Article

Butterflies (Lepidoptera: Hesperioidea and Papilionoidea) of the Moldo-Too Range (Inner Tien-Shan): faunistic analysis and vertical distribution

Stanislav K. Korb

Russian Entomological Society, Nizhny Novgorod Branch, PO Box 97, Nizhny Novgorod, 603009 Russia
stanislavkorb@list.ru

Received: 15.02.2021
Revised: 16.04.2021
Accepted: 20.05.2021
Published online: 13.08.2021

DOI: 10.23859/estr-210215
UDC 595.789

Translated by S.V. Nikolaeva

Abstract. Data on the fauna and vertical distribution of butterflies of the Moldo-Too Mountain Range (Inner Tien Shan) are presented. The material for research was collected during 12 summer seasons at 9 points of the ridge. The fauna of this mountainous region includes 118 species of Rhopalocera: 9 species of Hesperidae, 7 species of Papilionidae, 15 species of Pieridae, 21 species of Nymphalidae, 23 species of Satyridae, 1 species of Riodinidae and 42 species of Lycaenidae. The vertical distribution of this fauna on the Moldo-Too Range is as follows: 79 species in low mountains, 100 species in middle mountains, 60 species in high mountains and 31 species in ultrahigh mountains. The distribution of this fauna on the key habitats is as follows: 91 species in steppes, 105 species in dry meadows, 57 species in wet meadows, 14 species in screes, 23 species in rocks and rocky places and 18 species in the bushes. It is shown that the faunas of the low and middle mountains, high and ultrahigh mountains are similar, and that the faunas of two of the six key biotopes (steppes and dry meadows) are similar; possible causes of this similarity are discussed.

Keywords: butterflies, fauna, Central Asia, Kyrgyzstan.

To cite this article. Korb, S.K., 2021. Butterflies (Lepidoptera: Hesperioidea and Papilionoidea) of the Moldo-Too Range (Inner Tien-Shan): faunistic analysis and vertical distribution. *Ecosystem Transformation* 4 (3), 57–67. <https://doi.org/10.23859/estr-210215>

Introduction

Butterflies of the mountainous regions of Central Asia have been the subject of active study for over 150 years. However, this study mainly focuses on issues of taxonomy and nomenclature; summaries of the data on the fauna and ecology of diurnal butterflies in the region are quite rare. The best-studied region in this respect is the North Tien Shan; other mountainous areas have been studied much less. For the North Tien Shan, the vertical distribution of butterflies was studied for all ridges (Korb, 1994,

2012, 2015; Zhdanko, 1979, 1983); the composition of the faunas of this area has also been studied in detail (Korb, 2000).

In the Inner Tien Shan, the vertical distribution has not been studied for any ridge, and the composition of faunas is only known for two out of eight ridges: Suusamyrtoo (Korb, 2010) and Jumgaltoo (Korb, 2018). Meanwhile, the issues of studying the vertical distribution and composition of the faunas of individual ridges are extremely important for understanding the processes of faunogenesis in the mountainous

territories of Central Asia (Kryzhanovsky, 1965), especially because some of the mountain ranges of the region have a vertical belt distribution (Semenov, 1858), and some are mosaic (Zimin, 1964). In particular, in the North Tien Shan, four out of five ridges are characterized by a zonal vertical distribution of butterflies (Korb, 2012) and one ridge shows a mosaic distribution (Korb, 2015). In addition, it is possible to assume the presence of a mixed (belt-mosaic) vertical distribution of butterflies in the mountains of Central Asia, but so far this type of vertical distribution has not been shown for any ridge.

At present, there is not enough material to draw conclusions about how often vertical distribution of butterflies of the mosaic type occurs in Central Asia and whether there are patterns in its distribution. This work is a continuation of studies on the vertical distribution of Rhopalocera in the mountain ranges of Central Asia, and should serve as the next stage in the accumulation of the data necessary to understand its patterns. The Moldo-Too Range was chosen as a model for studying the vertical distribution of butterflies for the following reasons. Firstly, it is located almost entirely in the middle of the Inner Tien Shan and can be considered the standard of its Rhopalocera fauna. Secondly, almost all of its territory is easily accessible (a convenient highways run along the entire ridge). Thirdly, the piedmont plain has been cultivated for many centuries, and in the future our studies can form the basis for comparison with less or more disturbed faunas of other Inner Tien Shan ranges, as well as neighbouring mountainous regions.

