High Altitude Papilionoidea (Lepidoptera) Of Tsaghkunyatc mountains In Armenia and their diversity along the altitudinal gradient

Noushig A. Zarikian, Hasmik G. Khachatryan & Mark Yu. Kalashyan
Scientific Center of Zoology and Hydroecology, National Academy of Sciences of Armenia.
P. Sevak Street 7, 0014, Yerevan, Armenia.
Tel.: +374-77374784, Email: noushigz@hotmail.com

Abstract
This study tries to link the butterfly species diveristy along the altitudinal span of Tsaghkunyatc 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 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 typicaly 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, Papilionoidea, Species richness.*

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 durin 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 Tsaghkunyatc 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 (Minasasar, 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 Tsaghkunyatc 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 Papilionoidea and five readily identifiable families (Hesperiidae, Papilionidae, Pieridae, Lycaenidae and Nymphalidae). A total of 2114 individuals belonging to 129 species were identified (table4). 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.

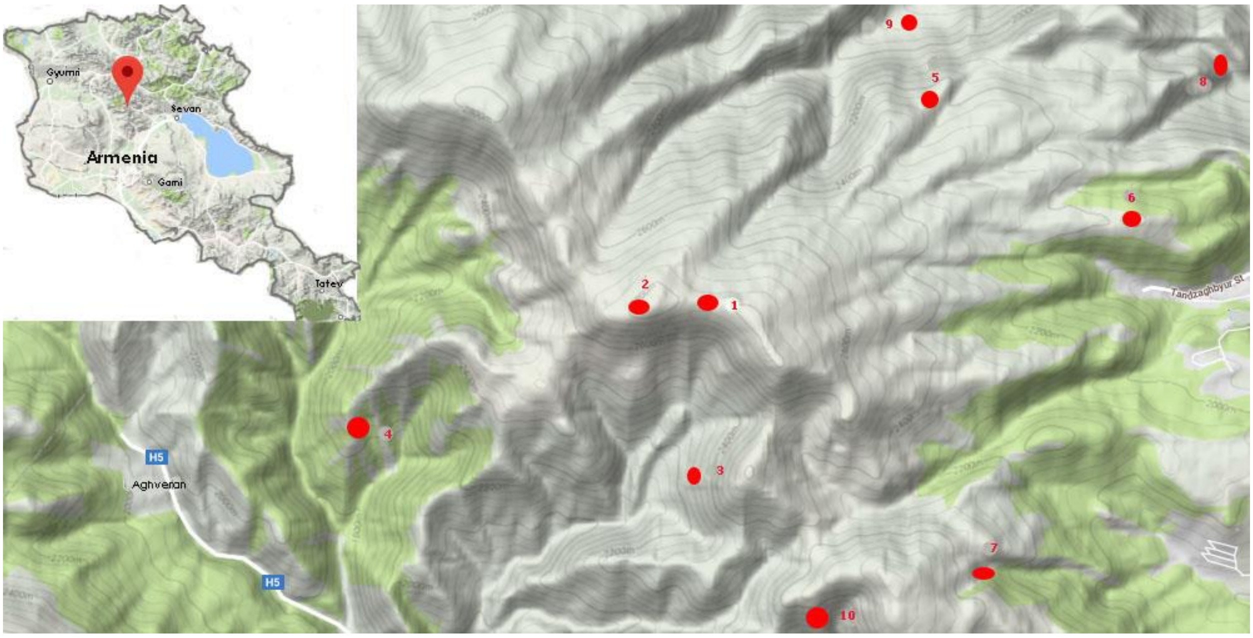

Figure1. Study Sites at Tsaghkunyatc mountain, Armenia . 1.T'eghenis Lerr, 2.Tsaghkunyats', 3.Dalar, 4.Aghveran, 5.T'evasar, 6.Chakat, 7.Chermak K'ari, 8.Tsaghkadzor, 9.Karmir Aghbyur, 10.Minasasar.

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 Tsaghkunyatc mountain, Armenia.

