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The butterflies (Lepidoptera: Papilionoformes) of three model mountainous badlands in Kyrgyzstan: a habitat without local or regional endemism

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Abstract. This paper deal with study of the butterfly fauna of three mountainous badlands in Kyrgyzstan (Naryn Adyr, Red Canyon and Kyrk-Kechik Canyon). The studied badlands fauna comprises of 47 species, namely: 42 species in Naryn Adyr, 33 species in Kyrk-Kechik Canyon, 30 species in Red Canyon. Most of the butterflies within these badlands feed on drought-resistant plants. About two thirds of the studied fauna is represented by species with wide ranges, a bit less than one third – by Central Asiatic species. The local and regional endemism which is highly characteristic for Central Asia, in the studied badlands is not present.

Key words: butterflies, fauna, analysis, badlands, Kyrgyzstan.

**Дневные бабочки (Lepidoptera: Papilionoformes)
трех модельных горных бедлендов Кыргызстана:
биотоп без локального и регионального эндемизма**

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Резюме. Настоящее сообщение посвящено фауне булавоусых чешуекрылых трех горных бедлендов Кыргызстана (Нарынский адыр, Красный каньон и каньон Кырк-Кечик). Фауна бедлендов содержит 47 видов дневных бабочек, а именно: 42 вида в Нарынском адыре, 33 вида в каньоне Кырк-Кечик, и 30 видов в Красном каньоне. Большинство видов в бедлендах развивается на засухоустойчивых растениях. Около двух третей фауны представлено видами с широким распространением, немногим менее одной трети – центральноазиатскими видами. На изученных территориях не обнаружен локальный или региональный эндемизм, весьма характерный для Центральной Азии.

Ключевые слова: дневные бабочки, фауна, анализ, бедленды, Кыргызстан.

Introduction

Badlands, as a type of landscapes, almost do not attract the attention of entomologists studying butterflies. Firstly, the species diversity in such landscapes is poor, and secondly, they are very inconvenient for field studies (very rough terrain, poor roads, etc.). The butterfly fauna of these landscapes is underestimated. No papers on the butterflies of the mountainous badlands of Kyrgyzstan are known to me.

Badland is a type of dry terrain where softer sedimentary rocks and clay-rich soils have been extensively eroded by wind and water [Arid zone..., 2011]. Badlands are characterized by steep slopes, minimal vegetation, lack of a substantial regolith, and high drainage density [Parsons, Abrahams, 2009]. Canyons, ravines, gullies, buttes, mesas, hoodoos and other such geologic forms are common in badlands. Due to their minimal vegetation and eroded land, badlands are difficult to explore by foot; normally they have no roads or traces. These features of badlands are the reasons why they are poorly studied by lepidopterologists as far as by other entomologists.

In Central Asia large badlands are named adyr; they are mainly located in desert foothills at altitudes from 500 to 1500 m above sea level [Zakirov, Zakirov, 1978]. Middle mountains have large badlands rarely. Small badlands

(several hundred meters long and wide) are out of interest, since the influence of the surrounding fauna on them is too strong and it is almost impossible to distinguish the fauna of small badland itself. Interesting are only badlands of a large size where the borders of badlands and surrounding habitats are clear.

Central Asiatic region is characterized by a high level of endemism [Kryzhanovsky, 1965, 2002]; the butterflies endemism can reach 70% in some Central Asiatic areas, and in whole Central Asia its rate is about 56% [Korb, 2005]. Surprisingly we found in studied badlands no local or regional endemism. It was the reason to process the detailed study of several badlands we select as model areas to be sure that we face the regular zoogeographical pattern in this territory and habitat type. Three badlands are studied for this research: relatively small, average and a big one. The second reason for doing this work is the lack of knowledge on badland Lepidoptera.

Material and methods

The material for this study was collected in three largest badlands of Kyrgyzstan: Naryn Adyr, Red Canyon and Kirk-Kechik Canyon (Fig. 1).

