishmann, E. and Murphy, D.D. 2009. A realistic assessment of the indicator potential of butterflies and other charismatic taxonomic groups. *Cons. Biol.*, **23**(5): 1109-1116.

Garia, A., Goswami, D. and Kaushal, B. R. 2016. Diversity and relative abundance of Lepidoptera in an oak forest of Kumaun Himalaya. *The Journal of Zoology Studies*, **3**(5): 87-94.

Hamdin, M. S., Mohammed, M. and Tokiman, L. 2015. Potential of entomotourism at Taman Negara Johor Endau Rompin. *Int. J. Adm. Gov.*, **1**(4): 92-97.

Hannyngton, F. 1910-11. Butterflies of Kumaun. *J. Bom. Nat. Hist. Soc.*, **20**(3): 871-872.

Haribal, M. 1992. *The Butterflies of Sikkim Himalaya and their Natural History*. Sikkim Nature Conservation Foundation, Gangtok.

Hayes, L., Mann, D. J., Monastyrskii, A. L. and Lewis, O.T. 2009. Rapid assessments of tropical dung beetle and butterfly assemblages: contrasting trends along a forest disturbance gradient. *Ins. Cons. Div.*, **2**: 194-203.

Hellmann, J. J. 2002. Butterflies as model systems for understanding and predicting climate change. p. 93-126.

In: Schneider, S. H. and Root, T. L. (eds.) *Wildlife Responses to Climate Change.* Island Press, Washington, D. C.

Hill, J. K., Thomas, C. D., Fox, R., Telfer, M. G., Willis, S. G., Asher, J. and Huntley, B. 2002. Responses of butterflies to twentieth century climate warming: implications for future ranges. *Proc. R. Soc. B*, **269**: 2163-2171.

Hopwood, J. 2013. Roadsides as habitat for pollinators: management to support bees and butterflies. Conference Paper: Proceedings of the 7th International Conference on Ecology and Transportation (IOECT): Canyons, Crossroads and Connections at Scottsdale, Arizona, U. S. A.

Ismail, N., Maryati, M., Kahirol, M. S., Khim, P. C. and Tokiman, R. S. 2018. Butterflies (Lepidoptera: Papilionoidea) diversity at Endau Rompin Johor National Park, Malaysia and prioritizing the potential groups for nature tourism product. *Journal of Wildlife and Parks*, **33**: In Press.

Joshi, P.C. and Arya, M. 2007. Butterfly communities along altitudinal gradients in a protected forest in the Western Himalayas, India. *The Natural History Journal of Chulalongkoon University*, **7**(1): 1-9.

Kala, C. P. 2013. Ecotourism and sustainable development of mountain communities: a study of Dhanolti ecopark in Uttarakhand state of India. *Appl. Ecol. Env. Sci.*, **1**(5): 98-103.

Kehimkar, I. 2014. *The Book of Indian Butterflies*. Bombay Natural History Society-Oxford University Press, Mumbai.

Kocher, S. D. and Williams, E. H. 2000. The diversity and abundance of North American butterflies, vary with habitat disturbances and geography. *J. Biog.*, **27**: 785-794.

Kumar, P. 2008. *Handbook on Common Butterflies of Uttarakhand*. Zoological Survey of India.

Kunte, K. J. 1999. Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. *J. Bios.*, **22**(5): 593-603.

Kunte, K. 2000. *Butterflies of Peninsular India.* Hyderabad: Universities Press.

Kurnianto, A.S., Wafa, I.Y., Alifianto, F. and Kurniawan, N. 2016. The potential of butterflies in Tourism diversify-cation product: case study at Coban Rais Waterfall, Batu, East Java. *Journal of Indonesian Tourism and Sustainable Developmental Studies*, **4**(3): 115-122.

Lopez-Collado, J., Cruz-Salas, L. L., Garcia-Albarado, J. C., Platas-Rosado, D.E. and Calyecac-Cortero, H.G.C. 2016. Size doesn't matter but color does: preference of neotropical butterfly species to make souvenirs. *J. Ento. Zool. Studies*, **4**(5): 159-165.

Mathew, G. and Anto, M. 2007. *In situ* conservation of butterflies through establishment of Butterfly Gardens: a case study at Peechi, Kerala, India. *Curr. Sci.*, **93**(3): 337-347.

Meena, D. S. and Dayakrishna, 2017. Study on the species composition and status of free ranging butterflies (Lepidoptera: Rhopalocera) in Pt. G. B. Pant High Altitude Zoo, Nainital, Uttrakhand. *J. Ento. Zool. Studies*, **5**(4): 1135-1139.

Monga, N., Bhalla, M. and Kaplash, S. 2016. Conceptual analysis of Utarakhand as a holiday destination and its contribution in tourism. *Int. J. Res. Fin. Mark.,* **6**(4): 83-88.

New, T. R. 2011. Launching and steering flagship Lepidoptera for conservation benefit. *Journal of Threatened Taxa*, **3**(6): 1805-1817.