No	Site	Site type	Vegetation type	Coordinates	Altitude (m)
1	**T'eghenis Lerr**	**upland**	**Alpine vegetation***	**N 40°53'173'' E44°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'evasar**	**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	**Minasasar**	**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 rugs, 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 caucasuca*); - 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 rauwolfii, 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 tirsa, 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 se how butterfly diversity changes with altitude several indives 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 diveristy 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:

alt1 = (altitude - 2180), if (altitude≥2013) alti1 = 0

alt2 = (altitude - 2180), if (altitude < 2013) alti2 = 0

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

int1 = 1, if (altitude ≥ 2013) int1 = 0

int2 = 1, if (altitude < 2013) 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^2	*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 spices 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.

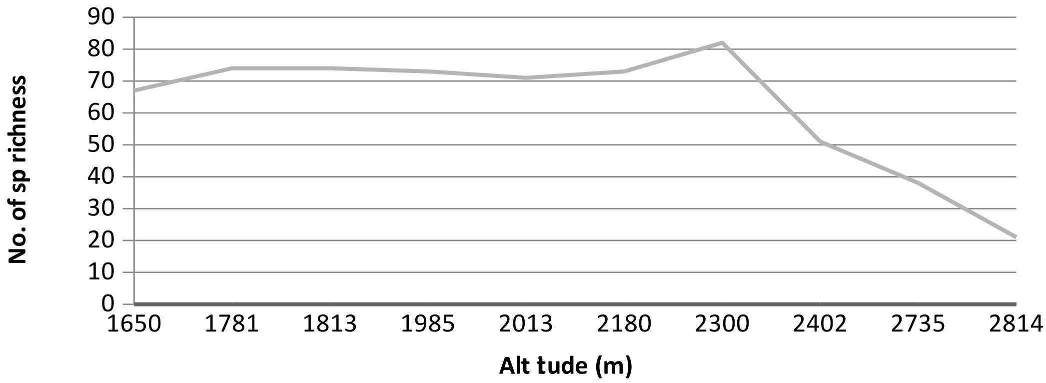

Figure 3. The relationship between species richness and altitude in Tsaghkunyatc mountain.