Naryn Adyr (Fig. 1, localities 2, 3, 4; Fig. 2). This badland is located along both banks of the Naryn River

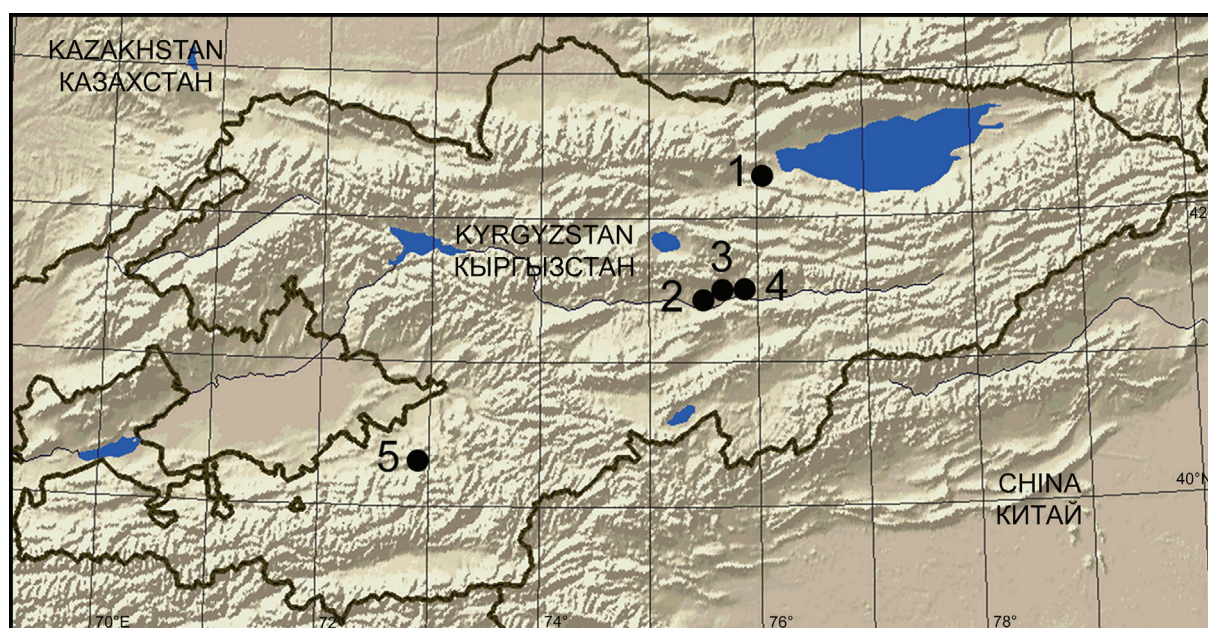


Fig. 1. Location of studied badlands.

1 – Red Canyon; 2–4 – Naryn Adyr: 2 – Koro-Goo Pass, 3 – Kulanak, 4 – Naryn environs; 5 – Kyrk-Kechik.

Рис. 1. Расположение исследованных бедлендов.

1 – Красный каньон; 2–4 – Нарынский адыр: 2 – перевал Коро-Гоо, 3 – Куланак, 4 – окрестности Нарына; 5 – каньон Кырк-Кечик.

and cover the space between the town of Naryn and Koro-Goo Pass, its total length is about 120 km and the width is from 1 to 3 km. Altitudes: 1800–2600 m. Studied localities: environs of Koro-Goo Pass near the village Ak-Kya (41°29.337'N / 74°50.010'E); Kulanak vicinities (41°21.242'N / 75°30.578'E); the town of Naryn environs (41°28.138'N / 76°3.595'E); Kara-Oy vicinities (41°30.495'N / 75°8.852'E). Vegetation is very poor, mostly Poaceae; the soils are clays and sands.

