

# High Altitude Papilioidea (Lepidoptera) Of Tsaghkunyats mountains In Armenia and their diversity along the altitudinal gradient

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## Abstract

*This study tries to link the butterfly species diversity along the altitudinal span of Tsaghkunyats mountain in Armenia. Butterflies were collected from March to October 2015-2017. A checklist of 129 species is given and their abundances/diversity was calculated for 10 altitudinal zones. This revealed that the relationship between the observed numbers and abundance of butterfly species and altitude follows hump-shaped curve – i.e the highest diversity in the mid elevation. A significant relationship was recorded between the altitude and the species richness and abundance and the relation followed the usual hump-shaped curve. However, the diversity and evenness indexes did not follow the hump-shaped pattern, but yielded a semi-constant relation with altitude. This could be explained by the existence of several species that typically found only on the highest altitudes. These results could be applied for habitat management in general and especially for planning of Protected Areas in this region.*

**Keywords:** Abundance, Armenia, evenness, Diversity, Papilioidea, Species richness.

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## Introduction

The mountain masses are initially characterized, with individual unique physical parameters that vary along altitudinal gradients inquired in isolation and combination. The responses of butterflies to these gradients, either directly or through their host plant, are discussed at the levels of the individual and sometimes population and community (Mani 1990). The high altitude ecosystem with various tree and shrub cover mountain could have complex habitat patterns within the landscape. They could host a mosaic of different habitat types, vegetation covers and microclimates. Utilization of these mosaic patches by different plants and animals reflects their specific life history strategies and ability to exploit a particular type of habitat at a particular altitude (Haslett 1997; Hodkinson 2005). Patterns in the altitudinal distribution of species richness have frequently been cited as compelling evidence for hypotheses that propose associations with productivity and ambient energy, as well as past and current climate, since these factors vary with altitude (Rahbek 2005). Therefore, it appears that the changes in species richness with altitude may be determined by more complicated mechanisms than previously believed. Proceeding from the same principle, many papers had published about vertical distribution of butterflies in Central Asia; which brought a new scientific experience in this field (Korb, 1994).

This study reflects the altitudinal distribution of butterflies in such mountainous area and the influence of altitude on their richness and abundance.

## **Materials And Methods**

### **Study sites**

Tsaghkunyats Mountain is part of Tsaghkunyats ridge of Armenia, which is situated mainly in the provinces of Kotayk and Aragatsotn. This is the main branch of Pambak mountains mass, ranges from Ughtakar Mountain in the South-East, to the right bank of Hrazdan River. Its length is 42 km and the highest peak Tegenis Mountain (2851 m).

The range is formed by a volcanic activity during the period from Pleistocene to Holocene and lava domes and cinder cones present the evidences of this activity

The climate is temperate, annual precipitation is 600-800 mm.

Tsaghkunyats Mountain represents a divider of Kasakh and Hrazdan rivers basins. It has a block mountains origin. The outer slopes are generally gentle, with many small gorges and a few large valleys. The tributaries of Dalar, Arai, Marmarik, Hrazdan and Kasakh begin at these slopes. Mountain-steppes, mountain-forests and mountain-meadows are the most common landscapes, but the most of the altitudinal range, up to 2,400 meters, is forested.

The eastern slopes (up to 2,300 m) are covered with oak, maple, orchard forests. This region is known as a resort zone. Here are the Hankavan, Tsaghkadzor, Bjni, Aghveran, Arzakan and Buzhakan. Tsakhkadzor is connected to the Tsaghkunyats peak by a three-tier ropeway.

Ten sites in Tsaghkunyats Mountains on the higher altitudes were sampled for this study (Figure 1, 2, and Table 1). These sites were selected based on accessibility from the lowest (Minasar, 1650 m) to the highest altitude (Teghenis, 2814 m). Sites were designated as either riparian or upland, depending on their proximity to the streams and springs. Altitudinal area (ha) data for Tsaghkunyats mountains was obtained from the Scientific center of Hydroecology and zoology Institute of NAS RA.

### **Butterfly data and sampling**

The Lepidopteran species targeted included the butterfly's families under the suborder of Papilioidea and five readily identifiable families (Hesperiidae, Papilionidae, Pieridae, Lycaenidae and Nymphalidae). A total of 2114 individuals belonging to 129 species were identified (table 4). Five families were represented in the collections by the following numbers of species Hesperiidae (16), Papilionidae (5), Pieridae (21) Lycaenidae (38), Nymphalidae (49) (See Table 1 for a species list). The study is based mainly on the analysis of our own materials, collected in all above mentioned sites. The material was collected during expeditions, conducted in 2005-2017. Specimens were collected using a sweep net and killed in killing jars with ethyl acetate. Each specimen was put into a labeled envelope and brought to the laboratory to be spread and dried.