Material and methods

The Moldo-Too range stretches in a latitudinal direction between the valleys of the Kkmeren and Naryn rivers; the length of the range is about 150 km. The highest peak reaches 4185 m above sea level. The range is composed mainly of limestone with extensive inclusions of clay and sandstone. The lower and middle parts of the slopes are occupied by steppe and in some places semi-desert vegetation (cereal and forb steppes, *Kobresia* communities, wormwood-*Kobresia* and wormwood-cereal semideserts); higher up, there are thickets of shrubs and trees (juniper, spruce).

The material was collected during the summer season (from June to August) in 1997, 1999, 2001, 2005, 2007, 2009, 2014–2019 in the following localities (Fig. 1): (1) Kok-Zherty Canyon (N 41°33'39" E 73°56'17"); (2) vicinity of the village of Dostuk (N 41°22'46" E 75°38'18"); (3) vicinity of the village of Kulanak (N 41°21'21" E 75°30'13"); (4) vicinity of the village of Ak-Tal (N 41°24'26" E 75°3'43"); (5) vicinity of the village of Ak-Kyya (N 41°27'15" E 74°59'51"); (6) Koro-Goo mountain pass (N 41°31'34" E 74°42'37"); (7) vicinity of Song-Kel Lake 12 km of the Kara-Kech coal mine (= Korum-Kechy in old papers)

(N 41°45'7" E 74°55'7"); (8) vicinity of Mount Kazarman (N 41°24'18" E 74°2'6").

To collect material, 3–5 straight routes were made to each point, radially diverging from the expedition camp, 3–7 km long, with climb. The material on linear routes was collected using an entomological net for not easily identified species; easily identifiable taxa were recorded based on instant observation. A total of 4000 specimens were collected and more than 25000 observations were made. In addition, collection materials were used from the Zoological Museum of Moscow State University (Moscow), the Zoological Institute of the Russian Academy of Sciences (St. Petersburg), the Institute of Biology of the Komi Scientific Center of the Ural Branch of the Russian Academy of Sciences (Syktyvkar), the Finnish Natural History Museum (Helsinki) and Berlin Museum of Natural History (Museum fr Naturkunde Leibniz-Institut fr Evolutions- und Biodiversittsforschung) (Berlin).

The collected material was processed using Microsoft Excel 2019 and IBM SPSS Statistics (version 26). The similarity of the faunas was assessed using the Jaccard similarity index; the K nearest neighbour algorithm (KNN) was used to construct the dendrogram (Pesenko, 1982). The systematics and nomenclature of the butterflies follows the modern catalogue (Korb and Bolshakov, 2016).

The belts of the vertical profile of the ridge are identified in accordance with the traditional division (Gorodkov, 1984), which we have modified and supplemented (Korb, 2012, 2019): low mountains, medium mountains, high mountains, and ultrahigh mountains. The types of biotopes are identified in accordance with their key role in the conservation of biological diversity and are determined according to the method described by A.V. Gribkov et al. (2017): steppe and steppe stations (Fig. 2A), dry meadows (Fig. 2B), wet meadows (Fig. 2C), talus (Fig. 2D, E), rocks (Fig. 2F) and bushes (Fig. 2G).

Results

On the Moldo-Too Range, 118 species of butterflies were recorded (Table 1). They are distributed along vertical belts as follows: 79 in the low mountains, 100 in the middle mountains, 60 in the highlands and 31 in the ultrahigh mountains. Division by key biotopes: 91 species were recorded in steppe and steppe zones, 105 – in dry meadows, 57 – in wet meadows, 14 – in talus, 23 – in rocks and 18 – in thickets of shrubs.

The analysis of the similarity of the faunas of the vertical belts (Table 2) shows that the faunas located below are more similar than those located above. The similarity index of the faunas of the low and middle mountains is 0.750, while for the faunas of the high and ultrahigh mountains the same index is 0.500. The latter value is a threshold for identifying faunas as

Fig. 1. Map of the study area. See the text for locality details.

similar. The faunas of the high and middle mountains are different. Thus, along the border of these two belts, a conditional line can be drawn between the faunas of allochthonous and autochthonous origin.

