The ground beetles (Coleoptera, Carabidae) of the Karatepa and Chakilkalyan mountains (west part of Zarafshan Mountains Range, Uzbekistan)

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Ground beetles (Carabidae) are one of the most numerous and well-studied families of Coleoptera. However, the study of the biodiversity of these beetles in Uzbekistan lags far behind other Central Asian countries. This research was carried out during 2018–2019 in two areas in the west part of the Zarafshan Mountain Range – in the Chakilkalyan and Karatepa mountains. In total, 49 species of ground beetles belonging to 31 genera, 16 tribes and 8 subfamilies were recorded. The most representative was the subfamily Harpalinae (32 species from 20 genera, 65.3%). By the number of individuals, representatives of Harpalinae made up 85.6% of all collected ground beetles. The Trechinae subfamily included five species from three genera (10.2%), the Scaritinae subfamily – four species from two genera (8.2%), the Carabinae subfamily – three species from two genera (6.1%), the Broscinae subfamily – two species from the same genus (4.1%). The subfamilies Brachininae, Cicindelinae and Nebrinae are represented by one species (2.0% each). In the Karatepa Mountains, 34 species from 23 genera were identified, and in the Chakilkalyan Mountains, 34 species from 21 genera. 19 species of ground beetles were common to the two mountains. The fauna of ground beetles in these mountains differed significantly in the composition of the dominant species. In the Karatepa Mountains, the dominant species were *Zabrus morio*, *Eocarterus chodshenticus*, *Amara aenea*, and *Acinopus laevigatus*, and the subdominant ones were *Brachinus expulso*, *Calathus ambiguus*, and *Poecilus longiventris*. In the Chakilkalyan Mountains, *Anchomenus dorsalis*, *Harpalus rufipes*, and *Chlaenius extensus* are dominant, while *Amara aenea*, *Harpalus distinguendus*, *Dolichus halensis* turned out to be subdominant. However, the composition of dominant species varied at different sites. The rarest species were *Anisodactylus binotatus*, *Cymindis andreae*, *Taphoxenus goliath*, *Calosoma sycophanta*, *Scarites subcylindricus*, *Chilotomus gentensis*, *Calathus peltatus* and *Broscus punctatus*. Different areas of both mountains differed significantly in the diversity of ground beetle fauna. In both mountains, the lowest diversity was noted at the highest altitude areas. In four areas of the Karatepa Mountains, the average value of the Zhakar and Chekanovsky-Sørensen indices was 0.27 and 0.11, and in five areas of the Chakilkalyan Mountains – 0.24 and 0.25. And the similarities between the communities of the two mountains were also insignificant (0.39 and 0.11).

Keywords: degree of dominance; faunal peculiarities; species composition; Cicindelinae; Carabinae; Harpalinae; Trechinae; Brachininae; Nebrinae.

Introduction

Ground beetles are a very large and diverse taxon among Coleoptera, and about 100 new species are discovered every year (Lorenz, 2005; Kotze et al., 2011). They are an important link in food chains and play a huge role in energy transformation (Skalski et al., 2011; Schimmel et al., 2012). They are sensitive to environmental changes, exhibiting strong habitat specificity and low ability to spread rapidly to neighbouring areas (Work et al., 2008). Therefore, ground beetles have been widely used to compare the ecology of pristine forests and artificial plantations (Finch, 2005), in the environmental monitoring of post-industrial ecosystems (Skalski et al., 2015; Bell et al., 2017; Kędzior, 2020). Many carabid species, as universal predators with a wide food spectrum, can enter as an important component of biological regulation (Symondson et al., 2002; Stiling & Cornelissen, 2005).

The works of Kryzhanovskij (1965) are of great importance in the study of the carabid fauna of Central Asia. As he argued, the fauna of the ground beetles of Central Asia is very diverse and includes more than 850 species, and is also characterized by many endemic forms. In subsequent works, the list of the species composition of ground beetles in this region has been significantly expanded (Kryzhanovskij et al., 1995; Mihaylov, 1995, 1998). Thus, in the Tien Shan mountain system, within the republics of Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, 819 species of ground beetles were recorded (Kryzhanovskij et al., 1995). On these mountains, there are 114 species of representatives of the genus *Carabus*

alone (Kabak, 2008). And the fauna of ground beetles of the Pamir-Alai mountain system, located in the southeastern part of Central Asia, is less diverse and includes 510 species (Kryzhanovskij et al., 1995). However, the registration of ground beetle species new to the region continues at the present time (Kabak, 2015; Kabak et al., 2016).

Although the registered species of ground beetles in Uzbekistan reaches 453 species (<http://carabidae.org/countries.2007-2020>), the study of the ecological faunistic features of ground beetles in this region, especially in the Zarafshan Valley, is clearly insufficient.