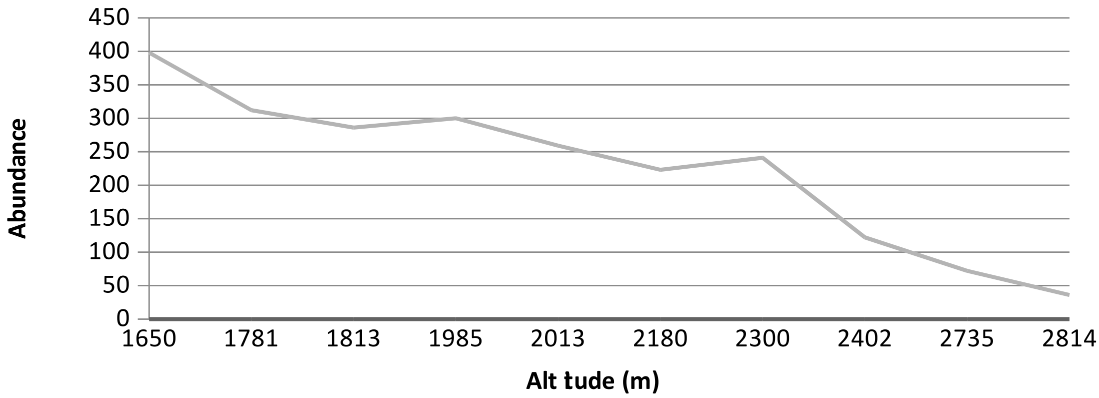

Figure 4. The relationship between abundance and altitude in Tsaghkunyatc

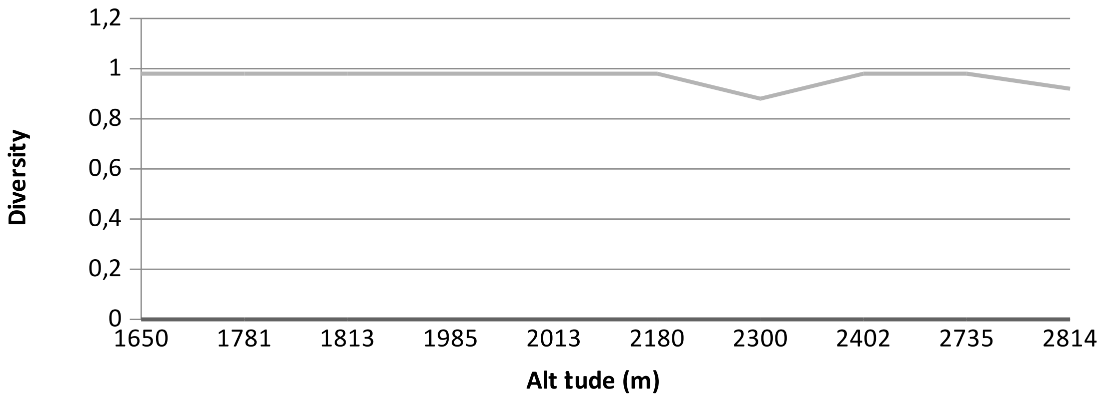

Figure 5. Relationship between species diversity index of the butterflies and altitude in Tsaghkunyatc mountain.

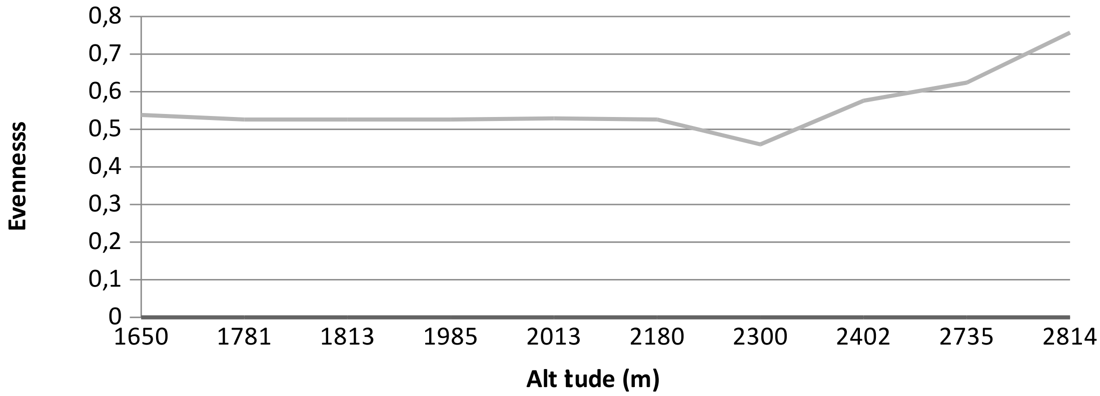

Figure 6. The relationship between the evenness index and altitudes in Tsaghkunyatc mountain.

