

EL NIÑO YEARS DECIMATE BUTTERFLY COMMUNITY IN A WEST HIMALAYAN FOREST

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ABSTRACT

The collapse of the butterfly community in Maheshkhan Reserve Forest, Uttarakhand following dry winters in 2009 and 2023 caused by El Niño is documented. 44% of the 95 species recorded in normal years were recorded in 2009 and 49% in 2023. More than 50% of butterfly species comprising the normal community were absent in both El Niño years. There were practically no butterflies on the wing in March and April, 2023 compared to hundreds of individuals belonging to 50+ species in normal years. In May and June, very few individuals were on the wing. All butterfly species using *Quercus leucotrichophora* as a larval hostplant were present in 2023, although only 57% were present in 2009.

INTRODUCTION

The emergence of butterflies from their pupae is triggered by certain environmental conditions such as day length, humidity and temperature. North and south of the tropics, the emergence of butterflies is restricted to particular

seasons, with some being univoltine and others bi- or multi-voltine. Dry weather spells often cause the desiccation of larvae and pupae of Lepidoptera resulting in comparatively greatly reduced populations (Smetacek, 2011). Hailstorms, prolonged inclement weather, such as dry periods and untimely wet spells and forest fires are some of the other factors known to cause widespread damage to Lepidopteran communities.

The El Niño effect refers to the unusual warming of the eastern Pacific Ocean in the Southern Hemisphere. The results are widespread, affecting global climatic patterns. The association between El Niño and deficient winter rainfall or drought is statistically significant over the subdivisions west of longitude 80° East and north of 12° North (Mooley & Parthasarathy, 1983). In the western Himalaya, this causes the failure of winter rains and very humid summers. The effects of the prolonged dry spell during winter on insect populations have not been previously studied, mainly because El Niño events are unpredictable.

Maheshkhan is a Reserve Forest on the southern face of the Gagar range in Nainital district of Uttarakhand, India (79°35'40" E 29°26' 7" N (Atkinson, 1882)) less than a degree east of the area designated by Mooley & Parthasarathy (1983) and equally affected by association between El Niño and deficient winter rainfall or drought. It comprises several hillsides between 1600 meters and 2400 meters. The lower reaches sustain dense broadleaf evergreen sub-tropical forest with Himalayan silver oak *Quercus leucotrichophora* A. Camus., *Quercus floribunda* Lindl., *Rhododendron arboreum* Smith, *Lyonia ovalifolia* (Wall.) Drude and *Acer oblongum* Wall. ex DC. Conifers are represented by Chir pine (*Pinus roxburghii* Sarg.) along the ridges and on dry hillsides with some *Cupressus* L. hybrids planted randomly on hillsides. There is an undergrowth of hill bamboo (*Arundinaria falcata* Nees) and grasses on ridges and in forest clearings.

The World Meteorological Organization (WMO) forecasted that there is a 90% probability of the El Niño event continuing during the second half of 2023 (Anonymous, 2023).

MATERIALS AND METHODS

Maheshkhan forest was visited several times in March, April, May and June 2023. Due to the very unusual rainy and cold weather on most days, visits were opportunistic. Easily identified butterfly species such as *Cyrestis thyodamas* Boisduval, 1846, *Sephisia dichroa* (Kollar, [1844]), *Auzakia danava* (Moore, [1858]), *Graphium cloanthus* (Westwood, 1841),

Aporia agathon (Gray, 1831), *Pieris canidia* (Linnaeus, 1768) and *Dodona durga* (Kollar, [1844]) were identified in the field and species belonging to the Lycaenidae and the genera *Ypthima* Huebner, 1818, *Lethe* Huebner, [1819], *Callerebia* Butler 1867, *Neptis* Fabricius, 1807 were photographed and later identified against identified specimens in the reference collection of the Butterfly Research Centre. In less than five cases, it was not possible to obtain photographs showing distinctive features of some individuals observed and these have been omitted from this study. Hesperidae have been entirely omitted from this study since specimens are required for confirming species level identification of many taxa.

Although butterfly activity begins early in the morning at low elevation in India, above 1800 m there is little activity before 10 a.m. or after 2 p.m. Therefore, observations were restricted to this period except on those days when observations were interrupted by rainfall. It is usual that, with the onset of the monsoon in the second half of June, butterfly activity rapidly diminishes. Satyrinae are usually still active, but there is a sharp drop in populations of other groups (Smetacek, 2011).