The very steep, narrow and snow-covered Zarafshan ridge is characterized by an abundance of rocky outcrops, ruggedness, steepness of the slopes, and the presence of sharp peaks. Within Uzbekistan, the western part of the ridge serves as a watershed of the river basins of Zarafshan and Kashkadarya.

The Zarafshan Ridge on the territory of Uzbekistan is divided into four parts: the Chakilkalyan, Karatepa, Zirabulak and Ziadin mountains. The Chakilkalyan Mountains, the eastern part of the Zarafshan Range within Uzbekistan, continue to the Takhtakaracha Pass. The height of the pass is 1630 m. The average height of the Chakilkalyan Mountains is 1000–2000 m. The Karatepa Mountains extend to the west of the Chakilkalyan Mountains (the highest point is Kamkutan Peak 2194 m, average altitude 1000–2000 m), which are mainly low-altitude (Zhumaev, 1989).

Invertebrate animals, in particular, beetles of these mountains, have a wide variety. However, directed scientific research on the study of the biodiversity of beetles, in particular, ground beetles in the studied territo-

ries, has not been carried out. There are studies on individual groups of ground beetles in other Central Asian republics (Kryzhanovskiy, 1965, 1994; Kabak, 2015). Furthermore, the data on the territory of Uzbekistan is outdated, and the new data is mainly based on museum exhibits. In general, ground beetles of Uzbekistan have been more or less studied in agroecosystems of cotton (Dadamirzaev, 1978; Bekmetova, 1991) and vegetable crops (Khalimov, 2008) as entomophages of agricultural pests.

Information about ground beetles of the Zarafshan Valley can be found in faunistic works (Alimjanov & Bronstein, 1956) or for the southern slopes of the Zarafshan Ridge located on the territory of Tajikistan (Mihaylov, 1998).

Our research aimed to study the species diversity and taxonomic composition of ground beetles of the Chakilkalyan and Karatepa mountains of the Zarafshan Ridge, located on the territory of Uzbekistan.

Material and Methods

The studies were conducted in the period 2018–2019 in the territories of the Chakilkalyan and Karatepa mountains, as well as in the foothill zones. The Karatepa Mountains are bordered on the east by the Chakilkalyan Mountains and join the Zirabulak Mountains. In this direction, the height of the mountains above sea level also decreases. According to the direction of the mountains, 4 areas were selected for the study: Takhtakoracha (39°17'47" N, 66°56'36" E), Yul-say (39°29'93" N, 66°95'04" E), Ettiylisay (39°43'42" N, 66°98'25" E) and Agalik-say (39°29'26" N,

66°51'46" E). All selected sites are characterized by meadow vegetation with a scattering of tree species. Artificially created forest biotopes prevailed only on the Ettiylisay site.

From the south, the Chakilkalyan Mountains start from the border of Uzbekistan with Tajikistan (Pejikent Province) and continues to the northwest 60–70 km to the Karatepa Mountains. Five sites were selected for research, one of which is on the southern slope (Hazrat Bashir, (39°15'58" N, 67°07'00" E), and the other four are on the northern slope (Yalpoktepa – 39°26'14" N, 67°14'31" E, Qumbel-say – 39°20'30" N, 67°19'06" E, Kamangaron-say – 39°22'05" N, 67°12'02" E, Sariduqon – 39°19'35" N, 67°13'48" E). One site (Yalpoktepa) is a cultivated landscape (vineyards). The Chakilkalyan Mountains differ from the Karatepa Mountains by the absence or scarcity of forest vegetation (except for the Kamangaron-say site).

In 2018, three expeditions were organized at each site (April, May, September), and in 2019, four expeditions (March, April, May, August). In order to collect beetles, soil traps of the Barber – Heideman type (Barber, 1931; Heydemann, 1955), light traps, exhauster, and manual collection were used. Glass jars (Karpova, 1992) with a capacity of 0.5 L and a hole diameter of 72 mm were used as traps (the jars were buried in the soil so that the edges were at the level of the soil) installed in a line of 10 traps at a distance of 5 m from each other. Some of the traps were without a retainer, and some with a fixing liquid. As a fixative, a 4% formalin solution was used, which filled soil traps in 1/3–1/2 volumes. Traps were sampled once every 10–12 days. Collected beetles were identified by species, counted and compiled.