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

Erebia aethiops (Esper, [1777])		2									2
Erebia graucasica (Jachontov, 1909)	3	5									8
Erebia medusa ([Schiffermuller], 1775)					1	2	2				5
Hipparchia parisatis (Kollar, 1849)								4	3		7
Hipparchia statilinus (Hufnagel, 1766)				3							3
Hyponephele lupina (Costa, [1836])						2	5	5	8	15	35
Hyponephele lycaon (Rottemburg, 1775)		2	2	3	4	5	5	9	9	10	49
Kirinia climene (Esper, [1783])						1		2	2	2	7
Lasiommata maera (Linnaeus, 1758)			2	2	3	3	5	6	6	10	37
Lasiommata megera (Linnaeus, 1767)	1	2	2	2	3	3	3	4	4	2	26
Maniola jurtina (Linnaeus, 1758)			2	2	4	4	5	6	10	10	43
Melanargia galathea (Linnaeus, 1758)				2	3	3	5	5	7	11	36
**Melanargia grumi* (Standfuss, 1892)								3			3
Melanargia larissa (Geyer, [1828])					2	4	4	7	7	9	33
Pararge aegeria (Linnaeus, 1758)								2	2		4
Proterebia afra (Fabricius, 1787)					2					2	4
Pseudochazara beroe (Freyer, 1843)					2	2	3				7
Pseudochazara geyeri (Herrich-Schaffer, [1846])				2	1						3
Limenitidinae											
Limenitis reducta (Staudinger, 1901)				5	2			6	2		15
*Neptis rivularis (*Scopoli, 1763)				3	3			4	3		13
Nymphalinae											
Aglais urticae (Linnaeus, 1758)	2	4	4	6	8	11	10	7	9	11	72
Inachis io (Linnaeus, 1758)				2	1			2	2		7
Nymphalis antiopa (Linnaeus, 1758)									1		1
Nymphalis polychloros (Linnaeus, 1758)				2				1	2		5
Nymphalis xanthomeles (Esper, [1781])									2		2
Pollygonia egea (Cramer, [1775])		1		1				1			3
Pollygonia c-album (Linnaeus, 1781)				1	1						2
Vanessa atalanta (Linnaeus, 1758)			2	2			1	2	1		8
Vanessa cardui (Linnaeus, 1758)	1	2	2	4	2	3	3	7	6	6	36
Argynninae											
Argynnis adippe ([Schiffermauler], 1775)				2	1			1			4
Argynnis aglaja (Linnaeus, 1758)	2	2	3	3				2	3		15
Argynnis pandora ([Schiffermauler], 1775)							3	5	5	6	19
Argynnis paphia (Linnaeus, 1758)				2	2						4
Boloria caucasica (Lederer, 1852)	1	1	2								4
Brenthis daphne ([Schiffermauler], 1775)				3							3
Brenthis hecate ([Schiffermauler], 1775)							1				1
Brenthis ino (Rottemburg, 1775)		1									1
Issoria lathonia (Linnaeus, 1758)			2	3	4	3	3	3	6	7	31
Melitaeinae											
Euphydryas aurinia (Rottemburg, 1775)	2	2	5	6	5	2	3	3	2		30
Melitaea didyma (Esper, [1778])						3	8	8	7	6	32
Melitaea athalia (Rottemburg, 1775)		1		2		1			2		5
Melitaea cinxia (Linnaeus, 1758)				1							1
Melitaea phoebe ([Schiffermauler], 1775)					1	1		1			3
Family Lycaenidae											
Callophrys danchenkoi Zhdanko, 1998			4								4
Callophrys paulae (Pfeiffer, 1932)						3				3	6
Callophrys rubi (Linnaeus, 1758)			4	4	3	2		4	4	3	24
Callophrys suaveola (Staudinger, 1881)			3	2				3	3		11
Celastrina argiolus (Linnaeus, 1758)							3	3	3	4	13
Cupido minimus (Fuessly, 1775)	2	2	1								5
Cupido osiris Meigen, 1829				2	2	2					6
Favonius quercus Verity, 1943				2			2	1	1	3	9
Glaucopsyche alcon ([Schiffermuller],				2	2	1	1				6