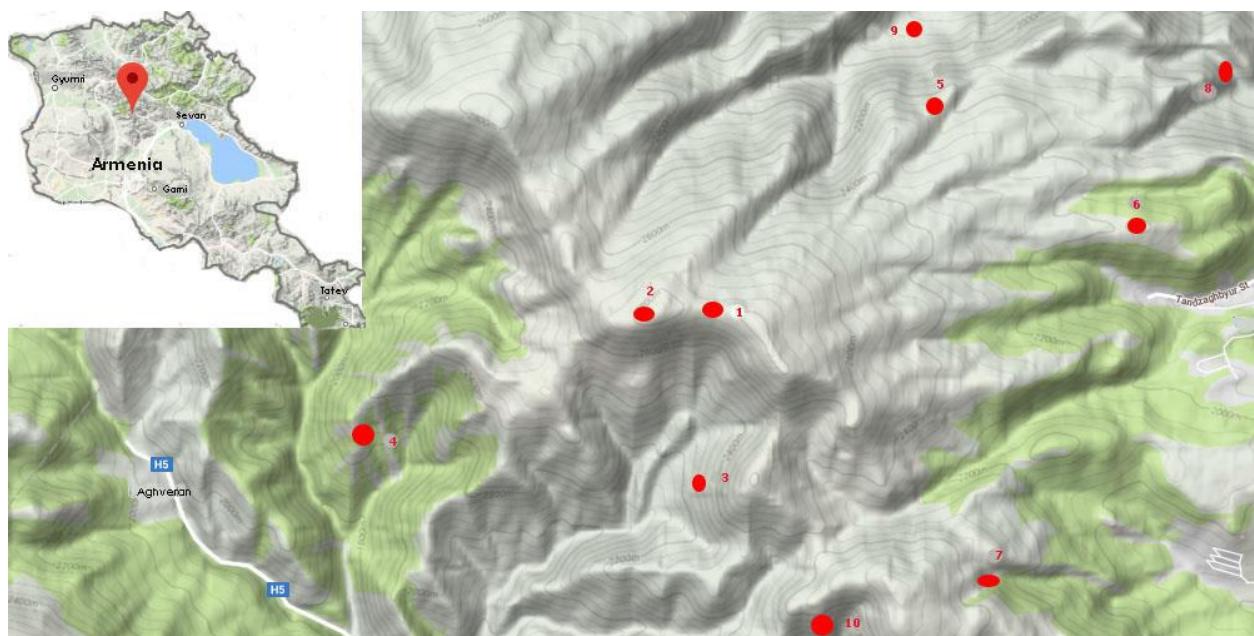


Figure1. Study Sites at Tsaghkunyats mountain, Armenia . 1.T'eghenis Lerr, 2.Tsaghkunyats', 3.Dalar, 4.Aghveran, 5.T'easar, 6.Chakat, 7.Chermak K'ari, 8.Tsaghkadzor, 9.Karmir Aghbyur, 10.Minasar.

Identification was carried out using the guides of Hesselbarth et al. (1995), Tuzov et al. (1997), Bozano (1999-2012), Kawahara and Breinholt (2014), Korb and Bolshakov (2016), and by comparison with author's reference collections. Besides, all available literature and collection data were taken into account.

Table 1. Description of the sites sampled in Tsaghkunyats mountain, Armenia.

| No | Site           | Site type         | Vegetation type                          | Coordinates               | Altitude (m) |
|----|----------------|-------------------|--|---------------------------|--------------|
| 1  | T'eghenis Lerr | upland            | Alpine vegetation*                       | N 40°53'173" E 44°64'589" | 2814         |
| 2  | Tsaghkunyats'  | upland            | Alpine vegetation                        | N 40°53'192" E 44°63'348" | 2735         |
| 3  | Dalar          | upland            | Subalpine vegetation**                   | N 40°51'392" E 44°64'728" | 2402         |
| 4  | Aghveran       | riparian          | Subalpine vegetation                     | N 40°52'581" E 44°57'29"  | 2300         |
| 5  | T'easar        | upland            | Subalpine vegetation                     | N 40°54'59" E 44°67'23"   | 2180         |
| 6  | Chakat         | upland            | Xeric grass and semi-shrub vegetation*** | N 40°54'169" E 44°70'007" | 2013         |
| 7  | Chermak K'ari  | riparian          | Xeric grass and semi-shrub vegetation    | N 40°48'328" E 44°68'048" | 1985         |
| 8  | Tsaghkadzor    | forests           | Hemi-xeric woodland vegetation****       | N 40°55'829" E 44°71'527" | 1813         |
| 9  | Karmir Aghbyur | Riparian &forests | Hemi-xeric woodland vegetation           | N 40°56'671" E 44°68'329" | 1781         |
| 10 | Minasar        | upland            | Hemi-xeric steppe vegetation*****        | N 40°47'089" E 44°65'289" | 1650         |

\*Alpine vegetation. The upper part of the alpine zone known for its dense vegetation and open coexistences diversity. Dense coexistence main types are the ruggs, which consisting of *Campanula tridentata*, *Chamaesciadium acaule*, *Carum caucasicum*, *Taraxacum stevenii*, *Minuartia oreina*, *Cerastium cerastoides*, *Bellardiachloa polychroa*. Alpine grasslands

include (*Festuca varia*, *F. chalcophaea*, *Alopecurus aucheri*, *Carex tristis*) and mats include *Sibbaldia parviflora*, *Alchemilla erythropoda*.

\*\* Subalpine vegetation. Subalpine woodland and grassland zone includes: - *Quercus macranthera* woodlands; - steppes (*Festuca valesiaca*, *Koeleria cristata*, *Sesleria phleoides*) subalpine meadows (*Bromopsis variegata*, *Phleum nodosum*, *Koeleria caucasica*); - meadow steppes (*Festuca valesiaca*, *F. ovina*, *Bromopsis variegata*, *Sesleria phleoides*).

\*\*\* Xeric grass and semi-shrub vegetation. This includes: - tomillares (*Thymus kotschianus*, *Scutellaria spp.*, *Stachchys inflata*); - friganoids (*Ambliopogon spp.*, *Caccinia rauwolffii*, *Hedysarum formosum*); - thorn-cushion communities (*Astragalus microcephalus*, *Onobrychis cornuta*, *Acantholimon glumaceum*); - steppes (*Stipa spp.*, *Festuca valesiaca*, *Bromopsis riparia*, *Carex humilis*).

\*\*\*\* Hemi-xeric woodland vegetation. This one includes: - *Quercus macranthera* woodlands; - low woodlands (*Pyrus spp.*, *Acer hyrcanum*, *Crataegus spp.*, *Juniperus polycarpos*); - hemi-xeric shrublands (*Cotoneaster spp.*, *Sorbus graeca*); - steppes (*Stipa tirsia*, *Festuca valesiaca*, *Koeleria cristata*, *Nepeta grossheimii*); - thorn-cushion communities (*Astragalus spp.*, *Onobrychis cornuta*, *Acantholimon glumaceum*); - meadow steppes (*Festuca ovina*, *Poa densa*, *Phleum phleoides*, *Carex humilis*) (Voskanian 1976; Baloyan 1987; Zazanashvili et al. 2000)



a.



b.