Red Canyon (Fig. 1, locality 1; Fig. 3). A series of badlands with extensive clay canyons in the lower part of Boom valley westwards of the Orto-Tokoy Reservoir. The length is about 25 km, the width is from 1 to 5 km. Altitudes: 1700–2200 m. Studied localities: Kok-Moynok vicinities (42°26.073'N / 75°59.755'E); Orto-Tokoy Reservoir environs (42°21.593'N / 76°3.885'E). Vegetation is very poor, mostly Poaceae and some Fabaceae; the soils are clays with rocks and stones.

Canyon Kirk-Kechik (Fig. 1, locality 5; Fig. 4) is located at the foot of Chiyyrchik Pass on the northern slope of the Alai Range (Ak-Buura State Reserve). It is about 25 km long and up to 1 km wide. Altitudes: 1700–2200 m. Studied locality: middle part of the Canyon (40°16.150'N / 73°6.708'E). Vegetation is very poor, mostly Poaceae; the soils are clays and sands with big stones and some rocks.

These badlands were selected for our study due to their size: Naryn Adyr is the largest in Kyrgyzstan, Red Canyon is medium and Kirk-Kechik Canyon is relatively small.

The studies were made in 1999–2018. Research method: collecting material on walking routes. The system of butterflies is used in accordance to the newest catalogue [Korb, Bolshakov, 2016]. The modified method of Shchetkin [2017] in zoogeographical analysis is used. The papers of V. and A. Lukhtanov [1994], Zhdanko [1997], and

Ottmüller [2016] are used in the trophic relations analysis; some zoogeographical data were taken from the paper of Tshkolovets [2005]. The calculations were made by the following software: IBM SPSS Statistica for Windows and Microsoft Excel.

Results and discussion

Forty-seven species of butterflies found in the fauna of three studied badlands altogether (Table 1). The largest number of species is in Naryn Adyr (42 species), the smallest – in Red Canyon (30 species); 33 species of butterflies collected in Kirk-Kechik Canyon. The greatest species diversity in the largest badland was predictable; the poorest species diversity in a medium sized badland (but not the smallest one) was a surprise.

Zoogeographically this fauna comprises of three complexes and 14 types of areas (Table 2). The complex of butterflies with wide ranges is almost two thirds of the studied fauna (61.7%). Butterflies with Central Asiatic ranges form almost a third of the lepidopterofauna of studied badlands (29.7%). The representatives of the species complex of Tian-Shanian areas comprises less than one tenth of the badland lepidopterofauna (8.6%).

The zoogeographical structure of the lepidopterofauna of the Naryn Adyr: the complex of butterflies with wide ranges is 64.2%, butterflies with Central Asiatic ranges – 28.6%, the Tian-Shanian complex – 7.2%. The zoogeographical structure of the lepidopterofauna of Red Canyon: the complex of butterflies with wide ranges is 76.6%, butterflies with Central Asiatic ranges – 16.6%, the Tian-Shanian complex – 6.8%. The same of Kirk-Kechik Canyon: the complex of butterflies with wide ranges is 69.7%, the Central Asiatic complex is 31.3%,

Table 1. Butterflies of the mountainous badlands of Kyrgyzstan.
Таблица 1. Булавоусые чешуекрылые горных бэдлендов Кыргызстана.