Fig. 1. Research Area Map (places of collection of material)

The degree of dominance was determined on the Skufin scale (Skufin, 1949), where more than 8% are dominant species, from 4% to 8% subdominant species, 1–3% are scarce species. Statistical calculations of biodiversity were carried out according to the guidance of Dunaev (1997):

– Margalef index – $D_{Mg} = (S-1) / \ln N$, where S is the number of identified species, N is the total number of individuals of all identified species, ln is the natural logarithm;

– Shannon's index – $H' = -\sum p_i \ln p_i$, where p_i is the proportion of individuals of the i – the species;

– Menhinick index – $D_{Mn} = S / \sqrt{N}$, where S is the total number of identified species, N is the total number of individuals of all species;

– Shannon alignment – $E = H' / \ln S$, where H' is the Shannon index, S is the number of species;

– Simpson index – $D(S_i) = \sum (n_i (n_i - 1)) / (N (N - 1))$, where n is the number of individuals of i species, N is the total number of individuals;

– Berger-Parker index – $d = N_{max} / N$, where N_{max} is the number of individuals of the most abundant species, N is the total number of individuals of all species of the sample;

– Chekanovsky-Sørensen coefficient – $CN = 2jN / (aN + bN)$, where aN + bN is the total number of individuals in sites A and B, jN is the smallest of the two abundance of species found in both sites;

– Jaccard coefficient: $C_j = j / (a + b - j)$, where j is the number of common species in both territories (sites, samples), and b is the number of species in each territory (sites, samples).

The compiled collection of ground beetles is stored in the Entomological Collection of Samarkand University, as well as in the Zoological Museum of the Institute for Systematics and Ecology of Animals of the Siberian Branch of the Russian Academy of Sciences (Russia).

Results

Taxonomic composition. Over the years of research in the two parts of the Zarafshan Ridge (Karatepa and Chakilkalyan mountains), 49 species of ground beetles were identified, belonging to 31 genera, 16 tribes and 8 subfamilies (Table 1). The most representative in terms of the number of species is the subfamily Harpalinae, which includes 32 species (65.3% of the total species diversity). In terms of the number of individuals, the subfamily Harpalinae makes up 85.6% of all collected ground beetles. Among the representatives of this subfamily, the tribe Harpalini has the largest number of species, which is represented by 12 species from 8 genera (genus *Harpalus* – 4 species, *Dixus* – 2 species, *Acinopus*, *Anisodactylus*, *Chilotomus*, *Carenochyrus*, *Eocarterus* and *Stenolophus* – one species each). Numerous representatives of these genera are *Acinopus laevigatus*, *Eocarterus chodshenticus*, *Harpalus rufipes*, and *Dixus eremita*.

The tribe Sphodrini is represented by 5 species from 3 genera (*Taphoxenus* and *Dolichus* – one species each and *Calathus* – 3 species), the most abundant representative of which is *Calathus ambiguus*. The tribe Pterostichini is also represented by 5 species from two genera

(*Pterostichus niger* and *Poecilus* – 4 species). Three species of the tribe Chlaeniini, belonging to the genus *Chlaenius*, have been identified. The most common is *Chlaenius extensus*. The tribe Zabryni also has three representatives (two species from the genus *Amara* and one species from

the genus *Zabrus*). *Amara aenea* and *Zabrus morio* are dominant species of the carabid fauna of the studied mountains. The tribes Lebiini (genus *Lebia* and *Cymindis*) and Platynini (genus *Agonum* and *Anchomenus*) are represented by two species.

Table 1

Taxonomic composition of ground beetles of the Karatepa and Chakilkalyan mountains of Uzbekistan