Figure.2 Tsaghkunyatc mountain. View from a. Tsaghkadzor b.Aghveran.

### Data analysis

The samples of butterflies for the two years were used in further analysis. In order to see how butterfly diversity changes with altitude several indices were calculated. Species richness (total number of species), abundance (total number of individuals), Simpson's diversity index (D) and the Shannon evenness index (E) were calculated for each site (altitude). Simpson's diversity index calculates the probability of any two individuals drawn at random from an infinitely large community belonging to the same species (Magurran 2003). The Shannon evenness index is  $H' / (\ln S)$  where  $H'$  is the Shannon diversity index and  $(\ln S)$  is the logtransformed species richness. Altitude, altitudinal area, species richness, and abundance were log-transformed prior to analysis.

Relationships among altitude, species richness, abundance, diversity and butterflies evenness

was also investigated. Prior to this analysis, the variables representing altitude, altitudinal area, species richness and abundance were log transformed. First, a correlation analyses between four dependent variables (species richness, abundance, Simpson's and Shannon evenness index) and altitude were executed to determine how species diversity indices correlate with altitude. Second, a piecewise regression was carried out with a breakpoint at 2180 m (Tevasar). The two models were combined into a single model by creating four new variables. Two of the new variables, alt1 and alt2, represent the effect of altitude on species richness above and below 2013 m, respectively:

$$\text{alt1} = (\text{altitude} - 2180), \text{ if } (\text{altitude} \geq 2013) \text{ alt1} = 0$$

$$\text{alt2} = (\text{altitude} - 2180), \text{ if } (\text{altitude} < 2013) \text{ alt2} = 0$$

The other two new variables, int1 and int2, represent the intercepts below and above 2090 m, respectively:

$$\text{int1} = 1, \text{ if } (\text{altitude} \geq 2013) \text{ int1} = 0$$

$$\text{int2} = 1, \text{ if } (\text{altitude} < 2013) \text{ int2} = 0$$

Shannon evenness is a measure of heterogeneity that considers the degree of evenness in species abundances in terms of the ratio of observed diversity to maximum diversity (Magurran 2003). All correlations and piecewise regression analyses were carried out using SPSS software (SPSS Inc. 2006).

## Results

**Table 2.** Summary of the species richness (total number of species), abundance (total number of individuals), Simpson's diversity (D) and Shannon's evenness (E) indices recorded at each of the sites.

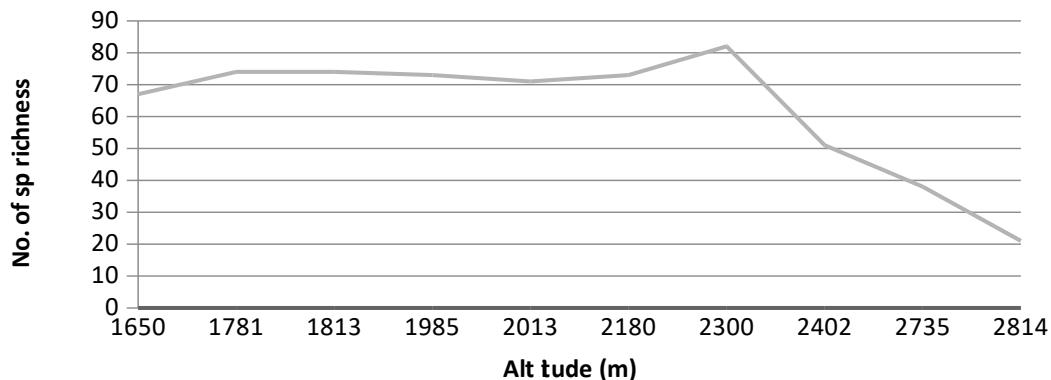
| Site | species richness | abundance | Simpson's diversity (1-D) | Shannon's evenness (E) |
|------|------------------|-----------|---------------------------|------------------------|
| 1    | 21               | 36        | 0.92                      | 0.757                  |
| 2    | 38               | 72        | 0.98                      | 0.624                  |
| 3    | 51               | 122       | 0.98                      | 0.576                  |
| 4    | 82               | 241       | 0.88                      | 0.460                  |
| 5    | 73               | 223       | 0.98                      | 0.526                  |
| 6    | 71               | 259       | 0.98                      | 0.529                  |
| 7    | 73               | 300       | 0.98                      | 0.526                  |
| 8    | 74               | 286       | 0.98                      | 0.526                  |
| 9    | 74               | 312       | 0.98                      | 0.526                  |
| 10   | 67               | 398       | 0.98                      | 0.538                  |