1775)											
Glaucopsyche alexis Poda, 1761		3									3
Glaucopsyche arion (Linnaeus, 1758)							3		3		6
Glaucopsyche nausithous (Bergstrasser, [1779])			2	2							4
Lampides boeticus (Linnaeus, 1767)		2	2	4	4						12
Lycaena alciphron (Rottemburg, 1775)	3	4									7
Lycaena candens (Herrich-Schäffer,[1844])	1	3	4	3	2	3	5	2	2	5	30
Lycaena thersamon (Esper, 1784)								5			5
Lycaena phlaeas Linnaeus, 1761			4	4	2	3	3	2	2	6	26
Lycaena tityrus (Poda, 1761)		2	2	5	5	5	5	2	2	2	33
Lycaena virgaureae (Linnaeus, 1758)											
Plebejus agestis (Denis & Schiffermüller, 1775)					3	3	4	5	5	5	25
Plebejus anteros (Züllich, 1929)				2	3	3	3	4	4	5	24
Plebejus argus (Linnaeus, 1758)			3	2	2	4	5	2	2	8	28
Plebejus artaxerexes (Fabricius, 1793)		1				3	2				6
Plebejus pyrenaicus (Boisduval, 1840)		2									2
Polyommatus amandus (Schneider, [1721])				1	2	2	2				7
Polyommatus bellargus (Rottemburg, 1775)				2	2	2	3	4	4	5	22
Polyommatus coelestinus (Eversmann, 1843)			1	3	2	3	3	2	2	3	19
Polyommatus corydonius (Herrich-Schäffer, [1852])		1	1	2	2	2	4	4	5	6	27
Polyommatus damone ([Schiffermuller], 1775)		1	1	2	2	3	3			1	13
Polyommatus daphnis (Denis & Schiffermüller, 1775)				4	5	5	4	4	5	7	34
Polyommatus eumedon (Esper, 1780)	2	2									4
Polyommatus icarus (Rottemburg, 1775)	2	3	2	2	3	5	5	5	7	11	45
Polyommatus semiargus (Rottemburg, 1775)					1	3	4	3	5	5	21
Polyommatus thersites (Cantener, 1834)						1	1	2	3	3	10
Satyrium abdominalis (Gerhard, [1850])			2	3	3	2	2	5	5	5	27
Satyrium ilicis Esper, 1779							1	3	4		8
Satyrium w-album (Knoch, 1782)				2	2	1		1			6
Tomares callimachus (Eversmann, 1848)							2	2	4	4	12
											2114

References

Baloyan, S.A. (1987). Seasonal dynamics of alpine plant communities in the Mt. Aragats. VINITI 3639-B87, Moscow: 7-38.

Bozano, G.C. (1999). Satyridae part I. Lethini Subfamily Elymniinae, Tribe Lethini (Lasiommata, Pararge, Lopinga, Kirinia, Chonale, Tatinga, Rhaphicera, Ninguta, Neope, Lethe, Neorina). In: G.C. Bozano (ed.) Guide to the butterflies of the palearctic region - Omnes Artes, Milano, 58 pp.

Bozano, G.C. (ed.). (2001). Lycaenidae I: Lycaeninae. Lycaena, Hycranana, Athamanthia, Phoenicurusia, Heliophorus. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano, 62 pp.

Bozano, G.C. (ed.). (2002). Satyridae II: Satyrini. 2. ed. Argestina, Boeberia, Callerebia, Grumia, Hemadara, Loxerebia, Paralasa, Proterebia. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano, 59 pp.

Bozano GC (ed.). (2002). Satyridae III: Melanargiina and Coenonymphina Melanargia, Coenonympha, Sinonympha, Triphysa. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano, 71 pp.

Bozano GC (ed.).(2003). Nymphalidae I. Argynnini. Argynnis, Issoria, Brenthis, Argyreus. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano, 86 pp.

Bozano GC (ed.). (2006). Nymphalidae 2. Boloria, Proclossiana, Clossiana. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 86 pp.

Bozano GC (ed.). (2007). Lycaenidae III: Theclinae: Tomarini, Aphnaeini, Theclini. partim). Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 97 pp.

Bozano GC (ed.). (2008). Nymphalidae III: Limenitidinae: Neptini. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 90 pp.

Bozano GC (ed.). (2009). Papilionidae I: Leptocircini and Teinopalpini. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 69 pp.

Bozano GC (ed.). (2010). Papilionidae II. Troidini. pp. 86. It includes a full revision of the genus Byasa. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano.

Bozano GC (ed.). (2011a). Satyrinae IV. Maniola, Pyronia, Aphantopus, Hyponephele. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 102 pp.

Bozano GC (ed.). (2011b). Nymphalidae 4: Apaturinae. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 90 pp.