During the summer of 2023, butterflies were about in such small numbers, usually singletons, that it was possible to actually count individuals, unlike in normal years, when the quantity, variety and continuous movement of butterflies makes such an exercise impossible. In cases where active and numerous butterflies made individual counts meaningless, the term “few” has

been used to suggest that less than 5 individuals were about; “several” would suggest less than 10 individuals while “common” implies around 25 individuals were active; “very many” was used when there appeared to be more than 100 individuals active. In the case of territorial butterflies like *Kaniska canace* (Linnaeus, 1763), only one is encountered at a time, in which case the term “several” refers to every traditional “beat” being occupied by an aggressive male.

Larvae of forest butterflies are usually quite choosy about the site of pupation. In the present context, this would be crucial to survival of the species. The numbers of individuals in 2009 and 2023 were highly reduced. The number of species that are usually present in normal years but did not occur in both El Niño years is small, around 34% of the total number of species recorded in the study area. Perhaps these species have a low threshold of tolerance for extended periods of low atmospheric humidity; perhaps it was only the luck of the draw, for even in cases where a species did manage to complete its life cycle in one or the other or even both El Niño years, the successful ones were represented by very few individuals. In no case in both El Niño years did a species of butterfly appear to be unaffected by the unusual weather pattern, as might have been reflected in the species being recorded in numbers comparable to normal years. Therefore, the presence or absence of some species in El Niño years might be random, determined by the choice of the pupation site chosen by individual caterpillars, which might happen to be in a location with relatively higher humidity,

enough to prevent desiccation of the pupae.

The terms “fresh” and “worn” in tables 2 and 3 describes the condition of the butterflies, suggesting when they emerged from their pupae.

The data obtained in 2009 (Smetacek, 2011) was compared with data generated in March, April, May and June, 2023 as well as data from previous years from 1986 onwards.

RESULTS AND DISCUSSION

Forest fires during spring and summer were observed to completely destroy the local butterfly community, as happened in the summer of 2009 (Smetacek, 2011). In the present study, the local forest guard clarified that there was no forest fire in the study area in Maheshkhan Reserve Forest during 2023.

Smetacek (2011) suggested that low atmospheric humidity during the winter of 2008-2009 resulted in reduced emergence the following season, with 52% of species not represented at all and greatly reduced populations of those that did manage to emerge, compared with the 23-year period from 1986 to 2008 when opportunistic observations were undertaken in the study area.

The drop in butterfly populations documented in the study area in 2009 was believed to be a one-off event until 2023, when a similar pattern repeated itself both in terms of low atmospheric humidity

during winter (Table 10) and reduced butterfly populations the following spring

and summer (Table 1-9).

Table 1: The total percentage of butterfly species recorded and percentage of butterfly species feeding on climbers and monocotyledons (grasses and bamboos).

	1986-2022	2009	2023	2009 & 2023	Remarks
Total percentage of butterfly species present	95 species (100%)	40 species (44%)	47 species (49%)	28 species (29.5%)	Less than half the species were present in 2009 and 2023; only 30 % were present in both years.
Climbers (6 species)	6 species (100%)	3 species (50%)	4 species (67%)	3 species (50%)	
Monocotyledons (11 species; 1986-2022)	11 species (100%)	7 species (63%)	6 species (54%)	0 species	
Monocotyledons (17 species, 1986-2023)	17 species (100%)	7 species (41%)	12 species (70.58%)	0 species	6 additional species were recorded 2023.

The drop in butterfly species richness and numbers in 2023 was so severe that butterflies were absent even on sunny days in March and April, 2023 and it was actually possible to reliably count individual butterflies during May and June, 2023, since the total number was usually less than 5 individuals of a given species seen in a day. This was drastic compared to the hundreds of individuals of each species normally witnessed at peak

flying times in the same location in normal years. Table 2 compares the butterfly community on the same dates on 28 April in two different years, 1989, a normal year and 2023, an El Niño year. Table 3 compares the community on two days, 4 June and 6 June, 1998 (a normal year) versus the community on 5 June, 2023, an El Niño year. There is a stark contrast in the numbers of butterflies on the wing.

Table 2

Few= less than 5; several = less than 10; common = less than 25; many = less than 50; very many = less than 100 individuals; abundant: more than 100 individuals