Species Вид	Badland Бэдленд			Type of the range Тип ареала	Host plants Кормовые растения
	NA	RC	CK		
<i>Carcharodus alceae</i> (Esper, 1780)	+	+	+	West Palaearctic / западнопалеарктический	Malvaceae, Euphorbiaceae
<i>Syrichthus nobilis</i> (Staudinger, 1882)	+	+	-	Central Asiatic / центральноазиатский	Lamiaceae
<i>S. proteus</i> (Staudinger, 1886)	+	+	+	Tian-Shan-Alai / тянь-шаньско-алайский	Lamiaceae
<i>Spialia orbifer</i> (Hübner, 1823)	+	+	+	Middle Palaearctic / среднепалеарктический	Rosaceae
<i>Thymelicus lineola</i> (Ochsenheimer, 1808)	+	+	+	Middle Palaearctic / среднепалеарктический	Poaceae
<i>Hesperia sylvana</i> (Esper, 1777)	+	-	-	Middle Palaearctic / среднепалеарктический	Poaceae
<i>Koramius davydovi</i> (Churkin, 2006)	+	-	-	Inner Tian-Shan / внутренне-тянь-шаньский	Fumariaceae
<i>Colias erate</i> (Esper, 1801)	+	+	+	Middle Palaearctic / среднепалеарктический	Fabaceae
<i>Anthocharis cardamines</i> (Linnaeus, 1758)	+	+	+	Middle Palaearctic / среднепалеарктический	Brassicaceae
<i>Euchloe daphalis</i> (Moore, 1865)	+	-	+	Central Asiatic-Himalayan / центральноазиатско-гималайский	Brassicaceae
<i>Pieris brassicae</i> (Linnaeus, 1758)	+	+	+	Palaearctic / палеарктический	Brassicaceae
<i>P. napi</i> (Linnaeus, 1758)	+	+	+	Holarctic / голарктический	Brassicaceae
<i>P. rapae</i> (Linnaeus, 1758)	-	+	+	Worldwide / всесветный	Brassicaceae
<i>Pontia daplidice</i> (Linnaeus, 1758)	+	+	+	Palaearctic / палеарктический	Brassicaceae
<i>Argynnis pandora</i> (Denis et Schiffermüller, 1775)	+	+	+	West Palaearctic / западнопалеарктический	Violaceae
<i>Issoria lathonia</i> (Linnaeus, 1758)	+	+	+	West Palaearctic / западнопалеарктический	Violaceae
<i>Nymphalis xanthomelas</i> (Esper, 1781)	+	+	+	Middle Palaearctic / среднепалеарктический	Salicaceae
<i>Aglais urticae</i> (Linnaeus, 1758)	+	+	+	Middle Palaearctic / среднепалеарктический	Urticaceae
<i>Vanessa cardui</i> (Linnaeus, 1758)	+	+	+	Worldwide / всесветный	Asteraceae, Urticaceae, Boraginaceae
<i>Melitaea didyma</i> (Esper, 1779)	+	+	-	Middle Palaearctic / среднепалеарктический	Plantaginaceae
<i>M. trivia</i> (Denis et Schiffermüller, 1775)	+	-	+	West Palaearctic / западнопалеарктический	Plantaginaceae
<i>M. sibina</i> Alphéraky, 1881	+	-	+	Central Asiatic / центральноазиатский	Plantaginaceae, Asteraceae
<i>Marginarge eversmanni</i> (Eversmann, 1847)	-	-	+	Central Asiatic-Pakistanian / центральноазиатско-пактистанский	Poaceae
<i>Melanargia parce</i> Staudinger, 1882	+	+	+	Centralasiatic / центральноазиатский	Poaceae
<i>Chortobius pamphilus</i> (Linnaeus, 1758)	+	+	+	West Palaearctic / западнопалеарктический	Poaceae
<i>Chazara briseis</i> (Linnaeus, 1764)	+	+	+	Middle Palaearctic / среднепалеарктический	Poaceae
<i>C. enervata</i> (Staudinger, 1881)	+	+	+	South Altai-Central Asiatic-Chitral / южноалтайско-центральноазиатско- читральский	Poaceae

Таблица 1 (окончание).
Table 1 (completion).