The relationship between the faunas of key biotopes looks much more interesting (Table 3). Here, the similarity is observed only between steppe and steppe stations and dry meadows, due to the obvious commonality of habitat conditions, such a regularity in the distribution of species over key biotopes is expected. The faunas of diurnal butterflies in other key biotopes of the Moldo-Too Range are different.

The taxonomic composition of the butterflies of the ridge includes 9 species of Hesperidae, 7 species of Papilionidae, 15 species of Pieridae, 21 species of Nymphalidae, 23 species of Satyridae, 1 species of Riodinidae and 42 species of Lycaenidae.

Lycaenidae and representatives of the nymphaloid complex (Nymphalidae and Satyridae; some authors consider them as subfamilies of the same family) are represented approximately equally and in general account for more than two thirds (72%) of the entire fauna. The remaining 28% of the fauna belongs to 4 families, of which the largest share of species belongs to Pieridae, and the smallest to Riodinidae.

The largest number of Hesperidae species was recorded in the low-mountain (7) and middle-mountain (8) belts. In the highlands, the number of skipper species sharply decreases (4 species were noted), in the ultrahigh mountains it is even fewer (2 species). For the Papilionidae, the opposite picture was noted: only 1 species was recorded in the low mountains, in the middle mountains the number of species increases markedly (4 species), and the

Fig. 2. Key biotopes: **A** – steppe and steppe stations, vicinity of the village of Kulanak, 1800 m; **B** – Dry meadows, vicinity of the Koro-Goo mountain pass, 2500 m; **C** – wet meadows, vicinity of lake Song-Kel near the Kara-Keche coal deposit, 3200 m; **D, E** – talus, vicinity of the Moldo-Ashuu mountain pass, 2000 m (in two angles); **F** – Rock cliffs, Kogo-Goo mountain pass, 2400–2600 m; **G** – thickets of bushes, the foothills of the Song-Kel-Ashuu mountain pass, 15 km on the way to the Kara-Keche coal deposit, 2200 m. Photographs by the author (**A, C–G**), E. Komarov (**B**).