Species	28.iv.1989	28.iv.2023
PAPILIONDAE		
<i>Atrophaneura aidoneus</i> (Doubleday, 1845)	A few fresh specimens	-
<i>Byasa dasarada</i> (Moore, 1858)	A few fresh males	-
<i>Graphium cashmirensis</i> (Rothschild 1895)	A few worn males and females	-
<i>Papilio agestor</i> Gray, 1831	2 worn females	-
PIERIDAE		
<i>Pieris brassicae</i> (Linnaeus, 1758)	Common	-
<i>Pieris canidia</i> (Linnaeus, 1768)	Common	-
<i>Gonepteryx nepalensis</i> Doubleday, 1847	Common	-
<i>Belenois aurota</i> (Fabricius, 1793)	1	-
RIODINIDAE		
<i>Dodona durga</i> (Kollar, [1844])	Abundant	-
<i>Dodona dipoea</i> Hewitson, 1866	Few, worn and fresh	-
<i>Dodona eugenes</i> Bates, [1868]	Few, worn	-
LYCAENIDAE		
<i>Heliophorus sena</i> (Kollar, [1844])	Fresh	-
<i>Celastrina huegeli</i> (Moore, 1882)/ <i>C. gigas</i> (Hemming 1928)	Fresh and worn specimens	-
<i>Pratapa icetas</i> (Hewitson, 1865)	1 female	-
<i>Rapala selira</i> (Moore, 1874)	Worn	-
NYMPHALIDAE		
<i>Mycalesis francisca</i> (Stoll, [1780])	2 fresh specimens	-
<i>Callerebia annada</i> (Moore, [1858])	Worn specimens	-
<i>Auzakia danava</i> (Moore, [1858])	Fresh males, worn females	-
<i>Athyma opalina</i> (Kollar, [1844])	Fresh, abundant	-
<i>Neptis soma</i> Moore, 1858	Few, worn specimens	-
<i>Junonia iphita</i> (Cramer, [1779])	Few, worn specimens	-
<i>Kaniska canace</i> (Linnaeus, 1763)	1	-
<i>Aglais caschmirensis</i> (Kollar, [1844])	1	-
<i>Libythea lepitata</i> Moore, [1858]	Fresh, many specimens	-

Table 3

Species	4.vi.1998	6.vi.1998	5.vi.2023
PAPILIONIDAE			
<i>Byasa dasarada</i> (Moore, 1858)	Few	Few	3
<i>Atrophaneura aidoneus</i> (Doubleday, 1845)	1 rotten, dead in stream		
<i>Graphium cloanthus</i> (Westwood, 1841)	Few	1	
<i>Graphium agamemnon</i> (Linnaeus, 1758)		1 female ovipositing	
PIERIDAE			
<i>Catopsilia pomona</i> (Fabricius, 1775)	Common		
<i>Pieris canidia</i> (Linnaeus, 1768)	Common		
<i>Pieris brassicae</i> (Linnaeus, 1758)			1 female
<i>Pontia daplidice</i> (Linnaeus, 1758)	Many between Bhimtal and Bhowali		
<i>Gonepteryx rhamni</i> Doubleday, 1847	Common		
<i>Delias sanaca</i> (Moore, 1857)	200+ dead in stream, hundreds on the wing	Few, mainly females	2
<i>Aporia agathon</i> (Gray, 1831)	200+ dead in stream, hundreds on the wing	Few	24
NYMPHALIDAE			
<i>Orinoma damaris</i> Gray, 1846	2	1	
<i>Lethe isana</i> (Kollar, [1844])	Common	Few	4
<i>Lethe confusa</i> Aurivillius, 1898			1
<i>Lethe sidonis</i> (Hewitson, 1863)	Several	Few	
<i>Callerebia nirmala</i> (Moore, 1865)	Very many	Many	29
<i>Ypthima nikaia</i> Moore,	Very many	Many	9

[1875]			
<i>Ypthima nareda</i> (Kollar, [1844])			1
<i>Lasioommata schakra</i> (Kollar, [1844])	Few	Few	
<i>Parantica aglea</i> (Stoll, [1782])	Several		
<i>Parantica sita</i> (Kollar, [1844])	Several	Several	1
<i>Euploea mulciber</i> (Cramer, [1777])		1 male	
<i>Athyma opalina</i> (Kollar, [1844])	Several	Several	1
<i>Neptis narayana</i> Moore, 1857	Several	Many	1
<i>Neptis mahendra</i> Moore, 1872	Several		
<i>Neptis sankara</i> (Kollar, [1844])	Several	Few	
<i>Neptis ananta</i> Moore, 1858		2	
<i>Neptis sappho</i> (Pallas, 1771)		Several	
<i>Neptis nata</i> Moore, [1858]		Few	
<i>Neptis soma</i> Moore, 1858			1
<i>Neptis miah</i> Moore, 1857			1
<i>Auzakia danava</i> (Moore, [1858])	1 female	1pair	1 female
<i>Euthalia patala</i> (Kollar, [1844])	4-5	Several	
<i>Sephis dichroa</i> (Kollar, [1844])	8-9	Few	2
<i>Pseudergolis wedah</i> (Kollar, 1848)	Several		
<i>Telchinia issoria</i> Huebner, [1819]	Several	Few	
<i>Phalanta phalantha</i> (Drury, [1773])	1 dead in water		