Species Вид	Badland Бэдленд			Type of the range Тип ареала	Host plants Кормовые растения
	NA	RC	CK		
<i>Pseudochazara turkestanica</i> (Grum-Grshimailo, 1893)	+	+	+	Central Asiatic / центральноазиатский	Poaceae
<i>Satyris ferula</i> (Fabricius, 1793)	+	–	–	West Palaearctic / западнопалеарктический	Poaceae
<i>Hyponephele lycaon</i> (Rottemburg, 1775)	+	–	–	West Palaearctic / западнопалеарктический	Poaceae
<i>H. dysdora</i> (Lederer, 1870)	+	–	+	Central Asiatic / центральноазиатский	Poaceae
<i>H. kirghisa</i> (Alphéraky, 1881)	–	+	–	Tian-Shanian / тянь-шаньский	Poaceae
<i>H. haberhaueri</i> (Staudinger, 1886)	+	–	–	Centralasiatic / центральноазиатский	Poaceae
<i>H. rueckbeili</i> (Staudinger, 1887)	+	–	–	Inner Tian-Shanian / внутренне-тянь-шаньский	Poaceae
<i>Fixsenia acaudata</i> (Staudinger, 1901)	+	+	+	Tian-Shanian / тянь-шаньский	Rosaceae
<i>Neolycaena tengstroemi</i> (Erschoff, 1874)	–	–	+	Central Asiatic / центральноазиатский	Fabaceae
<i>Lycaena phlaeas</i> (Linnaeus, 1760)	+	+	+	Holarctic / голарктический	Polygonaceae
<i>L. thersamon</i> (Esper, 1784)	+	+	+	West Palaearctic / западнопалеарктический	Polygonaceae
<i>L. margelanica</i> (Staudinger, 1881)	+	–	–	Central Asiatic / центральноазиатский	Polygonaceae
<i>Athamanthia dimorpha</i> (Staudinger, 1881)	+	–	–	Tian-Shan-Alai / тянь-шаньско-алайский	Polygonaceae
<i>Plebejus idas</i> (Linnaeus, 1760)	–	+	+	West Palaearctic / западнопалеарктический	Fabaceae
<i>P. maracandicus</i> (Erschoff, 1874)	+	–	–	South Europe-Central Asiatic / южноевропейско- центральноазиатский	Fabaceae
<i>Aricia agestis</i> (Denis et Schiffermüller, 1775)	+	+	+	West Palaearctic / западнопалеарктический	Geraniaceae
<i>Eumedonia eumedon</i> (Esper, 1780)	+	+	+	Middle Palaearctic / среднепалеарктический	Geraniaceae
<i>Polyommatus ripartii</i> (Freyer, 1830)	+	–	–	West Palaearctic / западнопалеарктический	Fabaceae
<i>P. melanius</i> (Staudinger, 1886)	+	–	–	Tian-Shan-Alai / тянь-шаньско-алайский	Fabaceae
<i>P. icadius</i> (Groum-Grshimailo, 1890)	+	+	+	South Europe-Central Asiatic-Iranian / южноевропейско- центральноазиатско-иранский	Fabaceae
In total / Всего	42	30	33		

Note. NA – Naryn Adyг; RC – Red Canyon; CK – Kyrk-Kechik Canyon.

Примечание. NA – Нарынский адыг; RC – Красный Каньон; CK – каньон Кырк-Кечик.

and the Tian-Shanian complex is not represented. Thus, the species with wide distribution prevail in the fauna of three mountainous badlands of Kyrgyzstan. Species with Central Asiatic distribution represent no more than a third of the fauna, species of the Tian-Shanian complex are no more than a tenth of the studied badlands fauna.

In the fauna of badlands there are no local or regional endemic species of butterflies found. There are no regions or habitats in Central Asia without the endemism [Korb, 2005]. Some areas of Central Asia may have the endemism

rate about 70% (it is especially characteristic for the high mountainous areas and habitats [Kryzhanovsky, 2002; Korb, 2005]).

Trophic relations (larval food plants) of the butterflies in the studied badlands (Tables 1, 3) are not diverse. The butterflies are associated with 16 plant families; 14 species use the representatives of Poaceae (29.8% of the fauna) and 7 species are feeding on Fabaceae (14.9% of the fauna). Trophic relations with these two plant families are present by almost half of the studied butterfly fauna (44.7%).



Figs 2–4. Badlands of Kyrgyzstan.
2 – Naryn Adyr, a view from the Koro-Goo Pass; 3 – Red Canyon, clay ravinings near Orto-Tokoy Reservoir; 4 – Kyrk-Kechik Canyon, sandstone walls and pillars.