No.	Species	Vertical belts				Biotores					
		I	II	III	IV	1	2	3	4	5	6
37	<i>Brenthis hecate</i> (Denis et Schiffermüller, 1775)	+	+	–	–	+	+	–	–	–	–
38	<i>Boloria erubescens</i> (Staudinger, 1901)	–	+	+	+	–	+	+	–	–	–
39	<i>B. generator</i> (Staudinger, 1886)	–	–	+	+	–	+	+	–	–	–
40	<i>Polygonia egea</i> (Cramer, 1775)	+	+	–	–	+	+	–	–	–	–
41	<i>Nymphalis xanthomelas</i> (Denis et Schiffermüller, 1775)	+	+	–	–	+	+	–	–	–	+
42	<i>Aglaia urticae</i> (Linnaeus, 1758)	+	+	+	+	+	+	+	–	–	+
43	<i>Inachis io</i> (Linnaeus, 1758)	+	+	+	+	+	+	+	–	–	+
44	<i>Vanessa cardui</i> (Linnaeus, 1758)	+	+	+	+	+	+	+	+	–	+
45	<i>Melitaea didyma</i> (Esper, 1778)	+	+	–	–	+	+	–	–	–	–
46	<i>M. ala</i> Staudinger, 1881	–	+	+	–	+	+	–	–	–	–
47	<i>M. fergana</i> Staudinger, 1881	–	+	+	+	+	+	+	+	–	–
48	<i>M. trivia</i> (Denis et Schiffermüller, 1775)	+	+	–	–	+	+	–	–	–	–
49	<i>M. minerva</i> Staudinger, 1881	+	+	+	–	+	+	+	–	–	–
50	<i>M. pallas</i> Staudinger, 1886	–	+	+	–	–	+	+	–	–	–
51	<i>M. sibina</i> Alphéraky, 1881	+	+	–	–	+	+	–	–	–	–
52	<i>M. arduinna</i> (Esper, 1793)	+	+	–	–	+	+	–	–	–	–
53	<i>Marginaria eversmanni</i> (Eversmann, 1847)	+	+	–	–	–	+	–	–	–	+
54	<i>Melanargia parce</i> Staudinger, 1882	+	+	–	–	+	+	–	–	–	–
55	<i>Chortobius pamphilus</i> (Linnaeus, 1758)	+	+	+	+	+	+	+	–	–	–
56	<i>C. sunbecca</i> (Eversmann, 1843)	–	+	+	–	+	+	–	–	–	+
57	<i>Paralasa kolesnichenkoi</i> Churkin et Zhdanko, 2001	–	+	+	–	+	+	–	+	+	–
58	<i>Erebia mopsos</i> Staudinger, 1886	–	–	+	+	–	–	+	+	+	–
59	<i>E. mongolica</i> Erschoff, 1888	–	–	+	+	–	–	+	+	+	–
60	<i>E. radians</i> Staudinger, 1886	–	–	+	+	–	–	+	–	–	–
61	<i>E. progne</i> Groum-Grshimailo, 1890	–	–	+	+	–	–	–	+	+	–
62	<i>Hipparchia autonoe</i> (Esper, 1783)	+	+	–	–	+	+	–	–	–	–
63	<i>Chazara briseis</i> (Linnaeus, 1764)	+	+	–	–	+	+	–	–	+	–
64	<i>C. enervata</i> (Staudinger, 1881)	+	+	+	+	+	+	+	–	+	–
65	<i>C. kaufmanni</i> (Erschoff, 1874)	+	+	–	–	+	+	–	–	–	–
66	<i>C. heydenreichi</i> (Lederer, 1853)	+	+	+	–	+	+	–	–	–	–
67	<i>Pseudochazara turkestan</i> (Grum-Grshimailo, 1893)	+	+	+	–	+	+	–	+	+	–
68	<i>Satyrus ferula</i> (Fabricius, 1793)	+	+	–	–	+	+	–	–	+	–
69	<i>Hyponephele interposita</i> (Erschoff, 1874)	+	+	–	–	+	+	–	–	–	–
70	<i>H. dysdora</i> (Lederer, 1870)	+	+	–	–	+	+	–	–	–	–
71	<i>H. laeta</i> (Staudinger, 1886)	+	+	–	–	+	+	–	–	–	–
72	<i>H. glasunovi</i> (Grum-Grshimailo, 1893)	+	+	–	–	+	+	–	–	+	–