Subfamily	Tribe	Species	Mt. Karatepa	Mt. Chakilkalyan	Share of species, %
Nebriinae	Nebriini	<i>Nebria psammophila</i> Solsky, 1874	–	+	0.7
Carabinae	Carabini	<i>Calosoma auropunctatum dzungaricum</i> Gilber, 1833	–	+	0.8
		<i>C. scyphanta</i> (Linnaeus, 1758)	+	–	0.2
		<i>Carabus fedtschenkoi</i> Solsky, 1874	+	–	1.8
Cicindelinae	Cicindelini	<i>Cicindela turkestanica</i> Ballion, 1871	+	–	1.7
Scaritinae	Scaritini	<i>Scarites basiplicatus</i> Heyden, 1884	+	+	1.0
		<i>S. terricola</i> Bonelli, 1813	+	+	1.0
		<i>S. subcylindricus</i> Chaudoir, 1843	+	–	0.2
	Clivinini	<i>Clivina collaris</i> Herbst, 1784	+	–	0.3
Broscinae	Broscini	<i>Broscus punctatus</i> (Dejean, 1828)	–	+	0.2
		<i>B. asiaticus</i> Ballion, 1871	–	+	5.3
Trechinae	Bembidiini	<i>Asaphidion flavicorne</i> (Solsky, 1874)	–	+	0.5
		<i>Bembidion piceocyanum</i> Solsky, 1874	–	+	0.3
		<i>B. luridicorne</i> Solsky, 1874	+	+	1.3
		<i>B. saxatile flavipalpe</i> Netolitzky, 1930	–	+	0.5
	Trechini	<i>Trechus quadristriatus</i> (Schrank, 1781)	+	+	1.8
Brachininae	Brachinini	<i>Brachinus explodens</i> Duftschmid, 1812	+	+	1.3
Harpalinae	Chlaeniini	<i>Chlaenius flavicornis</i> (Fischer von Waldheim, 1842)	+	+	1.1
		<i>Ch. extensus</i> Mannerheim, 1825	+	+	4.9
		<i>Ch. festivus</i> (Panzer, 1796)	+	+	0.3
	Harpalini	<i>Acinopus laevigatus</i> Menetries, 1832	+	+	7.7
		<i>Anisodactylus binotatus</i> (Fabricius, 1787)	+	–	0.2
		<i>Chilotomus gentensis</i> Schaubberger, 1932	+	–	0.3
		<i>Carenochyrus titanus</i> Solsky, 1874	–	+	0.7
		<i>Dixus eremita</i> Dejean, 1825	+	+	3.5
		<i>D. semicylindricus</i> Piochard de la Brûlerie, 1872	+	–	0.5
		<i>Eocarterus chodshenticus</i> (Ballion, 1871)	+	+	10.0
		<i>Harpalus rufipes</i> (De Geer, 1774)	–	+	3.3
		<i>H. griseus</i> (Panzer, 1796)	+	+	0.3
		<i>H. distinguendus</i> (Duftschmid, 1812)	–	+	2.5
		<i>H. rubripes</i> (Duftschmid, 1812)	–	+	0.7
		<i>Stenolophus abdominalis</i> Gené, 1836	+	+	0.3
	Lebiini	<i>Lebia cyanocephala</i> Linnaeus, 1758	+	–	1.5
		<i>Cymindis andreae</i> Ménéties, 1832	+	–	0.2
	Platynini	<i>Agonum viridicupreum</i> (Goeze, 1777)	+	–	0.3
		<i>Anchomenus dorsalis</i> (Pontoppidan, 1763)	+	+	5.3
	Pterostichini	<i>Pterostichus niger</i> (Schaller, 1783)	–	+	0.8
		<i>Poecilus cupreus</i> (Linnaeus, 1758)	+	+	2.8
		<i>P. liosomus</i> Chaudoir, 1876	+	+	2.8
		<i>P. longiventris</i> Solsky, 1874	+	–	1.3
		<i>P. sp.</i>	+	–	0.2
	Sphodrini	<i>Calathus ambiguus</i> (Paykull, 1790)	+	+	5.9
		<i>C. peltatus</i> Kolenati, 1845	–	+	0.2
		<i>C. melanocephalus</i> (Linnaeus, 1758)	+	+	0.5
		<i>Dolichus halensis</i> (Schaller, 1783)	–	+	1.8
		<i>Taphoxenus goliath</i> (Faldemann, 1836)	+	–	0.2
	Zabryni	<i>Amara similata</i> (Gyllenhal, 1810)	–	+	0.3
		<i>A. aenea</i> (De Geer, 1774)	+	+	11.0
		<i>Zabrus morio</i> Ménéties, 1832	+	–	9.7
8	16	49	34	34	100.0

In the carabid complex of the studied mountains from small ground beetles of the subfamily Trechinae, there are five species from two tribes and three genera. The Trechini tribe is represented only by *Trechus quadristriatus*, and the Bembidiini tribe includes 4 species (the *Asaphidion* genus – one species, the *Bembidion* genus – three species). Although in anthropogenic landscapes these species are widespread and numerous, in the studied mountains their number is low. In general, representatives of the subfamily Trechinae account for 4.4% of all individuals of ground beetles. Four species of beetles from the subfamily Scaritinae

belonging to the genera *Scarites* (three species) and *Clivina* (one species) have been identified. The subfamily Carabinae is represented by three species of two genera (genus *Carabus* – one species, genus *Calosoma* – two species). The Broscinae subfamily is represented by two species from the genus *Broscus*. The most abundant is *Broscus asiaticus*.

The subfamilies Brachininae, Cicindelinae, and Nebriinae are the only species in the complex of ground beetles in the studied territories.

Amara aenea, *Eocarterus chodshenticus*, and *Zabrus morio* are the dominant species in the Chakilkalyan and Karatepa Mountains, while

Acinopus laevigatus, *Calathus ambiguus*, *Broscus asiaticus*, *Anchomenus dorsalis* and *Chlaenius extensus* are subdominant species.

Among the few species, several species can be distinguished, which, in terms of the degree of dominance, are close to subdominant species. These are *Dixus eremita* and *Harpalus rufipes*. 27 species of ground beetles, the dominance of which is less than 1%, together account for 11.5% of the total carabid fauna.

The only rare specimens in our collections are *Anisodactylus binotatus*, *Cymindis andreae*, *Taphoxenus goliath*, *Calosoma sycophanta*, *Scarites subcylindricus* (Ettiuli-say Gorge) and *Chilotomus usgentensis* (Yul-say Gorge) from the Karatepa Mountains, *Calathus peltatus* (Kumbel-say gorge), *Broscus punctatus* (Kamangaron-say) from the Chakilkalyan Mountains.