Bozano GC (ed.). (2012). Nymphalidae 5: Nymphalini, Kallimini, Junoniini. Guide to the Butterflies of the Palearctic Region. Omnes Artes, Milano. 90 pp.

Colwell, R.K., & Lees DC. (2000). The mid-domain effect: geometric constraints on the geography of species richness. Trends in Ecology and Evolution 15: 70-76.

Despland, E., Humire, R., & San Martin, S. (2012). Species richness and phenology of butterflies along an altitude gradient in the desert of Northern Chile. Arctic, Antarctic and Alpine Research 44 423-431 10.1657/19384246-44.4.423

Fiedler, K., & Beck E. (2008). Investigating gradients in ecosystem analysis. In: Beck E, Bendix J, Kottke I, Makeschin F, Mosamdl R (eds.). Gradients in a Tropical Mountain Ecosystem of Ecuador. Springer, Berlin. Guliashvili VZ, Mahatadze LB, Prilipko LI. 1975. Rastitelnost Kavkaza. Nauka, Moscow.

Haslett, J.R. (1997). Insect communities and the spatial complexity of mountain habitats. Global Ecology and Biogeography 6: 49-56.

Hesselbarth, G., Van Oorschot, H., & Wagner, S. (1995). Die Tagfalter der Turkei unter berücksichtigung der angrenzenden länder, Bocholt (Selbstverlag), 3 Bande. 847pp. [Germany]

Hodkinson, I.D. (2005). Terrestrial insects along elevation gradients: species and community responses to altitude. Biological Reviews 80: 489-513.

Holubec, V., & Křivka, P. (2006). The Caucasus and its Flowers. LOXIA, Prague. 390 pp.

Kawahara, A.Y. & Breinholt, J.W. (2014). Phylogenomics provides strong evidence for relationships of butterflies and moths. Proceedings of the Royal Society of London 281 (1788): 20140970:1-8.

Korb, S.K. (1994). A Vertical distribution of Ropalocera (Lepidoptera) within the Kirghiz mountain ridge. Zoologicheskii zhurnal. 73(7–8): 123–129. [Russian].

Korb, S.K., & Bolshakov, L.V. (2016). A systematic catalogue of butterflies of the former Soviet Union (Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kyrgyzstan, Kazakhstan, Latvia, Lituania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan) with special account to their type specimens (Lepidoptera: Hesperioidea, Papilionoidea). Zootaxa 4160 (1): 1-324.

Lomolino, M.V. (2001). Elevation gradients of species-density: historical and prospective views. Global Ecology and Biogeography 10: 3-13.

Magurran, A.E. (2003). Measuring Biological Diversity. Blackwell, Malden, M.A. 260 pp.

Mani, M.S. (1968). Ecology and Biogeography of High Altitude Insects. Dr. W. Junk, The Hague , xiv + 527 pp.

Nazarian Kh. (1974). Aragats. Soviet Armenian Encyclopedia, Volume I: 677–678. [Armenian].

Pyrcz, T., Wojtusiak, J., & Garlacz, R. (2009). Diversity and distribution patterns of Pronophilina butterflies (Lepidoptera: Nymphalidae: Satyrinae) along an altitudinal transect in north-western Ecuador Neotropical Entomology 38: 716-726.

Rahbek, C. (2005). The role of spatial scale and the perception of large-scale species-richness patterns. Ecology Letters 8: 224-239.

SPSS INC. (2006): SPSS for Windows. Ver. 14.0. SPSS Inc.

Tembotova, F.A., & Tsepkova, N.L. (2009). On the problem of steppe ecosystem conservation in the Central Caucasus. Russian Journal of Ecology 40: 65-67.

Tshikolovets, V., Nekrutenko, Y. (2012). The butterflies of Caucasus and Transcaucasia. Tshikolovets Publications, Pardubice. 423 pp.

Tuzov, V.K. (1993). The synonymic List of Butterflies from the ex- USSR. Rosagroservice, Moscow. 74 pp.