No.	Species	Vertical belts				Biotopes					
		I	II	III	IV	1	2	3	4	5	6
73	<i>H. naricina</i> (Staudinger, 1870)	+	–	–	–	+	–	–	–	–	–
74	<i>H. haberhaueri</i> (Staudinger, 1886)	+	+	–	–	+	+	–	–	–	–
75	<i>H. naubidensis</i> (Erschoff, 1874)	+	+	–	–	+	+	–	–	–	–
76	<i>Polycaena tamerlana</i> Staudinger, 1886	–	–	+	+	–	–	–	+	+	–
77	<i>Fixsenia acaudata</i> (Staudinger, 1901)	+	+	–	–	+	+	–	–	–	+
78	<i>Neolycaena carbonaria</i> (Groum-Grshimaïlo, 1890)	+	+	–	–	+	+	–	–	–	+
79	<i>N. sinensis</i> (Alphéraky, 1882)	+	+	–	–	+	+	–	–	–	–
80	<i>Callophrys rubi</i> (Linnaeus, 1758)	+	+	–	–	–	+	–	–	–	+
81	<i>Lycaena phlaeas</i> (Linnaeus, 1761)	+	+	+	+	+	+	+	–	+	+
82	<i>L. thersamon</i> (Esper, 1784)	+	+	+	–	+	+	–	–	–	–
83	<i>L. solskyi</i> (Erschoff, 1874)	–	+	+	–	+	+	+	–	–	–
84	<i>L. dispar</i> (Haworth, 1802)	+	+	–	–	+	+	+	–	–	–
85	<i>L. splendens</i> (Staudinger, 1881)	–	+	+	–	+	+	+	–	–	–
86	<i>L. margelanica</i> (Staudinger, 1881)	–	–	+	+	+	+	–	–	+	+
87	<i>Athamanthia dilutior</i> (Staudinger, 1881)	+	+	–	–	+	+	–	–	–	–
88	<i>Cupido buddhista</i> (Alphéraky, 1881)	–	+	+	+	–	+	+	–	–	–
89	<i>C. prosecusa</i> (Erschoff, 1874)	+	+	–	–	+	+	–	–	–	–
90	<i>Celastrina argiolus</i> (Linnaeus, 1758)	+	+	–	–	–	+	+	–	–	+
91	<i>Glaucopsyche alexis</i> (Poda, 1761)	+	+	–	–	–	+	+	–	–	–
92	<i>G. aeruginosa</i> (Staudinger, 1881)	–	+	+	–	+	+	–	–	–	–
93	<i>Phengaris cyaneacula</i> (Eversmann, 1848)	+	+	+	–	+	+	+	–	–	–
94	<i>Plebejus idas</i> (Linnaeus, 1758)	+	+	–	–	+	+	–	–	–	–
95	<i>P. argivus</i> (Staudinger, 1886)	+	–	–	–	+	+	–	–	–	–
96	<i>P. rogneda</i> (Groum-Grshimaïlo, 1890)	+	+	–	–	+	+	–	–	–	–
97	<i>P. maracandicus</i> (Erschoff, 1874)	+	+	–	–	+	+	–	–	–	–
98	<i>Rueckbeilia fergana</i> (Staudinger, 1881)	+	+	+	–	+	+	+	–	+	+
99	<i>Alpherakya sarta</i> (Alphéraky, 1881)	+	+	–	–	+	+	–	–	+	–
100	<i>Glabroculus elvira</i> (Eversmann, 1854)	+	+	–	–	+	+	–	–	–	–
101	<i>Aricia agestis</i> (Denis et Schiffermüller, 1775)	+	+	–	–	+	+	+	–	–	–
102	<i>A. artaxerxes</i> (Fabricius, 1793)	+	+	+	–	+	+	+	–	–	+
103	<i>Afarsia sieversii</i> (Christoph, 1873)	–	+	–	–	+	+	–	–	–	–
104	<i>Agriades pheretiades</i> (Eversmann, 1843)	–	–	+	+	–	+	+	+	–	–
105	<i>Eumedonia eumedon</i> (Esper, 1780)	+	+	+	+	+	+	+	–	–	+
106	<i>E. persephatta</i> (Alphéraky, 1881)	–	+	+	–	+	+	+	–	–	–
107	<i>Cyaniris semiargus</i> (Rottemburg, 1775)	+	+	–	–	–	+	+	–	–	–
108	<i>Polyommatus amandus</i> (Schneider, 1792)	+	+	+	–	+	+	+	–	–	–
109	<i>P. ripartii</i> (Freyer, 1830)	+	+	–	–	+	+	–	–	–	–
110	<i>P. damon</i> (Denis et Schiffermüller, 1775)	+	+	–	–	+	+	–	–	–	–

No.	Species	Vertical belts				Biotopes					
		I	II	III	IV	1	2	3	4	5	6
111	<i>P. iphigenides</i> (Staudinger, 1886)	–	+	+	+	–	+	+	–	–	–
112	<i>P. samusi</i> Korb, 2017	–	+	–	–	+	+	–	–	–	–
113	<i>P. melanius</i> (Staudinger, 1886)	–	+	+	–	+	+	–	–	–	–
114	<i>P. phyllides</i> (Staudinger, 1886)	+	+	–	–	+	+	–	–	–	–
115	<i>P. thersites</i> (Cantener, 1835)	+	+	–	–	+	+	–	–	–	–
116	<i>P. venus</i> (Staudinger, 1886)	–	–	+	+	–	–	+	–	+	–
117	<i>P. icadius</i> (Groum–Grshimailo, 1890)	+	+	+	–	+	+	+	–	–	–
118	<i>P. icarus</i> (Rottemburg, 1775)	+	+	+	–	+	+	+	–	–	–
Bcero		79	100	60	31	91	105	57	14	23	18

Table 2. Jaccard similarity index of faunas of Rhopalocera of the vertical belts of the Moldo-Too Range. Designations of vertical belts as in Table 1.

Vertical belt	I	II	III	IV
I	1.000			
II	0.752	1.000		
III	0.212	0.386	1.000	
IV	0.101	0.140	0.500	1.000

Table 3. Jaccard similarity index of faunas of Rhopalocera from key biotopes of the Moldo-Too Range. Key biotopes are designated as in Table 1.