**Table 3.** Regression analysis of the abundance, species richness, diversity and evenness of butterflies.

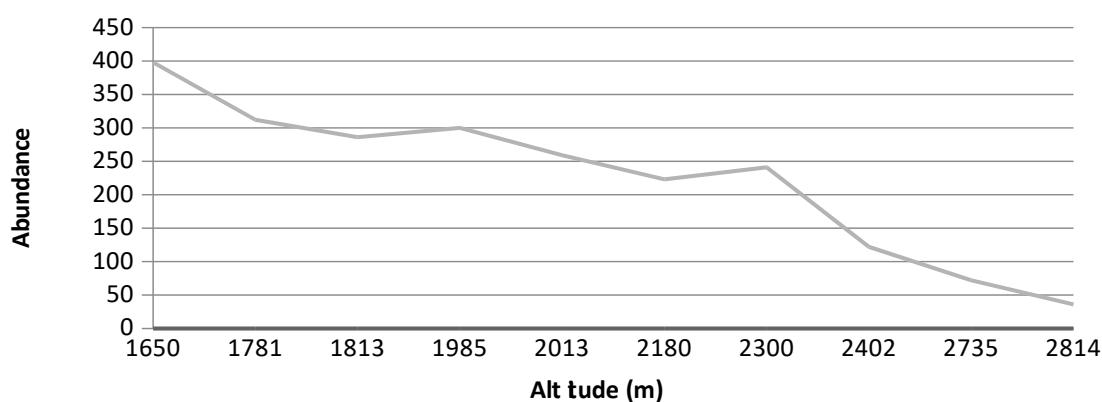
| Dependent variable | R <sup>2</sup> | F      | Independent variable |
|--------------------|----------------|--------|----------------------|
|                    |                |        | Altitude             |
| Species richness   | 0.72           | 17.956 | -0.848               |
| Abundance          | 0.92           | 83.827 | -0.961               |
| Diversity          | 0.15           | 1.267  | -0.391               |
| Evenness           | 0.54           | 8.46   | -0.74                |

Note: P < 0.01.

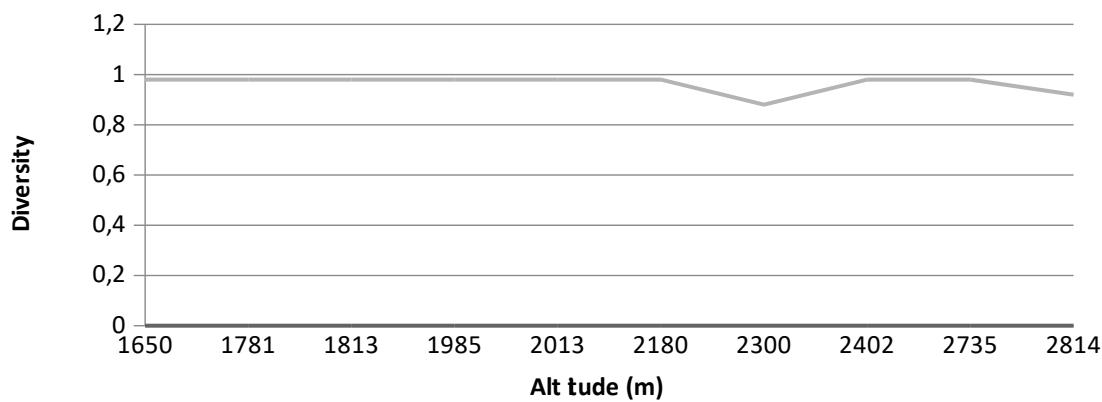
The results of our species diversity analysis are summarised in Table 2 showing species richness, abundance, diversity and evenness for each study locality. The distribution of these variables relative to altitude has a hump-shaped pattern, with the exception of the diversity index (Figures 3-6). The reverse correlation has been found between altitude and species richness (Pearson's  $r = -0.961$ ,  $P = 0.01$ ) and abundance (Pearson's  $r = -0.967$ ,  $P = 0.01$ ) (Table 3). Unlike species richness, abundance and evenness that decreased after certain latitude, the diversity indices were almost constant across all elevations.



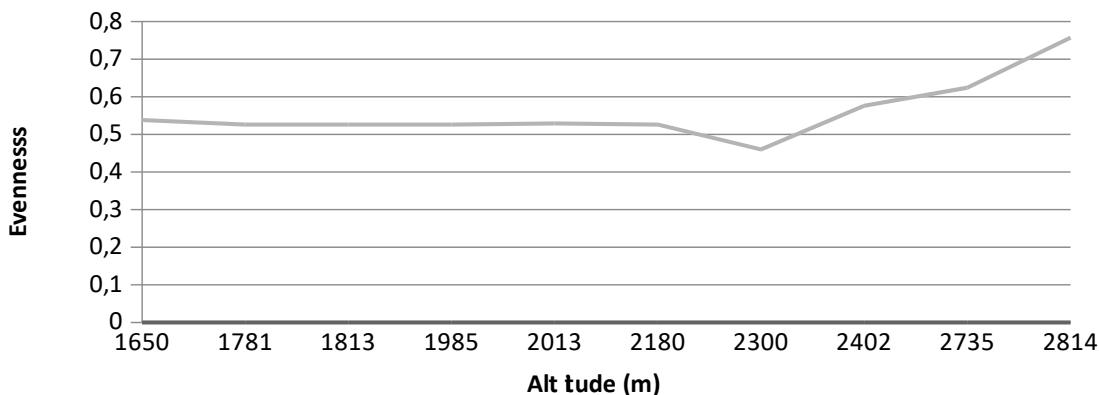
**Figure 3.** The relationship between species richness and altitude in Tsaghkunyatc mountain.