Diversity in the Karatepa Mountains. As studies show, the fauna of ground beetles of the Karatepa Mountains includes 34 species belonging to 6 subfamilies and 23 genera (Table 2). The highest diversity was recorded in the Ettiuyli-say gorge, which is the middle part of the mountain

(27 species), and the lowest diversity was observed in the upper part of the mountain, Takhtakoracha (8 species).

Among the identified species only *Eocartermus chodshenticus*, *Poecilus liosomus*, and *Cicindela turkestanica* were noted in all study sites. The dominant species of ground beetles of the Karatepa Mountains are *Zabrus morio* (14.8%), *Eocartermus chodshenticus* (13.6%), *Amara aenea* (13.1%), and *Acinopus laevigatus* (9.8%) and the degree of their dominance is quite high. Although *Zabrus morio* is the most abundant species, this species was not recorded in the highest (1550 m a. s. l.) site of Takhtakoracha, and its abundance increases with decreasing altitude. The same tendency is observed in relation to *Amara aenea*, as this species is noted and quite numerous in the Ettiuyli-say and Agalik-say areas. As for *Eocartermus chodshenticus*, on the contrary, its population grows with increasing altitude. Although this species is common in all study sites, it is the most numerous at the Takhtakoracha site. The Takhtakoracha site has one specific species, *Agonum viridicupreum*, which has not been recorded in other sites.

Table 2

Diversity and abundance of Carabidae in four mountain areas on Mt. Karatepa

Species	Montane habitat types				Total	Share of species, %
	Takhtakoracha (1550 m a. s. l.)	Yul-say (1221 m a. s. l.)	Ettiuyli-say (1059 m a. s. l.)	Agalik-say (1070 m a. s. l.)		
<i>Acinopus laevigatus</i>	—	8	31	—	39	9.8
<i>Agonum viridicupreum</i>	2	—	—	—	2	0.5
<i>Amara aenea</i>	—	—	43	9	52	13.1
<i>Anchomenus dorsalis</i>	—	—	5	3	8	2.0
<i>Anisodactylus binotatus</i>	—	—	1	—	1	0.2
<i>Bembidion luridicorne</i>	1	—	—	2	3	0.7
<i>Brachinus exsplodens</i>	—	—	—	28	28	7.0
<i>Calathus ambiguus</i>	—	—	23	7	30	7.5
<i>C. melanocephalus</i>	—	—	1	—	1	0.2
<i>Calosoma sycophanta</i>	—	—	1	—	1	0.2
<i>Carabus fedtschenkoi</i>	—	9	1	1	11	2.8
<i>Chilotomus gentensis</i>	—	1	—	—	1	0.2
<i>Chlaenius festinus</i>	—	—	—	1	1	0.2
<i>Ch. flavicornis</i>	—	—	5	—	5	1.3
<i>Ch. extensus</i>	—	—	1	9	10	2.5
<i>Cicindela turkestanica</i>	3	2	2	3	10	2.5
<i>Clivina collaris</i>	—	—	2	—	2	0.5
<i>Cymindis andreae</i>	—	—	1	—	1	0.2
<i>Dixus eremita</i>	1	1	11	—	13	3.3
<i>D. semicylindricus</i>	1	—	2	—	3	0.7
<i>Eocartermus chodshenticus</i>	37	8	4	5	54	13.6
<i>Harpalus distinguendus</i>	—	—	1	—	1	0.3
<i>Lebia cyanocephala</i>	—	—	9	—	9	2.3
<i>Poecilus cupreus</i>	—	1	—	1	2	0.5
<i>P. liosomus</i>	2	4	1	3	10	2.5
<i>P. longiventris</i>	—	11	6	—	17	4.3
<i>P. sp.</i>	—	6	—	2	8	2.0
<i>Scarites basiplicatus</i>	3	—	1	—	4	1.0
<i>S. terricola</i>	—	—	1	—	1	0.3
<i>S. subcylindricus</i>	—	—	1	—	1	0.3
<i>Stenolophus abdominalis persicus</i>	—	—	1	—	1	0.3
<i>Taphoxenus goliath</i>	—	—	1	—	1	0.3
<i>Trechus quadristriatus</i>	—	—	8	—	8	2.1
<i>Zabrus morio</i>	—	1	51	7	59	14.8
Number of individuals	50	52	215	81	398	100.0
Number of species	8	11	27	14	34	—
Species richness, Dmg	1.79	2.53	4.84	2.96	5.53	—
Diversity indicator Shannon, H	1.05	2.08	2.39	2.16	2.79	—
Berger – Parker dominance index, d	0.74	0.21	0.24	0.35	0.15	—