Key biotopes	1	2	3	4	5	6
1	1.000	–	–	–	–	–
2	0.848	1.000	–	–	–	–
3	0.336	0.438	1.000	–	–	–
4	0.051	0.054	0.145	1.000	–	–
5	0.130	0.134	0.194	0.370	1.000	–
6	0.149	0.162	0.154	0.067	0.108	1.000

family reaches the greatest diversity in the high mountains (6 species). In the ultrahigh mountains, the number of Papilionidae species again drops to 4.

The number of Pieridae species in low and middle mountains is approximately equal (10 and 12 species, respectively); it gradually decreases with an increase in absolute altitude (7 species in the highlands and 3 in the ultrahigh mountains). Nymphalids, like the previous family, have the maximum species diversity in the middle mountains (20 species); the low-mountain and high-mountain fauna of the Nymphalidae of

the Moldo-Too Range are approximately equal (14 and 13 species, respectively). The smallest number of species of the family was noted in the ultrahigh mountains (8 species). Satyrids in the low and middle mountains have approximately equal number of species (17 and 18 species, respectively), in the high mountains the number of species decreases markedly (10), in the ultrahigh mountains it drops even more (6 species).

Riodinidae, represented by only one species on the Moldo-Too Range, are absent in the low

and middle mountains. Lycaenidae have the highest species diversity in the middle mountains (38 species); in the lowlands, 30 species of this family have been recorded. The number of species of blues in the highlands is half that in the middle mountains (19 species); in ultrahigh mountains, their number again drops by more than half (up to 7 species).

Discussion

Distribution of Rhopalocera along the vertical belts of the Moldo-Too Range fits into the patterns discovered earlier (Korb, 2014, 2019): the highest species diversity is observed in the middle-mountain belt, the lowest in the ultra-high mountain zone; at the same time, the number of species first increases in the direction from bottom to top, and then conversely, decreases after the mid-mountain zone. This concerns both the general Rhopalocera fauna, and the faunas of individual families.

The relationship between faunas of diurnal butterflies in key biotopes of the Moldo-Too Range: similarity between key biotopes is observed only for steppe and steppe stations and dry meadows. This type of distribution indicates an absence of connections between the faunas of butterflies of low mountains-middle mountains and high mountains-ultrahigh mountains. Kryzhanovsky (1965) proposed a theory about different sources of origin for the faunas of the mountains of Central Asia: the low-mountainous-middle-mountain group of faunas is of allochthonous origin, and the high-mountainous-superhigh-mountain group is of autochthonous origin. The lack of connections between these groups in our data supports this theory.

It is noteworthy that the index of similarity of the Rhopalocera faunas of the highlands and ultra-highlands of the Moldo-Too Range is at the border between similarity and dissimilarity (0.500). In the mountain ranges of the North Tien Shan, the similarity between the alpine and ultra-alpine faunas of diurnal butterflies is higher; the minimum value of the similarity index was found for the Kyrgyz Range (0.540), maximum – for Trans-Ili Alatau (0.810) (Korb, 2012). In the mountains of the Southwestern Pamir, the index of similarity of the faunas of butterflies of highlands and ultrahigh mountains ranges from 0.561 to 0.612 (Korb, 2016). Most likely, the higher similarity of the Rhopalocera faunas of the highlands and ultra-highlands of the North Tien Shan is explained by the stronger influence of allochthonous processes on the genesis of the fauna of this territory since it is located at the beginning of the South Siberia-Central Asia migration corridor. This can also explain the average values of the similarity index of the faunas of diurnal butterflies of the highlands and ultrahighlands of the Southwestern Pamir: they are located approximately in the middle of the migration corridor between the

mountain uplifts of Central Asia and the Himalayas. It is obvious that the distant position of the ridges of the Inner Tien Shan (Moldo-Too Range) from these migration corridors makes the role of autochthonous processes in their faunogenesis higher.

The significance of the Moldo-Too Range, as a part of the Naryn arid refugium, consisted not only of autochthonous morphogenesis of conserved ancestral forms (leading, for example, to the formation of the endemic species of this mountain range, *Koramius davydovi*), but also in the conservation of desert and semi-desert species on its territory. In particular, among diurnal butterflies, these include *Hyponephele naricina*, *Cupido prosecusa*, and *Glabroculus elvira*.