Рис. 2–4. Бедленды Кыргызстана.
2 – Нарынский адыр, вид с перевала Коро-Гуо; 3 – Красный каньон, глиняные саи близ Орто-Токойского водохранилища; 4 – каньон Кырк-Кечик, стены и столбы из песчаника.

Brassicaceae are the food plants for almost all badland Pieridae (6 species). The single species of Papilionidae recorded from these badlands feeding on Fumariaceae. Hesperidae feed on 5 plant families, Nymphalidae feed on 6 plant families and Lycaenidae feed on 4 plant families.

The taxonomic composition: Hesperidae – 6 species in total (Naryn Adyr – 6, Red Canyon – 5, Canyon Kirk-Kechik – 4); Papilionidae – 1 species observed only in Naryn Adyr; Pieridae – 7 species in total (6 species each in Naryn Adyr and Red Canyon and 7 species in Kirk-Kechik Canyon); Nymphalidae – 8 species in total (Naryn Adyr – 8, Red Canyon – 6, Canyon Kirk-Kechik – 7); Satyridae – 12 species in total (Naryn Adyr – 10, Red Canyon – 6,

Canyon Kirk-Kechik – 7); Lycaenidae – 13 species in total (Naryn Adyr – 11, Red Canyon – 7, Canyon Kirk-Kechik – 8).

The richest in species among the badlands of Kyrgyzstan is Naryn Adyr. The reasons for that are: this badland is the largest of the studied ones (and the largest in the Central Asiatic mountains) and it is located in the Naryn arid refugium [Korb, 2015] so the desert Turanic species are found in its fauna (*Lycaena margelanica*, *Plebejus maracandicus*); these species are atypical for the mountainous regions of Central Asia.

The number of wide ranged species in studied badlands is about two thirds of the fauna, the number of species of Central Asiatic distribution is slightly less than a third.

Table 2. Arealogical structure of the butterfly fauna of the mountainous badlands of Kyrgyzstan (abbreviations as in Table 1).
Таблица 2. Ареалогическая структура фауны булавоусых чешуекрылых горных бэдлендов Кыргызстана (сокращения как в таблице 1).

№	Type of the range Тип ареала	Number of species Число видов			
		Total Всего	NA	RC	СК
I. Wide ranges complex / Комплекс обширных ареалов		29	27	23	23
1	Worldwide / Всесветный	2	1	2	2
2	Holarctic / Голарктический	2	2	2	2
3	Palaearctic / Палеарктический	2	2	2	2
4	Middle Palaearctic / Среднепалеарктический	10	10	9	8
5	West Palaearctic / Западнопалеарктический	11	10	7	8
6	South Europe-Central Asiatic / Южноевропейско-центральноазиатский	1	1	–	–
7	South Europe-Central Asiatic-Iranian / Южноевропейско-центральноазиатско-иранский	1	1	1	1
II. Central Asiatic ranges complex / Комплекс центральноазиатских ареалов		14	12	5	10
8	Central Asiatic / Центральноазиатский	8	7	3	5
9	Central Asiatic-Pakistanian / Центральноазиатско-пакистанский	1	–	–	1
10	South Altai-Central Asiatic-Chitral / Южноалтайско-центральноазиатско-читральский	1	1	1	1
11	Central Asiatic-Himalayan / Центральноазиатско-гималайский	1	1	–	1
12	Tian-Shan-Alai / Тянь-шаньско-алайский	3	3	1	2
III. Tian-Shan ranges complex / Комплекс тянь-шаньских ареалов		4	3	2	–
13	Tian-Shan / Тянь-шаньский	2	1	2	–
14	Inner Tian-Shan / Внутренне-тянь-шаньский	2	2	–	–

The number of species with Tian-Shanian ranges in two badlands is less than 10%; in third badland (Kyrk-Kechik Canyon) the species with this type of area are absent.