**Figure 4.** The relationship between abundance and altitude in Tsaghkunyatc



**Figure 5.** Relationship between species diversity index of the butterflies and altitude in Tsaghkunyatc mountain.



**Figure 6.** The relationship between the evenness index and altitudes in Tsaghkunyatc mountain.

## Discussion

The results from the present study doesn't completely agree with previous observations where the insect communities at high altitudes are characterized by fewer species, but a greater abundance of individuals (Mani 1968). The high altitude insect communities characterizes with independence and isolation due to the generally extreme conditions at high altitudes (Mani 1968). In contrast to the previous study, we didn't find clear altitudinal vegetation zones (Despland et al., 2012). Butterflies are closely linked to plants, both as herbivores and pollinators. Our work suggests that the altitudinal distribution of a butterfly is tightly connected with the presence of its larval host plant (Pyrcz et al., 2009), thus the inclusion of plants in the analysis could result in better attitudinal model of butterfly diversity. The larval forms and host plants have been described for some of the species (Tshikolovets et al. 2011) and these ate in line with our field observations. For instance, *C. croceus* larvae develop on Alfalfa (*Medicago sativa*) which was common in all sites within the reserve and in the surrounding area. Their adults feed primarily Dandelion nectar (*Taraxacum* sp.), which is common within the xeric and hemi-xeric vegetation. The highest altitudes (2814 m) host 21 butterfly species, which is unexpected in first sight and could be explained by favorable climate. On the other side some host plants were present in the highest altitudes, while the butterflies were absent here. An example is the existence of plants from the genus *Ferula* everywhere in the studied area, although *Papilio alexanor* butterfly has been found just in sites 3, 4, 5. Equally, a better understanding of the extent and speed of adaptation is crucial to the responses of biodiversity and ecosystems to climate change, which are still unclear for these sites. However, the ability to acclimate to human-modified landscapes is clearly variable among our study species. Comparative studies of altitudinal gradients are needed to identify the consistent patterns in scale effects, which can then be used to study the effects of contemporary climate, history and stochastic factors (Rahbek 2005). Further study of the pattern in the altitudinal distribution of butterflies of Tsaghkunyatc mountains must be carried out in comparison with those for other taxa (e.g. spiders, beetles, breeding birds, etc.). Also the underlying mechanisms determining the different altitudinal patterns were not examined in the present study; Analysis of different taxa dependent altitudinal patterns (monotonic decrease vs. hump-shaped) in species richness at the same locality, Tsaghkunyatc mountains, Armenia is intriguing.

**Table 4.** The recorded butterfly in each site (sites referred by their numbers according to table1).

| Family / scientific name                             | 1 | 2 | 3  | 4 | 5  | 6  | 7  | 8  | 9  | 10 | Total |
|--|---|---|----|---|----|----|----|----|----|----|-------|
| <b>Family Hesperiidae</b>                            |   |   |    |   |    |    |    |    |    |    |       |
| <i>Carcharodus alceae</i> (Esper, [1780])            | 1 | 1 | 3  | 3 | 3  | 2  | 2  | 3  | 2  | 3  | 23    |
| <i>Carcharodus flocciferus</i> (Zeller, 1847)        |   |   |    |   |    |    |    | 1  | 2  | 2  | 5     |
| <i>Carcharodus lavatherae</i> (Esper, [1783])        |   |   | 1  | 1 | 2  |    |    |    |    |    | 4     |
| <i>Carcharodus stauderi</i> (Reverdin, 1913)         |   |   |    |   |    | 1  | 2  | 2  | 2  | 3  | 10    |
| <i>Erynnis marloyi</i> (Boisduval, [1834])           |   |   |    | 2 |    |    | 1  |    |    | 1  | 4     |
| <i>Erynnis tages</i> (Linnaeus, 1758)                |   | 1 | 2  | 2 | 3  | 3  |    |    | 2  | 3  | 16    |
| <i>Muschampia poggei</i> (Lederer, 1858)             |   |   | 3  |   | 2  | 2  | 2  |    | 3  | 2  | 14    |
| <i>Pyrgus armoricanus</i> (Oberthür, 1910)           |   |   | 2  |   |    |    |    |    |    |    | 2     |
| <i>Pyrgus jupei</i> (Alberti, 1967)                  | 2 | 2 | 2  | 1 |    | 2  | 3  | 3  | 4  | 5  | 22    |
| <i>Pyrgus melotis</i> (Duponchel, [1834])            |   |   | 2  | 2 | 1  | 2  |    |    |    |    |       |
| <i>Pyrgus serratulae</i> (Rambur, [1839])            | 1 | 2 | 3  | 2 | 2  | 3  |    |    | 3  | 4  | 20    |