The modern picture of the vertical distribution of butterflies on the Moldo-Too Range (the highest species richness of blues, nymphalids and satyrids in the middle and low mountains; a gradual decrease in the species richness of families in more high vertical belts) is presumably associated with an increase in the humidity of habitats with an increase in absolute altitude.

Acknowledgements

The author is sincerely grateful to the colleagues who participated in expeditions: A.A. Shaposhnikov (Podolsk), A.G. Belik (Saratov), A.N. Samus (Volgograd), E.V. Komarov (Volgograd), O.P. Komarov (Volgograd). The author is also grateful to G.A. Anufriev (Nizhny Novgorod) and Yu. Shchetkin (Taganrog) for developing the study of the vertical distribution of phytophagous insects in mountainous Central Asia, and for the invaluable knowledge that they shared. I would like to express my deep gratitude to the curators of the Lepidoptera, who provided access to collections: A.V. Sviridov (Zoological Museum of Moscow State University), S.Yu. Sinev and A.L. Lvovsky (Zoological Institute RAS), A.G. Tatarinov and O.I. Kulakova (Institute of Biology, Komi Science Center, Ural Branch of the Russian Academy of Sciences), J. Kullberg and L. Kaila (Finnish Natural History Museum), W. Mey (Museum für Naturkunde).

ORCID

C.K. Korb [0000-0002-1120-424X](https://orcid.org/0000-0002-1120-424X)

References

- Gorodkov, K.B., 1984. Tipy arealov nasekomykh tyndry i lesnykh zon evropeyskoy chasti SSSR [Types of insect habitats in the tundra and forest zones of the European part of the USSR]. In: Gorodkov, K.B. (ed.), *Arealny nasekomykh yevropeyskoy chasti SSSR. Karty 179–221* [Geographic ranges of insects of the European part of the USSR. Maps 179–221]. Nauka, Leningrad, USSR, 3–20. (In Russian).