<i>Argynnis childreni</i> Gray, 1831	3	3	
<i>Symbrenthia niphanda</i> Moore, 1872		1	
<i>Kaniska canace</i> (Linnaeus, 1763)	Several	Several	
<i>Vanessa indica</i> (Herbst, 1794)	Several		
<i>Aglais caschmirensis</i> (Kollar, [1844])		1	
<i>Junonia iphita</i> (Cramer, [1779])	Several	Several	2
<i>Cyrestis thyodamas</i> Boisduval, 1846	Several	Several	2
RIODINIDAE			
<i>Dodona durga</i> (Kollar, [1844])	Many	Many	6
<i>Dodona dipoea</i> Hewitson, 1866	Many	Many	
<i>Dodona eugenae</i> Bates, [1868]	Many	Many	3
<i>Dodona ouida</i> Moore, 1866	1 female		
LYCAENIDAE			
<i>Inomataozephyrus syla</i> (Kollar, [1844])	Several	10	4
<i>Shirozuozephyrus birupa</i> (Moore, 1877)	1 male	2 males	1 female
<i>Thermozephyrus ataxus</i> (Westwood, 1851)		5 males	
<i>Shizuyaozephyrus ziha</i> (Hewitson, [1865])	Several	Many	
<i>Euaspa milionia</i> (Hewitson, 1869)	1 dead in stream		
<i>Chaetoprocta odata</i> (Hewitson, 1865)		2	
<i>Chliaria kina</i> (Hewitson, 1869)	Several		
<i>Arhopala rama</i> (Kollar, [1844])	Several	Few	2
<i>Arhopala dodonea</i>	Several	Few	

Moore, [1858]			
<i>Arhopala ganesa</i> (Moore, [1858])	Few	Many	4
<i>Ancema ctesia</i> (Hewitson, 1865)		1 male	
<i>Rapala nissa</i> (Kollar, [1844])	Several	Few	
<i>Spindasis nipalicus</i> (Moore, 1884)	1	Few	2
<i>Oreolyce vardhana</i> (Moore, [1875])	1	1	
<i>Aricia agestis</i> (Denis & Schiffermueller, 1775)		1	
<i>Acytolepis puspā</i> (Horsfield, [1828])	Several	Several	
<i>Celatoxia marginata</i> (de Niceville, 1884)	Several		
<i>Udara albocoerulea</i> (Moore, 1879)		Males	1
<i>Celastrina hugelii</i> (Moore, 1882)		Males and females	1 male
<i>Heliophorus sena</i> (Kollar, [1844])	Several	Several	1
<i>Lampides boeticus</i> (Linnaeus, 1767)	Several		

Data presented in Table 1 shows that, of the total 95 species recorded from Maheshkhan between 1986 and 2009, 56% did not appear in the survey in 2009 while 51% did not appear in 2023. That is, the emergence of more than half the butterfly species are affected in El Niño years and those that do emerge do so in much smaller numbers than in normal years.

Of interest is that out of a total of 95 species, 29.5% appeared both in 2009 and 2023; 14% of the species appeared only in 2009 while 19% of the species appeared only in 2023. 34% of the total species

recorded did not appear in both 2009 and 2023. It is likely that the 34% of species that did not appear in both 2009 and 2023 are exceptionally prone to desiccation during winter. Four species (5%) of those that did not appear in both the years were judged migrants, breeding at lower elevation (*Papilio demoleus* Linnaeus, 1758; *Danaus chrysippus* (Linnaeus, 1758); *D. genutia* (Cramer, [1779]) and *Phalanta phalantha* (Drury, [1773]) which means that 27 species (29%) of residents did not appear in both El Niño years.

An unusual observation in 2023 was the appearance of 12 species that had not been observed in the area in previous years. Of

these, *Ypthima baldus* (Fabricius, 1775) and *Y. nareda* were probably ignored earlier, as was *Prosotas nora* (C. Felder, 1860) (Smetacek, 2011). However, species such as *Neptis zaida* Doubleday, [1848], *N. miah*, *Symbrenthia lilaea* (Hewitson, 1864), *Libythea myrrha* Godart, 1819, *Lethe confusa*, *L. kansa* (Moore, 1857) and *Colias erate* (Esper, 1805) were definitely not present between 1986-2022. This would take the number of species recorded over the years from Maheshkhan to 107 species of which 44% were present in 2023. Although 44% appears a reasonable proportion for emergence in years of climatic irregularities, one needs to take into consideration the fact that populations were very low, usually less than 10 individuals encountered in a day compared to 20-50 and, in cases like *Delias sanaca*, *Aporia agathon*, *Dodona durga* (Kollar, [1844]), hundreds of individuals in a day during late May and early June. Also of interest is that all the 12 new species records for Maheshkhan are of butterflies previously recorded at lower elevations in

the area, usually in the Bhimtal-Sattal area and below, that is below 1500 m.