| <i>Pyrgus sidae</i> (Esper, [1784])                  |   |   | 3  | 2 | 3  | 2  | 2  | 2  | 3  | 3  | 18    |
| <i>Spiralia orbifer</i> (Hubner, [1823])             |   | 1 | 4  | 1 | 2  | 2  | 2  | 2  | 3  | 3  | 18    |
| <i>Spiralia phlomidis</i> (Herrich-Schäffer, [1845]) |   |   |    | 2 |    |    | 2  |    |    |    | 4     |
| <i>Thymelicus lineola</i> (Ochsenheimer, 1808)       |   |   |    | 3 | 3  | 4  | 4  | 7  | 8  | 8  | 37    |
| <i>Thymelicus sylvestris</i> (Poda, 1761)            | 2 | 2 | 3  | 3 | 4  | 3  | 3  | 2  | 3  | 4  | 29    |
| <b>Family Papilionidae</b>                           |   |   |    |   |    |    |    |    |    |    |       |
| <i>Iphiclides podalirius</i> Linnaeus, 1758          | 1 | 1 | 2  | 1 | 2  | 2  | 1  |    |    | 3  | 13    |
| <i>Papilio alexanor</i> Esper, 1799                  |   |   | 1  | 6 | 1  |    |    |    |    |    | 8     |
| <i>Papilio machaon</i> Linnaeus, 1758                |   | 1 | 3  | 4 | 4  | 4  | 6  |    |    | 10 | 32    |
| <i>Parnassius apollo</i> Linnaeus, 1758              |   |   | 1  | 6 | 1  |    |    |    |    |    | 8     |
| <i>Parnassius mnemosyne</i> Linnaeus, 1758           |   | 1 | 3  | 4 | 4  | 4  | 6  |    |    | 10 | 32    |
| <b>Family Pieridae</b>                               |   |   |    |   |    |    |    |    |    |    |       |
| <i>Anthocharis cardamines</i> Linnaeus, 1758         |   |   | 4  | 3 | 8  | 9  | 10 | 2  | 2  | 10 | 48    |
| <i>Anthocharis damone</i> Boisduval, 1836            | 1 | 3 | 6  | 2 | 1  | 1  | 1  | 1  | 1  | 5  | 22    |
| <i>Anthocharis gruneri</i> Herrich-Schäffer, 1851    |   | 6 | 10 | 7 | 8  | 8  | 2  | 2  | 2  | 5  | 48    |
| <i>Aporia crataegi</i> Linnaeus, 1758                | 1 | 1 | 2  | 4 | 11 | 21 | 20 | 12 | 12 | 10 | 94    |
| <i>Colias alfacariensis</i> Staudinger, 1871         |   |   | 3  | 3 | 4  | 4  | 4  |    |    | 3  | 17    |
| <i>Colias aurorina</i> Herrich-Schäffer, 1850        |   |   |    | 1 | 3  | 2  |    |    |    |    | 5     |
| <i>Colias croceus</i> Geoffroy, 1785                 |   | 2 | 2  | 2 | 5  | 5  | 8  | 2  | 5  | 12 | 47    |
| <i>Colias thisoa</i> Ménétriés, 1832                 |   |   | 1  | 1 |    |    |    |    |    |    |       |
| <i>Euchloe ausonia</i> Hubner, 1805                  |   |   |    |   |    | 6  | 6  | 4  | 4  | 6  | 24    |
| <i>Gonepteryx farinosa</i> Zeller, 1847              |   |   | 3  | 4 | 4  | 3  | 2  |    |    | 7  | 23    |
| <i>Gonepteryx rhamni</i> Linnaeus, 1758              |   |   |    |   |    |    |    | 8  | 10 |    | 18    |
| <i>Leptidea duponcheli</i> Staudinger, 1871          |   |   |    |   |    |    | 9  |    |    | 5  | 14    |
| <i>Leptidea sinapis</i> Linnaeus, 1758               |   |   |    |   |    | 2  | 2  | 4  | 5  |    | 13    |
| <i>Pieris brassicae</i> Linnaeus, 1758               | 3 | 3 | 4  | 6 | 8  | 6  | 9  | 9  | 13 | 13 | 74    |
| <i>Pieris krueperi</i> Staudinger, 1860              |   | 1 |    |   |    |    |    |    |    |    | 1     |
| <i>Pieris mannii</i> Mayer, 1851                     |   |   |    | 2 | 2  |    |    |    | 1  | 2  | 7     |
| <i>Pieris napi</i> Linnaeus, 1758                    |   |   |    | 3 | 6  | 6  | 8  | 4  | 4  | 4  | 35    |
| <i>Pieris pseudorapae</i> Verity, [1908]             |   |   |    | 1 | 3  | 5  | 5  | 6  | 4  | 6  | 30    |
| <i>Pieris rapae</i> Linnaeus, 1758                   |   |   | 2  | 2 | 4  | 8  | 8  | 10 | 10 | 12 | 56    |
| <i>Pontia chloridice</i> Hubner, 1803                | 1 | 1 |    |   |    |    |    |    |    |    | 2     |
| <i>Pontia daplidice</i> Linnaeus, 1758               |   |   | 4  | 4 | 5  | 6  | 6  | 5  | 5  | 8  | 43    |
| <b>Family Nymphalidae</b>                            |   |   |    |   |    |    |    |    |    |    |       |
| <b>Satyrinae</b>                                     |   |   |    |   |    |    |    |    |    |    |       |
| <i>Aretusana aretusa</i> (Schiffermüller, 1775)      |   |   | 1  | 3 |    |    |    |    |    |    | 4     |
| <i>Chazara briseis</i> (Linnaeus, 1764)              |   |   |    |   |    | 2  | 4  | 4  | 2  | 5  | 17    |
| <i>Chazara persephone</i> (Hunber, [1805])           |   | 1 | 2  | 2 |    |    |    |    |    |    | 5     |
| <i>Coenonympha arcania</i> (Linnaeus, 1767)          |   |   | 4  | 4 | 5  | 4  | 5  | 2  | 5  | 29 |       |
| <i>Coenonympha glycerion</i> (Borkhausen, 1788)      | 1 | 3 |    | 5 | 5  | 4  | 2  |    |    |    | 20    |
| <i>Coenonympha pamphilus</i> (Linnaeus, 1758)        |   |   |    |   |    | 5  | 5  | 8  | 9  | 15 | 42    |