Chilotomus usgentensis is a specific species in Yul-say (1221 m a. s. l.) territory, and it couldn't be found in other researched areas. The rather large-sized species *Carabus fedtschenkoi* is quite abundant in this area, but in other areas this species is scarce and not recorded in the highest area (Takhtakoracha). The greatest species diversity of the carabid fauna was noted in the area with a predominance of forest biotopes – Ettiuyli-say. Here, along with the aforementioned dominant species (except for *Eocartermus chodshenticus*), *Dixus eremita*, *Calathus ambiguus*, and *Lebia cyanocephala* are abundant. The fauna of ground beetles in the northern part of the Karatepa Mountains, the Agalik-say section, is peculiar. The most abundant species in this site is *Brachinus exsplodens*, which makes

up 34.6% of all collected ground beetles. However, this species was not observed in other areas (Table 1). In addition, no species of the genus *Dixus* (*D. eremita*, *D. semicylindricus*) were found in this area, and *Chlaenius extensus* is among the dominant species. Another species of this genus, *Ch. festinus*, was also noted, which was not found in other areas.

Comparative analysis of the species composition of ground beetles in the studied areas shows a rather low level of similarity (Table 3). Thus, the Jaccard/Chekanovsky-Sørensen indices varied from 0.21/0.06 to 0.39/0.17 (with an average value of only 0.27/0.11). The greatest similarity is observed between the Yul-say and Agalik-say sections (0.39/0.17), and the least similarity is between Ettiuyli-say and Takhtakorach (0.21/0.06).

Table 3

Similarity of the Carabidae species composition of the four areas on Mt. Karatepa (Jaccard/Chekanovsky-Sørensen indices)

Sites	Yul-say	Taxtaqoracha	Ettiuyli-say	Agalik-say
Yul-say (1221 m a. s. l.)	–	0.27	0.27	0.39
Taxtaqoracha (1550 m a. s. l.)	0.16	–	0.21	0.22
Ettiuyli-say (1059 m a. s. l.)	0.08	0.06	–	0.28
Agalik-say (1070 m a. s. l.)	0.17	0.12	0.09	–

Diversity in the Chakilkalyan Mountains. 34 species of ground beetles belonging to 7 subfamilies and 21 genera were identified in the Chakilkalyan Mountains (Table 4). The smallest diversity was noted at the highest Sariduqon site (6 species), where the bulk of the material is

Eocartermus chodshenticus. An interesting fact is that this species was not recorded in other areas of the Chakilkalyan Mountains, although in the Karatepa Mountains it was found in all the studied areas. The greatest variety of ground beetles was found in the areas Qumbel-say (18 species) and Yalpoqtepa (17 species). Although these areas are similar in species diversity, they differ significantly in altitude above sea level, and this probably results in a high difference in species composition (only 8 common species). On the Yalpoqtepa site, there are numerous species common in agroecosystems – *Harpalus distinguendus*, *H. rufipes*, *Broscus asiaticus*, *Poecilus liosomus*. The species *Calosoma auropunctatum dsungaricum*, *Carenochyrus titanus*, *Harpalus griseus* and *Asaphidion flavicorne* identified in this area were recorded neither in other areas of Chakilkalyan nor in the Karatepa Mountains.

Table 4

Diversity and abundance of Carabidae in five mountain areas on Mt. Chakilkalyan

Species	Montane habitat types					Total	Share of species, %
	Yalpoqtepa (agroecosystems) (890 m a. s. l.)	Qumbel-say (1480 m a. s. l.)	Kamanga-ron-say (1300 m a. s. l.)	Sariduqon (2350 m a. s. l.)	Hazrat Bashir (1225 m a. s. l.)		
<i>Acinopus laevigatus</i>	1	3	1	–	3	8	3.8
<i>Amara similata</i>	–	2	–	–	–	2	1.0
<i>A. aenea</i>	3	10	–	–	2	15	7.2
<i>Anchomenus dorsalis</i>	3	16	1	1	3	24	11.5
<i>Asaphidion flavicorne</i>	3	–	–	–	–	3	1.4
<i>Bembidion luridicorne</i>	5	–	–	–	–	5	2.4
<i>B. piceocyaneum</i>	–	2	–	–	–	2	1.0
<i>B. saxatile flavipalpe</i>	–	3	–	–	–	3	1.4
<i>Brachinus eximius</i>	–	1	–	–	3	4	1.9
<i>Broscus asiaticus</i>	7	–	1	–	–	8	3.8
<i>B. punctatus</i>	–	–	1	–	–	1	0.5
<i>Calathus ambiguus</i>	1	3	2	–	–	6	2.8
<i>C. peltatus</i>	–	1	–	–	–	1	0.5
<i>C. melanocephalus</i>	–	1	1	–	–	2	1.0
<i>Calosoma auropunctatum dsungaricum</i>	5	–	–	–	–	5	2.4
<i>Carenochyrus titanus</i>	4	–	–	–	–	4	1.9
<i>Chlaenius festinus</i>	–	–	–	–	1	1	0.5
<i>C. flavicornis</i>	2	–	–	–	–	2	1.0
<i>C. extensus</i>	–	17	–	1	2	20	9.6
<i>Dixus eremita</i>	–	–	–	1	7	8	3.8
<i>Dolichus halensis</i>	1	9	–	–	1	11	5.3
<i>Eocartermus chodshenticus</i>	–	–	–	7	–	7	3.3
<i>Harpalus distinguendus</i>	12	1	1	–	–	14	6.7
<i>H. griseus</i>	2	–	–	–	–	2	1.0
<i>H. rubripes</i>	–	4	–	–	–	4	1.9
<i>H. rufipes</i>	11	5	1	1	2	20	9.6
<i>Nebria psammophila</i>	–	4	–	–	–	4	1.9
<i>Poecilus cupreus</i>	3	–	–	–	–	3	1.4
<i>P. liosomus</i>	6	1	–	–	–	7	3.3
<i>Pterostichus niger</i>	1	–	–	–	–	1	0.5
<i>Scarites basiplicatus</i>	–	–	2	–	–	2	1.0
<i>S. terricola</i>	–	–	–	–	5	5	2.4
<i>Stenolophus abdominalis persicus</i>	–	1	–	–	1	2	0.9
<i>Trechus quadristriatus</i>	–	–	–	2	1	3	1.4
Number of individuals	70	84	11	13	31	209	100.00
Number of species	17	18	9	6	12	34	–
Species richness, Dmg	3.77	3.84	3.34	1.95	3.2	6.18	–
Diversity indicator Shannon, H	2.56	2.44	2.15	1.41	2.28	3.15	–
Berger – Parker dominance index, d	0.17	0.20	0.18	0.54	0.23	0.11	–