Regarding larval hostplants, of the 95 species of butterflies known from Maheshkhan, the larval hostplants of 9 species are unknown: these are *Auzakia danava*, *Neptis mahendra*, *Neptis sankara*, *Neptis ananta*, *Neptis narayana*; *Argynnis childreni*, *Euspa milionia*, *Shizuyaozephyrus ziha* and *Thermozephyrus ataxus* (Table 8) (Robinson *et al.*, 2010).

Of the 86 species whose larval hostplants are known, 6 are known to feed on climbers; *Atrophaneura aidoneus*, *Byasa polyeuctes* (Doubleday, 1842), *Byasa dasarada*, *Parantica aglea*, *Parantica sita* and *Kaniska canace* (Linnaeus, 1763). Of these 6 species, *Byasa polyeuctes* did not appear in 2009 and 2023, *P. aglea* and *P. sita* did not appear in 2009 (Table 4).

Table 4

Climber feeders	2009	2023	Absent in both years
<i>Atrophaneura aidoneus</i> (Doubleday, 1845)	Present	Present	
<i>Byasa polyeuctes</i> (Doubleday, 1842)	Present	-	
<i>Byasa dasarada</i> (Moore, 1858)	Present	Present	
<i>Parantica aglea</i> (Stoll, [1782])	-	-	Absent
<i>Parantica sita</i> (Kollar, [1844])	-	Present	
<i>Kaniska canace</i> (Linnaeus, 1763)	Present	Present	

Of the 95 species, 11 species, all Satyrinae, feed on monocotyledons, all Poaceae. Of these, *Mycalesis francisca* and

Neope pulaha (Moore, [1858]) did not appear in 2009 or 2023; *Lethe sidonis*, *Lasiommata schakra* and *Melanitis leda*

(Linnaeus, 1758) were present in 2009 but absent in 2023, while *Orinoma damaris* and *Callerebia annada* were absent in 2009 and present in 2023. The species that appeared in both 2009 and 2023 were *Lethe isana*, *Callerebia nirmala* and *Ypthima nikaea*. In addition, in 2023, *Lethe kansa* (Moore, 1857), *Callerebia*

hybrida Butler, 1880, *Lethe confusa*, *Ypthima baldus*, *Y. nareda* and *Y. sakra* Moore, 1857 were recorded, which were never before recorded from Maheshkhan. In short, 8 of the total of 17 species of Satyrinae ever recorded from Maheshkhan were active in 2009, while 13 of the 17 species were active in 2023 (Table 5).

Table 5

Monocotyledon feeders	2009	2023	Absent in both years
<i>Mycalesis francisca sanatana</i> Moore, [1858]	-	-	Absent
<i>Melanitis leda</i> (Linnaeus, 1758)	Present	-	
<i>Lethe sidonis</i> (Hewitson, 1863)	Present	-	
<i>Lethe isana</i> (Kollar, [1844])	Present	-	
<i>Lethe verma</i> (Kollar, [1844])	Present	-	
<i>Lethe kansa</i> (Moore, 1857)	-	Present	
<i>Lethe confusa</i> Aurivillius, 1898	-	Present	
<i>Neope pulaha</i> (Moore, [1858])	-	-	Absent
<i>Lasiommata schakra</i> (Kollar, [1844])	Present	-	
<i>Orinoma damaris</i> Gray, 1846	-	-	
<i>Callerebia annada</i> (Moore, [1858])	-	-	
<i>Callerebia nirmala</i> (Moore, 1865)	Present	-	
<i>Callerebia hybrida</i> Butler, 1880	-	Present	
<i>Ypthima nikaea</i> Moore, [1875]	Present	-	
<i>Ypthima nareda</i> (Kollar, [1844])	-	Present	
<i>Ypthima sakra</i> Moore, 1857	-	Present	
<i>Ypthima baldus</i> (Fabricius, 1775)	-	Present	

Regarding the 9 species that feed on herbs and non-woody shrubs, 5 species, namely, *Pontia daplidice*, *Issoria lathonia* (Linnaeus, 1758), *Aricia agestis*, *Lycaena panava* and *Pseudozizeeria maha*, did not appear in both 2009 and 2023. 4 species, i.e. *Pieris brassicae*, *Pieris canidia*, *Colias fieldii* Menetries, 1855 and *Lampides boeticus* appeared both in 2009 and 2023. There were no herb feeders that appeared in one of these years and not in the other (Table 6). However, *Colias erate* (Esper, 1805), an herb feeder, was recorded twice in 2023 and represents an addition to the butterflies recorded in Maheshkhan forest.