In the fauna of studied badlands predominate the representatives of the butterfly families Satyridae and

Table 3. Trophic relations of butterflies of the Kyrgyzstan's badlands (abbreviations as in Table 1).

Таблица 3. Кормовые растения гусениц дневных бабочек бэдлендов Кыргызстана (обозначения как в таблице 1).

№	Plant family Семейство растений	Number of feeding species / Число видов, питающихся на растениях семейства		
		NA	RC	СК
1	Malvaceae	1	1	1
2	Lamiaceae	2	2	1
3	Rosaceae	2	2	2
4	Poaceae	12	7	8
5	Fumariaceae	1	–	–
6	Fabaceae	5	3	4
7	Brassicaceae	5	5	6
8	Violaceae	2	2	2
9	Salicaceae	1	1	1
10	Urticaceae	2	2	2
11	Boraginaceae	1	1	1
12	Asteraceae	2	1	2
13	Plantaginaceae	3	1	2
14	Polygonaceae	4	2	2
15	Geraniaceae	2	2	2
16	Euphorbiaceae	1	1	1
Trophic specialization / Пищевая специализация				
1	Monophagous / Монофар	39	28	30
2	Olygophagous / Олигофар	2	1	2
3	Polyphagous / Полифар	1	1	1

Lycaenidae (12 and 13 species respectively; in general, slightly less than a half of the entire fauna). Host plants of all badland Satyridae are Poaceae. Almost half of Lycaenidae recorded in studied badlands feed on Fabaceae (6 species). In general, 90% of the studied butterfly fauna feeding on drought-resistant plants (Table 3). The single species of Papilionidae found in these badlands (*Koramius davydovi*) feed on *Corydalis kovakensis* Mikh. (Fumariaceae) [Ottmüller, 2016], a succulent species accumulating water in thickened leaves.

It is important to note that all studied badlands are located on the territories of large formogenetic centers of mountainous Central Asia: Naryn Adyr belongs to the Naryn arid refugium [Korb, 2015], Red Canyon belongs to the Issyk-Kul refugium [Korb, 2014] and Kirk-Kechik Canyon refers to Ferghana refugium [Korb, 1997]. These badlands were formed as a result of the Central Asiatic climate aridization about 14,000 years ago [Chumakov, 1993; Chistyakov et al., 2000; Shatravin, 2007].

The butterfly fauna of the studied badlands of Kyrgyzstan contain about 15% of the country fauna [Tshikolovets, 2005; Korb, 2018]. It can be determined in few words as highly depleted due to adverse environmental conditions, almost devoid of individual appearance, composed mainly of widespread species with high ecological plasticity.

The most interesting question regarding this study is: why there is no endemism within the studied badlands? It may be explained by three reasons. First of all, the territory of badlands is relatively small, it is always quite narrow. Secondly, there is no evidence that in the past the areas of these badlands were significantly larger. And thirdly, the living conditions in these badlands are so bad so only species with high ecological plasticity can survive there.

Conclusions

1. The butterfly fauna of three mountainous badlands of Kyrgyzstan (Naryn Adyr, Red Canyon and Kirk-Kechik Canyon) is studied and described for the first time.

2. The butterfly fauna of studied badlands comprises of 47 species, namely: Naryn Adyr – 42 species, Kirk-Kechik Canyon – 33 species, Red Canyon – 30 species.

3. The butterfly fauna of studied badlands contain about 15% of the butterfly fauna of Kyrgyzstan.

4. Two-thirds of the studied butterfly fauna are species with wide ranges and high ecological plasticity, a little less than one third are species of Central Asiatic distribution.

5. Local and regional endemism is not present in the studied badlands.

6. Butterflies of studied badlands feed on drought-resistant plants; about half of the fauna is associated with representatives of the Poaceae and Fabaceae plant families.

7. The reasons why there is no endemism in the studied badlands of Kyrgyzstan: the small area (and no evidence that it was significantly larger in the past) and bad living conditions.

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