- Gribkov, A.V., Pozhidaeva, L.V., Kuzmenkin, D.V., Shchur, A.V., 2017. Polevoy opredelitel' klyuchevykh biotopov i ob'yektov, podlezhashchikh sokhraneniyu pri osvoyenii lesosek na territorii Respubliki Altay [Field guide to key biotopes and objects to be preserved during the development of cutting areas in the Altai Republic]. World Wide Fund for Nature (WWF), Krasnoyarsk, Russia, 54 p. (In Russian).
- Korb, S.K., 1994. Vertikal'noe raspredelenie bulavousykh cheshuekrylykh (Lepidoptera, Rhopalocera) na Kirfizskom khrebe [Vertical distribution of butterflies (Lepidoptera, Rhopalocera) on the Kyrgyz ridge]. *Zoologicheskii zhurnal [Zoological Journal]* 73 (7, 8), 123–129. (In Russian).
- Korb, S.K., 2000. Ocherk fauny bulavousykh cheshuekrylykh (Lepidoptera, Rhopalocera) Severnogo Tyan-Shanya [Essay on the fauna of butterflies (Lepidoptera, Rhopalocera) of the North Tien Shan]. *Zoologicheskii zhurnal [Zoological Journal]* 79 (7), 824–832. (In Russian).
- Korb, S.K., 2010. Bulavousye cheshuekrylye (Lepidoptera, Rhopalocera) Suusamyrskoy doliny (Kyrgyzstan): obzor fauny s opisaniem dvukh novykh vidov [Butterflies (Lepidoptera, Rhopalocera) of the Suusamyr valley (Kyrgyzstan): an overview of the fauna with a description of two new species]. *Altayskiy zoologicheskii zhurnal [Altay Zoological Journal]* 2009 (3), 31–42. (In Russian).
- Korb, S.K., 2012. Zoogeographicheskiy analiz poyasnoy struktury fauny bulavousykh cheshuekrylykh Severnogo Tyan-Shanya (Lepidoptera: Rhopalocera) i voprosy genezisa fauny Tsentralnoy Azii [Zoogeographic analysis of the belt structure of the fauna of butterflies of the North Tien Shan (Lepidoptera: Rhopalocera) and questions of the origin of the fauna of Central Asia]. *Kavkazskiy entomologicheskii byulleten' [Caucasian Entomological Bulletin]* 8 (2), 283–296. (In Russian).
- Korb, S.K., 2015. Vertikal'noe raspredelenie bulavousykh cheshuekrylykh na khrebe Terskey Ala-Too (Severniy Tyan-Shan) (Lepidoptera, Papilionoformes) [Vertical distribution of butterflies on the Terskey Ala-Too Ridge (North Tien Shan) (Lepidoptera, Papilionoformes)]. *Trudy Mordovskogo gosudarstvennogo prirodnogo zapovednika imeni P.G. Smidovicha [Proceedings of Mordovian State Natural Reserve named after P.G. Smidovich]* 14, 255–266. (In Russian).
- Korb, S.K., 2016. Sravnitel'nyi analiz vertikal'nogo raspredeleniya bulavousykh cheshuekrylykh (Lepidoptera: Hesperioidea, Papilionoidea) v gorakh Yugo-Zapadnogo Pamira (Tadzhikistan) [Comparative analysis of the vertical distribution of butterflies (Lepidoptera: Hesperioidea, Papilionoidea) in the mountains of the Southwestern Pamir (Tajikistan)]. *Kavkazskiy entomologicheskii byulleten' [Caucasian Entomological Bulletin]* 12 (2), 289–296. (In Russian).
- Korb, S.K., 2018. Butterfly fauna of Dzhungal-Too mountain ridge in Kyrgyzstan (Lepidoptera: Papilionoidea and Hesperioidea). *Acta Biologica Sibirica* 4 (2), 53–60.
- Korb, S.K., 2019. Zakonomernosti vertikal'nogo raspredeleniya bulavousykh cheshuekrylykh (Lepidoptera: Hesperioidea, Papilionoidea) Sredney Azii [Patterns of the vertical distribution of butterflies (Lepidoptera: Hesperioidea, Papilionoidea) in Central Asia]. *Kavkazskiy entomologicheskii byulleten' [Caucasian Entomological Bulletin]* 15 (1), 187–202. (In 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, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan) with special account to their type specimens (Lepidoptera: Hesperioidea, Papilionoidea). *Zootaxa* 4160, 1–324.
- Kryzhanovsky, O.L., 1965. *Sostav i proiskhozhdeniye nazemnoy fauny Sredney Azii [Composition and origin of the terrestrial fauna of Central Asia]*. Nauka, Moscow – Leningrad, USSR, 419 p. (In Russian).
- Pesenko, Yu.A., 1982. Printsipy i metody kolichestvennogo analiza v faunisticheskikh issledovaniyakh [Principles and methods of quantitative analysis in faunistic research]. Nauka, Moscow, USSR, 288 p. (In Russian).
- Semenov, P.P., 1858. Pervaya poezdka na Tyan-Shan ili Nebesnyi khrebet do verkhovya sistemy r. Yaksarta ili Syr-Dar'yi v 1857 godu [The first trip to the Tien Shan or the Nebesnyi Ridge to the upper reaches of the Jaxartes or Syr Darya River in 1857]. *Vestnik Imperatorskogo Russkogo Geograficheskogo Obshchestva [Bulletin of the Imperial Russian Geographical Society]* 23, 1–25.

- Zhdanko, A.B., 1979. Vertikal'noe raspredelenie dnenykh babochek (Lepidoptera, Rhopalocera) Zailiyskogo Alatau [Vertical distribution of diurnal butterflies (Lepidoptera, Rhopalocera) of the Trans-Ili Alatau]. *Novosti entomologii Kazakhstana* [News of entomology of Kazakhstan]. Alma-Ata, Kazakhstan, 79–84. (In Russian).
- Zhdanko, A.B, 1983. Vertikal'noe raspredelenie dnevnnykh babochek (Lepidoptera, Rhopalocera) v gorakh Severnogo Tyan-Shanya i Yushnogo Altaya [Vertical distribution of diurnal butterflies (Lepidoptera, Papilionoidea) in the mountains of the North Tien Shan and South Altai]. *Entomologicheskoye obozreniye* [Entomological Review] **62** (4), 716–727. (In Russian).
- Zimina, R.P, 1964. Zakonomernosti vertikal'nogo rasprostraneniya mlekopitayushchikh [Patterns of vertical distribution of mammals. Nauka, Moscow, USSR, 158 p. (In Russian).