Smetacek (2002) noted that the population of *Pontia daplidice* collapsed in Nainital district during summer 1999, since the failure of the winter rains during 1998-1999 prevented its larval hostplant, *Lepidium virginicum*, from germinating over most of the district. The population subsequently recovered in the next year. It is of interest that 1997-98 was regarded as one of the most powerful El Niño - Southern Oscillation events in recorded history (Slingo & Annamalai, 2000). Unfortunately, the butterflies of Maheshkhan forest were not surveyed at all in 1999.

Table 6

Herbs and annuals	2009	2023	Absent in both years
<i>Pieris brassicae</i> (Linnaeus, 1758)	Present	Present	
<i>Pieris canidia</i> (Linnaeus, 1768)	Present	Present	
<i>Colias fieldii</i> Menetries, 1855	Present	Present	
<i>Pontia daplidice</i> (Linnaeus, 1758)	-	-	Absent
<i>Issoria lathonia</i> (Linnaeus, 1758)	-	-	Absent
<i>Aricia agestis</i> (Denis & Schiffermueller, 1775)	-	-	Absent
<i>Pseudozizeeria maha</i> (Kollar, [1844])	-	-	Absent
<i>Lampides boeticus</i> (Linnaeus, 1767)	Present	Present	
<i>Lycaena panava</i> (Westwood, 1852)	-	-	Absent

Of the 60 species that feed on woody dicotyledons excluding climbers, 18 species were present in both 2009 as well as 2023, and 19 were absent in both these

years, representing 30% and 32% respectively of the total. 9 of the 60 species were present in 2009 and not in 2023 while 12 of the 60 species were

present in 2023 but not in 2009. Species that are known to feed on *Quercus leucotrichophora*, namely *Euthalia patala*, *Sephisa dichroa*, *Arhopala dodonea*, *Shirozuozeephyrus birupa*, *Inamataozeephyrus syla*, *Arhopala rama* and *A. ganesa* were present in both 2009 and 2023, although at very low density. It is of interest that 57% of the 7 species that

feed on *Q. leucotrichophora* were not recorded in 2009, while 100% appeared in 2023 (Table 9). Similarly, species that are known to feed on *Berberis chitria* Buch.-Ham. ex Ker Gawl., namely *Aporia agathon* and *Athyma opalina* were also present in both years, again at much lower densities than normal (Table 7).

Table 7

Woody shrubs /tree feeders	2009	2023	Absent in both years
<i>Papilio agestor</i> Gray, 1831	Present	-	
<i>Papilio protenor</i> Cramer, [1775]	Present	-	
<i>Papilio demoleus</i> Linnaeus, 1758	-	-	
<i>Graphium sarpedon</i> (Linnaeus, 1758)	-	-	Absent
<i>Graphium cloanthus</i> (Westwood, 1841)	-	Present	
<i>Graphium cashmirensis</i> (Rothschild, 1895)	Present	-	
<i>Aporia soracta</i> Moore, 1857	-	-	
<i>Aporia agathon</i> (Gray, 1831)	Present	Present	
<i>Delias belladonna</i> (Fabricius, 1793)	Present	-	
<i>Delias sanaca</i> (Moore, 1857)	-	Present	
<i>Gonepteryx rhamni</i> Doubleday, 1847	Present	-	
<i>Eurema hecabe</i> (Linnaeus, 1758)	Present	-	
<i>Belenois aurota</i> (Fabricius, 1793)	Present	Present	
<i>Catopsilia pomona</i> (Fabricius, 1775)	Present	-	
<i>Euploea mulciber</i> (Cramer, [1777])	-	Present	
<i>Danaus chrysippus</i> (Linnaeus, 1758)	-	-	Absent
<i>Danaus genutia</i> (Cramer, [1779])	-	-	Absent
<i>Polyura dolon</i> (Westwood, 1847)	-	-	Absent
<i>Sephisa dichroa</i> (Kollar, [1844])	-	Present	
<i>Euthalia patala</i> (Kollar, [1844])	-	Present	
<i>Athyma opalina</i> (Kollar, [1844])	Present	Present	
<i>Neptis sappho</i> (Pallas, 1771)	-	Present	

