EL NIÑO YEARS DECIMATE BUTTERFLY COMMMUNITY 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, *Sephisa 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. Hesperiidae 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 than10; common = less than 25; many = less than 50; very many = less than100 individuals; abundant: more than 100 individuals

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

Table 3

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

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

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

Moore, [1858]			
Arhopala ganesa (Moore, [1858])	Few	Many	4
Ancema ctesia (Hewitson, 1865)		1 male	
Rapala nissa (Kollar, [1844])	Several	Few	
Spindasis nipalicus (Moore, 1884)	1	Few	2
Oreolyce vardhana (Moore, [1875])	1	1	
Aricia agestis (Denis & Schiffermueller, 1775)		1	
Acytolepis puspa (Horsfield, [1828])	Several	Several	
Celatoxia marginata (de Niceville, 1884)	Several		
Udara albocoerulea (Moore, 1879)		Males	1
Celastrina hugelii (Moore, 1882)		Males and females	1 male
Heliophorus sena (Kollar, [1844])	Several	Several	1
Lampides boeticus (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*, *Euaspa 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**
Atrophaneura aidoneus (Doubleday, 1845)	Present	Present	
Byasa polyeuctes (Doubleday, 1842)	Present	-	
Byasa dasarada (Moore, 1858)	Present	Present	
Parantica aglea (Stoll, [1782])	-	-	Absent
Parantica sita (Kollar, [1844])	-	Present	
Kaniska canace (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**
Mycalesis francisca sanatana Moore, [1858]	-	-	Absent
Melanitis leda (Linnaeus, 1758)	Present	-	
Lethe sidonis (Hewitson, 1863)	Present	-	
Lethe isana (Kollar, [1844])	Present	-	
Lethe verma (Kollar, [1844])	Present	-	
Lethe kansa (Moore, 1857)	-	Present	
Lethe confusa Aurivillius, 1898	-	Present	
Neope pulaha (Moore, [1858])	-	-	Absent
Lasiommata schakra (Kollar, [1844])	Present	-	
Orinoma damaris Gray, 1846	-	-	
Callerebia annada (Moore, [1858])	-	-	
Callerebia nirmala (Moore, 1865)	Present	-	
Callerebia hybrida Butler, 1880	-	Present	
Yphthima nikaea Moore, [1875]	Present	-	
Ypthima nareda (Kollar, [1844])	-	Present	
Ypthima sakra Moore, 1857	-	Present	
Ypthima baldus (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**
Pieris brassicae (Linnaeus, 1758)	Present	Present	
Pieris canidia (Linnaeus, 1768)	Present	Present	
Colias fieldii Menetries, 1855	Present	Present	
Pontia daplidice (Linnaeus, 1758)	-	-	Absent
Issoria lathonia (Linnaeus, 1758)	-	-	Absent
Aricia agestis (Denis & Schiffermueller, 1775)	-	-	Absent
Pseudozizeeria maha (Kollar, [1844])	-	-	Absent
Lampides boeticus (Linnaeus, 1767)	Present	Present	
Lycaena panava (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*, *Shirozuozephyrus birupa*, *Inamataozephyrus 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**
Papilio agestor Gray, 1831	Present	-	
Papilio protenor Cramer, [1775]	Present	-	
Papilio demoleus Linnaeus, 1758	-	-	
Graphium sarpedon (Linnaeus, 1758)	-	-	Absent
Graphium cloanthus (Westwood. 1841)	-	Present	
Graphium cashmirensis (Rothschild, 1895)	Present	-	
Aporia soracta Moore, 1857	-	-	
Aporia agathon (Gray, 1831)	Present	Present	
Delias belladonna (Fabricius, 1793)	Present	-	
Delias sanaca (Moore, 1857)	-	Present	
Gonepteryx rhamni Doubleday, 1847	Present	-	
Eurema hecabe (Linnaeus, 1758)	Present	-	
Belenois aurota (Fabricius, 1793)	Present	Present	
Catopsilia pomona (Fabricius, 1775)	Present	-	
Euploea mulciber (Cramer, [1777])	-	Present	
Danaus chrysippus (Linnaeus, 1758)	-	-	Absent
Danaus genutia (Cramer, [1779])	-	-	Absent
Polyura dolon (Westwood, 1847)	-	-	Absent
Sephisa dichroa (Kollar, [1844])	-	Present	
Euthalia patala (Kollar, [1844])	-	Present	
Athyma opalina (Kollar, [1844])	Present	Present	
Neptis sappho (Pallas, 1771)	-	Present	