|  |   |   |   |   |   |    |    |    |    |    |
|--|---|---|---|---|---|----|----|----|----|----|
| <i>Erebia aethiops</i> (Esper, [1777])                 |   | 2 |   |   |   |    |    |    |    | 2  |
| <i>Erebia graucasica</i> (Jachontov, 1909)             | 3 | 5 |   |   |   |    |    |    |    | 8  |
| <i>Erebia medusa</i> ([Schiffermuller], 1775)          |   |   | 1 | 2 | 2 |    |    |    |    | 5  |
| <i>Hipparchia parisatis</i> (Kollar, 1849)             |   |   |   |   |   | 4  | 3  |    |    | 7  |
| <i>Hipparchia statilinus</i> (Hufnagel, 1766)          |   |   | 3 |   |   |    |    |    |    | 3  |
| <i>Hyponephele lupina</i> (Costa, [1836])              |   |   |   | 2 | 5 | 5  | 8  | 15 | 35 |    |
| <i>Hyponephele lycaon</i> (Rottemburg, 1775)           | 2 | 2 | 3 | 4 | 5 | 5  | 9  | 10 | 49 |    |
| <i>Kirinia climene</i> (Esper, [1783])                 |   |   |   |   | 1 |    | 2  | 2  |    | 7  |
| <i>Lasiommata maera</i> (Linnaeus, 1758)               | 2 | 2 | 3 | 3 | 5 | 6  | 6  | 10 |    | 37 |
| <i>Lasiommata megera</i> (Linnaeus, 1767)              | 1 | 2 | 2 | 3 | 3 | 4  | 4  | 2  |    | 26 |
| <i>Maniola jurtina</i> (Linnaeus, 1758)                |   |   | 2 | 2 | 4 | 5  | 6  | 10 | 10 | 43 |
| <i>Melanargia galathea</i> (Linnaeus, 1758)            |   |   |   | 2 | 3 | 5  | 5  | 7  | 11 | 36 |
| * <i>Melanargia grumi</i> (Standfuss, 1892)            |   |   |   |   |   | 3  |    |    |    | 3  |
| <i>Melanargia larissa</i> (Geyer, [1828])              |   |   |   | 2 | 4 | 4  | 7  | 7  | 9  | 33 |
| <i>Pararge aegeria</i> (Linnaeus, 1758)                |   |   |   |   |   |    | 2  | 2  |    | 4  |
| <i>Proterebia afra</i> (Fabricius, 1787)               |   |   |   | 2 |   |    |    |    | 2  | 4  |
| <i>Pseudochazara beroe</i> (Freyer, 1843)              |   |   |   | 2 | 2 | 3  |    |    |    | 7  |
| <i>Pseudochazara geyeri</i> (Herrich-Schaffer, [1846]) |   |   | 2 | 1 |   |    |    |    |    | 3  |
| <b>Limenitidinae</b>                                   |   |   |   |   |   |    |    |    |    |    |
| <i>Limenitis reducta</i> (Staudinger, 1901)            |   |   |   | 5 | 2 |    | 6  | 2  |    | 15 |
| <i>Neptis rivularis</i> (Scopoli, 1763)                |   |   |   | 3 | 3 |    | 4  | 3  |    | 13 |
| <b>Nymphalinae</b>                                     |   |   |   |   |   |    |    |    |    |    |
| <i>Aglais urticae</i> (Linnaeus, 1758)                 | 2 | 4 | 4 | 6 | 8 | 11 | 10 | 7  | 9  | 72 |
| <i>Inachis io</i> (Linnaeus, 1758)                     |   |   |   | 2 | 1 |    |    | 2  | 2  | 7  |
| <i>Nymphalis antiopa</i> (Linnaeus, 1758)              |   |   |   |   |   |    |    | 1  |    | 1  |
| <i>Nymphalis polychloros</i> (Linnaeus, 1758)          |   |   |   | 2 |   |    |    | 1  | 2  | 5  |
| <i>Nymphalis xanthomelas</i> (Esper, [1781])           |   |   |   |   |   |    |    | 2  |    | 2  |
| <i>Polygonia egea</i> (Cramer, [1775])                 |   | 1 |   | 1 |   |    |    | 1  |    | 3  |
| <i>Polygonia c-album</i> (Linnaeus, 1781)              |   |   |   | 1 | 1 |    |    |    |    | 2  |
| <i>Vanessa atalanta</i> (Linnaeus, 1758)               |   |   | 2 | 2 |   |    |    |    |    | 8  |
| <i>Vanessa cardui</i> (Linnaeus, 1758)                 | 1 | 2 | 2 | 4 | 2 | 3  | 3  | 7  | 6  | 36 |
| <b>Argynninae</b>                                      |   |   |   |   |   |    |    |    |    |    |
| <i>Argynnis adippe</i> ([Schiffermuller], 1775)        |   |   |   |   | 2 | 1  |    | 1  |    | 4  |
| <i>Argynnis aglaja</i> (Linnaeus, 1758)                | 2 | 2 | 3 | 3 |   |    |    |    |    | 15 |
| <i>Argynnis pandora</i> ([Schiffermuller], 1775)       |   |   |   |   |   | 3  | 2  | 5  | 6  | 19 |
| <i>Argynnis paphia</i> (Linnaeus, 1758)                |   |   |   |   | 2 | 2  |    |    |    | 4  |
| <i>Boloria caucasica</i> (Lederer, 1852)               | 1 | 1 | 2 |   | 3 |    |    |    |    | 4  |
| <i>Brenthis daphne</i> ([Schiffermuller], 1775)        |   |   |   |   |   |    |    |    |    | 3  |
| <i>Brenthis hecate</i> ([Schiffermuller], 1775)        |   |   |   |   |   |    | 1  |    |    | 1  |
| <i>Brenthis ino</i> (Rottemburg, 1775)                 |   | 1 |   |   |   |    |    |    |    | 1  |
| <i>Issoria lathonia</i> (Linnaeus, 1758)               |   |   | 2 | 3 | 4 | 3  | 3  | 3  | 6  | 7  |
| <b>Melitaeinae</b>                                     |   |   |   |   |   |    |    |    |    |    |
| <i>Euphydryas aurinia</i> (Rottemburg, 1775)           | 2 | 2 | 5 | 6 | 5 | 2  | 3  | 3  | 2  | 30 |
| <i>Melitaea didyma</i> (Esper, [1778])                 |   |   |   |   |   | 3  | 8  | 8  | 7  | 32 |
| <i>Melitaea athalia</i> (Rottemburg, 1775)             | 1 |   | 2 |   | 1 |    |    | 2  |    | 5  |
| <i>Melitaea cinxia</i> (Linnaeus, 1758)                |   |   |   | 1 |   |    |    |    |    | 1  |
| <i>Melitaea phoebe</i> ([Schiffermuller], 1775)        |   |   |   |   | 1 | 1  |    | 1  |    | 3  |
| <b>Family Lycaenidae</b>                               |   |   |   |   |   |    |    |    |    |    |
| <i>Callophrys danchenkoi</i> Zhdanko, 1998             |   |   | 4 |   |   |    |    |    |    | 4  |
| <i>Callophrys paulae</i> (Pfeiffer, 1932)              |   |   |   |   | 3 |    |    |    | 3  | 6  |
| <i>Callophrys rubi</i> (Linnaeus, 1758)                | 4 | 4 | 3 | 2 |   |    | 4  | 4  | 3  | 24 |
| <i>Callophrys suaveola</i> (Staudinger, 1881)          | 3 | 2 |   |   |   |    | 3  | 3  |    | 11 |
| <i>Celastrina argiolus</i> (Linnaeus, 1758)            |   |   |   |   |   | 3  | 3  | 3  | 4  | 13 |
| <i>Cupido minimus</i> (Fuessly, 1775)                  | 2 | 2 | 1 |   |   |    |    |    |    | 5  |
| <i>Cupido osiris</i> Meigen, 1829                      |   |   |   | 2 | 2 | 2  |    |    |    | 6  |
| <i>Favonius quercus</i> Verity, 1943                   |   |   |   | 2 |   | 2  | 1  | 1  | 3  | 9  |
| <i>Glauopsyche alcon</i> ([Schiffermuller], 1775)      |   |   |   | 2 | 2 | 1  | 1  |    |    | 6  |