On the Qumbel-say site, the most numerous are *Chlaenius extensus*, *Anchomenus dorsalis*, and *Amara aenea*. The only research point, located on the southern slope of Chakilkalyan, Hazrat Bashir is characterized by the same species that are common on the northern slope. However, there are some species that have been recorded only in this area (*Chlaenius festinus* and *Scarites terricola*). *Dixus eremita* and *Scarites terricola* are relatively abundant in this zone.

In general, only *Anchomenus dorsalis* and *Harpalus rufipes* were recorded in all sites studied. In the complex of ground beetles of the Chakilkalyan Mountains, the dominant species are *Anchomenus dorsalis* (11.5%), *Harpalus rufipes* (9.6%) and *Chlaenius extensus* (9.6%) (Table 4).

Although the number of individuals collected from the Chakilkalyan Mountains is not very large, we tried to analyze the coefficients of similarity between different study points (Table 5). The value of the Jaccard

index varied 0.10–0.38, which means the minimum similarity of the studied territories. Moreover, the Chekanovsky-Sørensen index varied 0.12–0.50. However, the Sariduqon and Hazrat Bashir sites are the most similar (Jaccard coefficient 0.38).

In general, the species diversity of the ground beetle fauna of the Chakilkalyan and Karatepa mountains is very close. In our collections, the number of species identified in each territory is the same (34 species each), of which 19 species are characteristic of both territories. However, a comparison of different indices of species richness shows that the species richness of the biocenoses of the Chakilkalyan Mountains is slightly higher in comparison with the biocenoses of the Karatepa Mountains (Table 6). However, the measures of dominance, that is, the proportion of dominant species, is higher in the community of the Karatepa Mountains, which means a low levelling and diversity. Furthermore, the similarity of the

communities of the two mountains is insignificant (Chekanovsky-Sørensen coefficient – 0.112, Jaccard coefficient – 0.39).

Table 5

The similarity of the Carabidae species composition of the five areas on Mt. Chakilkalyan (Jaccard/Chekanovsky-Sørensen indices)

Sites	Yalpoqtapa	Qumbel-say	Kamangaron-say	Sariduqon	Hazrat Bashir
Yalpoqtapa (agrosenoses) (890 m a. s. l.)	–	0.26	0.30	0.10	0.21
Qumbel-say (1480 m a. s. l.)	0.22	–	0.29	0.14	0.36
Kamangaron-say (1300 m a. s. l.)	0.22	0.19	–	0.16	0.17
Sariduqon (2350 m a. s. l.)	0.14	0.12	0.50	–	0.38
Hazrat Bashir (1225 m a. s. l.)	0.24	0.21	0.43	0.27	–

Table 6

Assessment of the ecological diversity of the ground beetle fauna of the Chakilkalyan and Karatepa mountains

Indices	Chakilkalyan Mountains	Karatepa Mountains
Species richness indices		
Margalef Index:	6.18	5.51
Shannon Index:	3.15	2.79
Menhinick Index:	2.35	1.70
Shannon Alignment:	0.89	0.79
Measures of dominance		
Simpson Index:	0.052	0.083
Berger Parker Index:	0.115	0.148
Similarity factors		
Chekanovsky-Sørensen coefficient		0.112
Jaccard coefficient		0.39