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

Spindasis nipalicus (Moore, 1884)	Present	Present	
Chaetoprocta odata (Hewitson, 1865)	-	-	Absent
Ancema ctesia (Hewitson, 1865)	-	-	Absent
Pratapa icetas (Hewitson, 1865)	-	-	Absent
Tajuria illurgioides de Niceville, 1890	-	-	Absent
Horaga onyx (Moore, 1858)	Present	-	
Chilaria kina (Hewitson, 1869)	-	-	Absent
Rapala manea schistacea (Moore, 1879)	-	Present	
Rapala selira (Moore, 1874)	-	-	Absent
Rapala nissa (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. Loranthaceae, 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**
Auzakia danava (Moore, [1858])	-	Present	
Neptis mahendra Moore, 1872	-	-	Absent
Neptis sankara (Kollar, [1844])	-	Present	
Neptis ananta Moore, 1858	-	-	Absent
Neptis narayana Moore, 1857	Present	Present	
Argynnis childreni (Gray, 1831)	-	-	Absent
Euaspa milionia (Hewitson, 1869)	-	-	Absent
Shizuyaozephyrus ziha (Hewitson, [1865])	-	-	Absent
Thermozephyrus ataxus (Westwood, 1851)	-	-	Absent

Table 9

Quercus leucotrichophora and *Quercus floribunda* feeders	2009	2023
Sephisa dichroa (Kollar, [1844])	-	Present
Euthalia patala (Kollar, [1844])	-	Present
Shirozuozephyrus birupa (Moore, 1877)	-	Present
Inomataozephyrus syla (Kollar, [1844])	-	Present
Arhopala dodonea Riley & Godfrey, 1921	Present	Present
Arhopala rama (Kollar, [1844])	Present	Present
Arhopala ganesa (Moore, [1858])	Present	Present

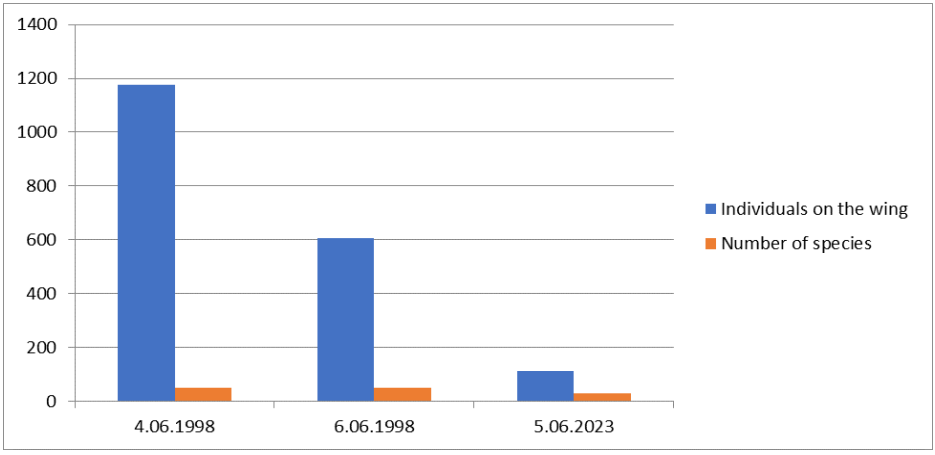

Figure 1. Showing number of individuals (blue) and species (brown) on the wing

Table 10

Year 2022	**Maximum temperature (^{0}C)**	**Minimum temperature (^{0}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 (^{0}C)**	**Minimum temperature (^{0}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).

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