Pollard, E. 1979. A national scheme for monitoring the abundance of butterflies. The First Three Years British Entomological and Natural History Society. *Proc. Trans*., **12**: 77-99.

Pollard, E. and Yates, T. J. 1993. *Monitoring Butterflies for Ecology and Conservation.* Chapman and Hall. London.

Ramya, R. S., Kumar, M. G. and Ranjith, M. 2017. Influence of weather parameters on seasonal abundance of arthropods in a floricultural ecosystem. *J. Ento. Zool. Studies*, **5**(3): 1672-1676.

Revathy, V. S. and Mathew, G. 2014. Seasonal fluctuations of butterfly population: a study in butterfly garden at Peechi, Kerala, India. *Int. J. Agr., Env. Bios.*, **7**(1): 29-35.

Sajjad, A., Saeed, S. and Syed, B. 2012. Year long association of butterfly populations with flowering plants in Multan, Pakistan. *Pak. Ent.*, **34**(2): 105-110.

Sanwal, C. S., Dhakate, P.M., Joshi, K. K. and Lakshmi M, N. 2017. Habitat conservation through butterfly zone: A new approach to *in-situ* conservation of butterfly diversity. *J. Ent. Zool. Studies*, **5**(6): 2195-2199.

Sawchik, J., Dufrene, M. and Lebrun, P. 2005. Distribution patterns and indicator species of butterfly assemblages of wet meadows in southern Belgium. *Belg. J. Zool.*, **135**(1): 43-52.

Shah, S., Tewari, A. and Tewari, B. 2009. Impact of human disturbance on forest vegetation and water resources of

Nainital catchment. *Nature and Science*, 74-78 pp.

Shobana, G., Gunasekaran, C., Lena, M., Agnes, D. and Sharmila, B.A. 2012. Diversity and abundance of butterflies in Villupuram district, Tamil Nadu, South India. *Int. J. Rec. Sci. Res.*, **3**(7): 637-639.

Shoo, R. A. and Songorwa, A. N. 2013. Contribution of ecotourism to nature conservation and improvement of livelihoods around Amani nature reserve, Tanzania. *Journal of Ecotourism*, **12**(2): 75-89.

Singh, A.P. 2017. *Butterflies of India*. Om Books International, Noida, U.P., India.

Singh, J. S. and Singh, S. P. 1992. *Forest of Himalaya: Structure, Functioning and Impact of Man*. Gyanodya Prakashan, Nainital.

Smetacek, P. 2002. The genus *Pontia* Fabricius (Lepidoptera: Pieridae) in the Kumaon Himalaya. *J. Bom. Nat. Hist. Soc.*, **99**: 224-231.

Smetacek, P. 2004. Descriptions of new Lepidoptera from the Kumaon Himalaya. *J. Bom. Nat. Hist. Soc.*, **101**: 269-276.

Smetacek, P. 2011. Four new Lycaenid records from the Kumaon Himalaya. *Journal of Threatened Taxa*, **3**(2): 1555-1558.

Smetacek, P. 2012. Butterflies (Lepidoptera: Papilionoidea and Hesperoidea) and other protected fauna of Jones Estate, a dying watershed in the Kumaon Himalaya, Uttarakhand, India. *Journal of Threatened Taxa*, **4**(9): 2857-2874.

Sondhi, S. 2017. First records of butterflies *Anthene emolus emolus* (Godart, [1924]) (Lepidoptera: Lycaenidae: Polyommatinae) and *Gandaca harina assamica* Moore, [1906] (Lepidoptera: Pieridae: Coliadinae) from Kumaon, Uttarakhand, India. *Journal of Threatened Taxa*, **9**(6): 10355-10357.

Sondhi, S. and Kunte, K. 2018. *Butterflies of Uttarakhand- A Field Guide.* Bishen Singh Mahendra Pal Singh (Dehradun), Titli Trust (Dehradun) National Centre for Biological Sciences (Bengaluru).

Tamta, A. K. 2016. Impact of seasonality in tourism and sustainable development (a study of Nainital town). *Scholarly Research Journal for Interdisciplinary Studies*, **4**(27): 3380-3389.

Thomas, J. A. 2005. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. *Phil. Trans. Roy. Soc. B*, **360**: 339-357.

Tiple, A. D., Deshmukh, V. P. and Dennis, R. L. H. 2006. Factors influencing nectar plant resource visits by butterflies on a university campus:

implications for conservation. *Nota Lepidopteralogica*, **28**(3/4): 213-224.

Tyagi, R., Joshi, P. C. and Joshi, N. C. 2011. Butterfly diversity of district Nainital, Uttarakhand (India). *J. Env. BioSci.*, **25**(2): 273-278.

Verma, A. and Arya, M. K. 2018. A preliminary study on the status and distribution of Butterfly Fauna in and around the valley of Reetha Sahib, Champawat, Kumaun Himalaya, India. *Biological Forum- An International Journal*, **10**(1): 43-51.