Discussion

Our primary data on the fauna of ground beetles of the Karatepa and Chakilkalyan mountains of the Zarafshan Range did not show a very high biodiversity. The fauna of ground beetles in the eastern part of the Zarafshan Range has a fairly high diversity (204 species), while the neighbouring Turkestan and Alai ranges located in Tajikistan include 145 species, the Eastern Pamirs – 47 species (Mikhaylov, 1998). In general, the data obtained on the fauna of ground beetles in different mountain ranges of Asia are ambiguous. So, according to the data of Dudko et al. (2010), the ridges located in the Altai (Russia) differ significantly in the diversity of ground beetles (the Shapshal Ridge includes 23 species, the Chigachev Ridge 32 species, the Saylyugem Ridge 46 species, the South Chuya Ridge 48 species, Southern Altai Ridge 24 species). In the Chinese Changbai Mountains, which coincide in altitude range with our mountains, but is a forest ecosystem, the diversity of ground beetle fauna was 47 species (Zou et al., 2014), and in the Beijing Mountains, 23 species (Warren-Thomas et al., 2014).

The diversity of the ground beetle fauna largely depends on the vegetation cover and the location of the area above sea level. Thus, in mixed mountain forests, the ground beetle fauna is richer than that of pine or oak forests (Finch, 2005; Warren-Thomas et al., 2014). The species richness of the carabid complex decreased with increasing altitude (Hanski & Hammond 1986; Maveety et al., 2011; Dudko et al., 2010). Besides, agrosenoses located in mountainous regions are richer in species composition of ground beetles than natural cenoses. Our results also confirm this. However, the dominance measures disagree with some volatile data (Warren-Thomas et al., 2014), where the share of the most abundant species in different mountain biotopes ranged 42–64%.

Ground beetles are highly sensitive to environmental changes, showing strong habitat specificity and low rates of distribution between sites (Work et al., 2008; Koivula, 2011). Apparently, this can also be the reason for the low coefficients of similarity of the ground beetle fauna in different parts of the mountain territories in our studies. In our studies, the main part

of the ground beetle fauna of the studied mountains was represented by species of the subfamily Harpalinae. In addition to adapting to the soil environment, Harpalinae also have morphological adaptations to life on plants (Ober, 2003). In addition, they are also adapted to feed on seeds, mainly the seeds of herbaceous plants (Honek et al., 2003). Thus, this ability can lead to the presence of a large number of Harpalinae species in the mountains (Qodri et al., 2016).

Conclusion

In the course of our initial research in the Chakilkalyan and Karatepa mountains of the Zarafshan Ridge, 49 species of ground beetles were recorded belonging to 31 genera, 16 tribes and 8 subfamilies. The most representative was the subfamily Harpalinae (32 species from 20 genera (65.3%). The Trechinae subfamily included five species from three genera (10.2%), the Scaritinae subfamily – four species from two genera (8.2%), the Carabinae subfamily – three species from two genera (6.1%), the Broscinae subfamily – two species from the same genus (4.1%). The subfamilies Brachininae, Cicindelinae and Nebriinae are represented by one species (2.0% each).

In the Karatepa Mountains, 34 species from 23 genera have been identified, and in the Chakilkalyan Mountains, 34 species from 21 genera. These two mountains have 19 common types and 15 unique ones. In the Karatepa Mountains, the dominant species are *Zabrus morio*, *Eocarterus chodshenticus*, *Amara aenea*, and *Acinopus laevigatus*, and the subdominant ones are *Brachinus explodens*, *Calathus ambiguus*, and *Poecilus longiventris*. In the Chakilkalyan Mountains, *Anchomenus dorsalis*, *Harpalus rufipes*, and *Chlaenius extensus* are dominant, while *Amara aenea*, *Harpalus distinguendus*, *Dolichus halensis* turned out to be subdominant. However, at different sites, the dominant species vary. The variation in dominant and subdominant species in different parts of the mountains is explained both by differences in food resources and by microclimatic conditions corresponding to the ecological characteristics of a particular taxon.

Different areas of both mountains differ significantly in the diversity of ground beetle fauna. In both mountains, the lowest diversity was noted at the highest altitudes (Sariduqon and Takhtakoracha). The similarity of the fauna of different parts of both mountains, on average, was low. Thus, in four areas of the Karatepa Mountains, the average value of the Jaccard and Chekanovsky-Sørensen indices was 0.27 and 0.11, and in five areas of the Chakilkalyan Mountains – 0.24 and 0.25. And the similarity of the communities of the two mountains with each other was also insignificant (Chekanovsky-Sørensen coefficient – 0.112, Jaccard coefficient – 0.39).

The presented ecological-faunistic study of ground beetles of two mountains of the Zarafshan ridge is of a preliminary nature. These studies will be continued and expanded.

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