|   |   |   |   |   |   |   |   |   |   |    |    |    |
|---|---|---|---|---|---|---|---|---|---|----|----|----|
| 1775)   |   |   |   |   |   |   |   |   |   |    |    |    |
| <i>Glauopsyche alexis</i> Poda, 1761                      |   | 3 |   |   |   |   |   |   |   |    |    | 3  |
| <i>Glauopsyche arion</i> (Linnaeus, 1758)                 |   |   |   |   |   |   | 3 |   |   |    |    | 6  |
| <i>Glauopsyche nausithous</i> (Bergstrasser, [1779])      |   |   | 2 | 2 |   |   |   |   |   |    |    | 4  |
| <i>Lampides boeticus</i> (Linnaeus, 1767)                 | 2 | 2 | 4 | 4 |   |   |   |   |   |    |    | 12 |
| <i>Lycaena alciphron</i> (Rottemburg, 1775)               | 3 | 4 |   |   |   |   |   |   |   |    |    | 7  |
| <i>Lycaena candens</i> (Herrich-Schäffer, [1844])         | 1 | 3 | 4 | 3 | 2 | 3 | 5 | 2 | 2 | 5  | 30 |    |
| <i>Lycaena thersamon</i> (Esper, 1784)                    |   |   |   |   |   |   |   | 5 |   |    |    | 5  |
| <i>Lycaena phlaeas</i> Linnaeus, 1761                     |   | 2 | 4 | 4 | 2 | 3 | 3 | 2 | 2 | 6  | 26 |    |
| <i>Lycaena tityrus</i> (Poda, 1761)                       |   | 2 | 2 | 5 | 5 | 5 | 5 | 2 | 2 | 2  | 33 |    |
| <i>Lycaena virgaureae</i> (Linnaeus, 1758)                |   |   |   |   |   |   |   |   |   |    |    |    |
| <i>Plebejus agestis</i> (Denis & Schiffermüller, 1775)    |   |   |   |   | 3 | 3 | 4 | 5 | 5 | 5  | 25 |    |
| <i>Plebejus anteros</i> (Zülich, 1929)                    |   |   |   |   | 2 | 3 | 3 | 3 | 4 | 4  | 5  | 24 |
| <i>Plebejus argus</i> (Linnaeus, 1758)                    |   | 3 | 2 | 2 | 4 | 5 | 2 | 2 | 8 | 8  | 28 |    |
| <i>Plebejus artaxerxes</i> (Fabricius, 1793)              | 1 |   |   |   |   | 3 | 2 |   |   |    |    | 6  |
| <i>Plebejus pyrenaicus</i> (Boisduval, 1840)              | 2 |   |   |   |   |   |   |   |   |    |    | 2  |
| <i>Polyommatus amandus</i> (Schneider, [1721])            |   |   |   |   | 1 | 2 | 2 | 2 |   |    |    | 7  |
| <i>Polyommatus bellargus</i> (Rottemburg, 1775)           |   |   |   |   | 2 | 2 | 2 | 3 | 4 | 4  | 5  | 22 |
| <i>Polyommatus coelestinus</i> (Eversmann, 1843)          |   | 1 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3  | 19 |    |
| <i>Polyommatus corydonius</i> (Herrich-Schäffer, [1852])  | 1 | 1 | 2 | 2 | 2 | 4 | 4 | 5 | 6 | 6  | 27 |    |
| <i>Polyommatus damone</i> ([Schiffermuller], 1775)        | 1 | 1 | 2 | 2 | 3 | 3 |   |   |   | 1  | 13 |    |
| <i>Polyommatus daphnis</i> (Denis & Schiffermüller, 1775) |   |   |   |   | 4 | 5 | 5 | 4 | 4 | 5  | 7  | 34 |
| <i>Polyommatus eumedon</i> (Esper, 1780)                  | 2 | 2 |   |   | 3 | 5 | 5 | 5 | 7 | 11 |    | 4  |
| <i>Polyommatus icarus</i> (Rottemburg, 1775)              | 2 | 3 | 2 | 2 |   |   |   |   |   |    |    | 45 |
| <i>Polyommatus semiargus</i> (Rottemburg, 1775)           |   |   |   |   | 1 | 3 | 4 | 3 | 5 | 5  | 5  | 21 |
| <i>Polyommatus thersites</i> (Cantener, 1834)             |   |   |   |   |   | 1 | 1 | 2 | 3 | 3  | 10 |    |
| <i>Satyrium abdominalis</i> (Gerhard, [1850])             |   | 2 | 3 | 3 | 2 | 2 | 5 | 5 | 5 | 5  | 27 |    |
| <i>Satyrium ilicis</i> Esper, 1779                        |   |   |   |   |   | 1 | 3 | 4 | 4 |    |    | 8  |
| <i>Satyrium w-album</i> (Knoch, 1782)                     |   |   |   |   | 2 | 2 | 1 |   | 1 |    |    | 6  |
| <i>Tomares callimachus</i> (Eversmann, 1848)              |   |   |   |   |   |   | 2 | 2 | 4 | 4  | 4  | 12 |

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