<i>Neptis soma</i> Moore, 1858	-	Present	
<i>Cyrestis thyodamas</i> Boisduval, 1846	Present	Present	
<i>Pseudergolis wedah</i> (Kollar, 1848)	-	Present	
<i>Junonia iphita</i> (Cramer, [1779])	Present	Present	
<i>Vanessa cardui</i> (Linnaeus, 1758)	Present	Present	
<i>Vanessa indica</i> (Herbst, 1794)	Present	Present	
<i>Aglais cashmirensis</i> (Kollar, [1844])	-	-	Absent
<i>Symbrenthia niphanda</i> Moore, 1872	-	-	Absent
<i>Phalanta phalantha</i> (Drury, [1773])	-	-	Absent
<i>Telchinia issoria</i> (Huebner, [1819])	-	Present	
<i>Libythea lepita</i> Moore, [1858]	-	-	Absent
<i>Dodona durga</i> (Kollar, [1844])	Present	Present	
<i>Dodona dipoea</i> Hewitson, 1866	Present	Present	
<i>Dodona eugenes</i> Bates, [1868]	Present	Present	
<i>Dodona ouida</i> Moore, 1866	-	-	Absent
<i>Abisara fylla</i> (Westwood, 1851)	-	-	
<i>Acytolepis puspa</i> (Horsfield, [1828])	-	-	Absent
<i>Oreolyce vardhana</i> (Moore, [1875])	-	-	Absent
<i>Udara albocaerulea</i> (Moore, 1879)	-	Present	
<i>Celastrina argiolus</i> (Linnaeus, 1758)	-	Present	Absent
<i>Celastrina hugelii</i> (Moore, 1882)	Present	Present	
<i>Celastrina gigas</i> (Hemming, 1928)	Present	Present	
<i>Heliophorus sena</i> (Kollar, [1844])	-	Present	
<i>Shirozuozeephyrus birupa</i> (Moore, 1877)	-	Present	
<i>Inomataozeephyrus syla</i> (Kollar, [1844])	-	Present	
<i>Arhopala dodonea</i> Riley & Godfrey, 1921	Present	Present	
<i>Arhopala rama</i> (Kollar, [1844])	Present	Present	
<i>Arhopala ganesa</i> (Moore, [1858])	Present	Present	

<i>Spindasis nipalicus</i> (Moore, 1884)	Present	Present	
<i>Chaetoprocta odata</i> (Hewitson, 1865)	-	-	Absent
<i>Ancema ctesia</i> (Hewitson, 1865)	-	-	Absent
<i>Pratapa icetas</i> (Hewitson, 1865)	-	-	Absent
<i>Tajuria illurgioides</i> de Niceville, 1890	-	-	Absent
<i>Horaga onyx</i> (Moore, 1858)	Present	-	
<i>Chilaria kina</i> (Hewitson, 1869)	-	-	Absent
<i>Rapala manea schistacea</i> (Moore, 1879)	-	Present	
<i>Rapala selira</i> (Moore, 1874)	-	-	Absent
<i>Rapala nissa</i> (Kollar, [1844])	-	Present	

Species that feed on climbers, that is, *Aristolochia dilatata* N.E.Br. for *Byasa* Moore, 1882 and *Atrophaneura* Reakirt, [1865] and *Smilax* for *Kaniska* Moore, 1899, were present in both years, although *Byasa polyeuctes* was absent in 2023 (Table 4). Of the 5 species that feed on parasitic plants, i.e. Lorantheae, the Lycaenidae (*Ancema ctesia*, *Pratapa icetas* and *Tajuria illurgioides*) were

entirely absent in 2009 and 2023, while of the two Pieridae, *Delias belladonna* was present in 2009 but not in 2023 and *D. sanaca* (Moore, 1857) was absent in 2009 but present at very low density in 2023.

Table 8 lists those butterfly species whose larval hostplants are unknown. It is likely that most of them feed on woody shrubs or trees, judging from closely related species or genera where the larval hostplants are known.

Table 8

Larval food plant unknown	2009	2023	Absent in both years
<i>Auzakia danava</i> (Moore, [1858])	-	Present	
<i>Neptis mahendra</i> Moore, 1872	-	-	Absent
<i>Neptis sankara</i> (Kollar, [1844])	-	Present	
<i>Neptis ananta</i> Moore, 1858	-	-	Absent
<i>Neptis narayana</i> Moore, 1857	Present	Present	
<i>Argynnis childreni</i> (Gray, 1831)	-	-	Absent
<i>Euspa milionia</i> (Hewitson, 1869)	-	-	Absent
<i>Shizuyaozephyrus ziha</i> (Hewitson, [1865])	-	-	Absent
<i>Thermozephyrus ataxus</i> (Westwood, 1851)	-	-	Absent

Table 9

<i>Quercus leucotrichophora</i> and <i>Quercus floribunda</i> feeders	2009	2023
<i>Sephisa dichroa</i> (Kollar, [1844])	-	Present
<i>Euthalia patala</i> (Kollar, [1844])	-	Present
<i>Shirozuozeephyrus birupa</i> (Moore, 1877)	-	Present
<i>Inomataozeephyrus syla</i> (Kollar, [1844])	-	Present
<i>Arhopala dodonea</i> Riley & Godfrey, 1921	Present	Present
<i>Arhopala rama</i> (Kollar, [1844])	Present	Present
<i>Arhopala ganesa</i> (Moore, [1858])	Present	Present

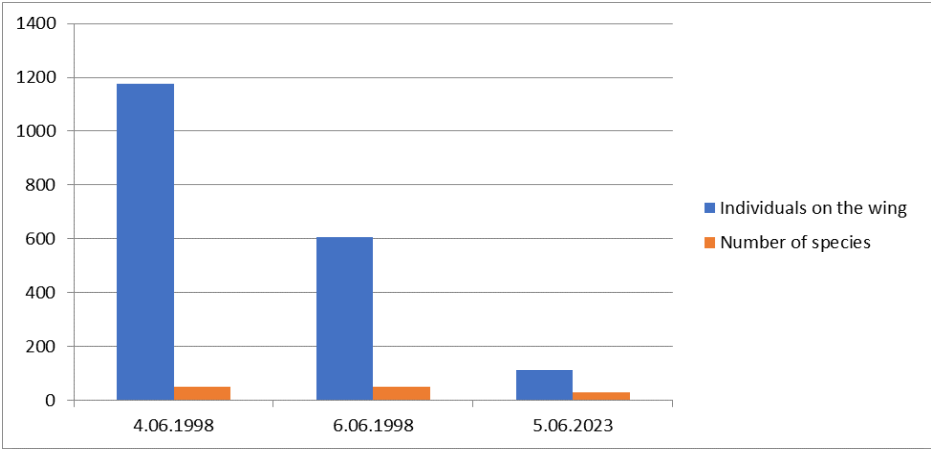


Figure 1. Showing number of individuals (blue) and species (brown) on the wing

Table 10

Year 2022	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity %	Total rainfall (mm)
January	10.86	9.54	77.36	106
February	12.06	10.65	68.44	72.4
March	21.13	19.10	52.05	0
April	26.27	24.37	34.34	0.8
May	24.52	22.75	65.82	58.2
June	26.96	24.79	62.98	2
July	24.90	23.77	86.62	N/A
August	24.40	23.26	87.91	68.8
September	22.96	21.71	87.44	28.6
October	19.27	18.05	78.26	2.6
November	16.20	14.58	69.09	0
December	14.24	12.34	62.51	2.2
Year 2023	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity %	Total rainfall (mm)
January	16.45	9.51	80.67	0
February	24.35	12.64	61.05	0
March	28.87	19.67	58.35	N/A
April	21.31	19.14	46.64	2
May	22.82	21.07	62.48	1.2

June	25.85	24.16	68.14	68.2
July	24.11	22.90	90.33	451.2

(Data in Table 10 indicates no winter rainfall in the first two months of 2023. Data has been taken from Jeolikote Forest Research Centre, Uttarakhand. Rainfall data for July, 2022 and March, 2023 is not available.)

CONCLUSION

From the above, it seems likely that the lack of precipitation during winter months can devastate butterfly communities at elevations of 1600-2400 m in the western Himalaya. The main reason as suggested by Smetacek (2011) might be desiccation of the pupae during the dry winter and following spring. However, there might equally well be a bouquet of causes and consequences relevant to El Niño years that result in the decimation of butterfly communities in this forest. Anecdotal personal observations from 2023 in other forests at similar elevation by other workers in Nepal, Sikkim and parts of Uttarakhand indicate a similar decimation of butterfly communities there, suggesting that this phenomenon is probably not restricted to Maheshkhan forest but widespread in the Himalaya.

Regarding the effect on appearance of species in El Nino years due to the type of host plant, it appears that butterflies using climbers as host plant are a bit less affected than those using other host plants, but the climber sample is rather small (2/3 versus usually <1/2 of the species present).

ACKNOWLEDGEMENT

We would like to thank Mr. Sanjeev Chaturvedi, CCF, Uttarakhand Forestry Research Institute for support and encouragement throughout the research work as well as Mr. H.S. Garia, R.F.O., Jeolikote, Nainital.

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