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Taxonomic and Ecological Analysis of the Fauna of Ground Beetles (Coleoptera, Carabidae) of the Lower Zarafshan (Uzbekistan)

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ABSTRACT:
The taxonomic composition and ecological-faunistic characteristics of the fauna of ground beetles in the lower reaches of the Zarafshan River were analyzed. 43 species of ground beetles belonging to 28 genera, 19 tribes and 9 subfamilies were identified. The dominant species are *Calathus ambiguus* (20.21%), *Machozetuslehmanni* (17.44%), *Harpalus distinguendus* (16.23%), *Scarites bucida* (7.6%) and *Machozetus concinnus* (5.35%), while the subdominant – *Scarites terricola* (4.32%) *Megacephala euphratica* (3.97%), *Amara aenea* (2.94%), *Amara ovata* (2.25%) and *Harpulus rubripes* (2.07%). The composition of the carabid fauna consists of two ecologically sharply different species complexes: *xerophiles* (inhabiting desert biotopes) and *mesohygrophiles* (inhabiting agrcenoses). *Syntomusobscuro guttatus*, *Harpalus affinis,* and *Scarites subcylindricus* were noted for the fauna of Uzbekistan for the first time.

Keywords: Zarafshan River, ground beetles, taxonomic composition, similarity coefficient, new records.

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INTRODUCTION

The family Carabidae is one of the largest families of beetles. According to some estimates, the number of ground beetle species in the world fauna exceeds 40000 (Thiele, H.U., 1977). However, the number of described species increases every year, and about 100 new species of these beetles are discovered every year (Kotze et al., 2011).

Along with the fact that ground beetles occupy an important place in the food chain in nature, they can be indicators of biodiversity (Duelli and Obrist, 1998) and changes in the state of biotopes (Niemela, 2000). And in agricultural landscapes, they constitute the main group of the herpetobiont complex and are able to maintain the ecological balance, limiting the number of harmful insects and weeds (Moritz et al., 2017; Khalimov et al., 2020; Ali et al., 2021; Serée et al., 2021).

Information about the fauna of ground beetles in Uzbekistan, in particular the Zarafshan Range, can be found in the works of A. Dadamirzaev (Dadamirzaev, 1978) and F. Khalimov (Khalimov, 2020, 2023, Zakirova and Khalimov, 2022). In Uzbekistan, ground beetles, as entomophages of crop pests, have been studied in more detail in cotton agrocenoses (Dadamirzaev, 1978, Bekmetova, 1991) and vegetable crops (Adashkevich and Shukuraliev, 1990, Halimov, 2020).

Although, some information about the beetles of the Bukhara and Karakul oases, located in the lower reaches of the Zarafshan River, is available in the works of R.A. Alimjonov and S.G. Bronshtein (1956), A.G. Davletshina et al. (1979), A. Dadamirzaev (1978), special studies on the study of the carabid fauna of this region were not carried out.

MATERIAL AND METHODS

The studies were carried out in the period 2020-2022 in the territories of the Bukhara and Karakul oases and adjacent territories. The beetles were collected using soil traps of the Barber–Heydemann type (Barber, 1931; Heydemann, 1955), light traps, an exhauster, and manual collection. As traps, we used glass jars (Karpova, 1992) with a capacity of 0.5 L and a hole diameter of 72 mm (the jars were buried in the soil so that the edges were at the level of the soil) placed in a line of 10 traps at a distance of 5 m from each other. Some of the traps were without fixative, and some were with fixing liquid. A 4% formalin solution was used as a fixative, which was used to fill soil traps by 1/3–1/2 of the volume. Traps were sampled once every 10–12 days. The collected beetles were identified by species, counted and made a collection. To study the species composition of ground beetles, desert biocenoses and agrocenoses (wheat, corn, cotton, potatoes, and alfalfa) were taken.

The degree of dominance was determined according to the Renkonen scale (Renkonen, 1944), where more than 5% are dominant species, from 2% to 5% are subdominant species, 1–2% are few, and less than 1% are rare species.

Statistical calculations of biodiversity were carried out according to the guidance of E.A. Dunaev (1997):

Margalef index: $DMg = (S-1) / \ln N$,
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: $H' = -\Sigma pi \ln pi$,
Where, pi is the proportion of individuals of the i - the species, Σ-sum, ln-natural logarithm;

Mönchnik index: $DMn = S / \sqrt{N}$,
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: $D (S\lambda) = \Sigma (ni (ni-1)) / N (N-1)$, where, n is the number of individuals of the i - the species, N is the total number of individuals, Σ is the sum of the indicators for all species;

Berger-Parker index: $d = Nmax / N$,
Where, Nmax 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;

Jacquard coefficient: $Cj = j / (a + b-j)$,
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.

RESULTS AND DISCUSSION

During the research, 43 species of ground beetles were identified, belonging to 28 genera, 19 tribes and 9 subfamilies (Table 1).

Table 1: Taxonomic composition of ground beetles of the Lower Zarafshan of Uzbekistan

Subfamily	Tribe	*Species*	Desert biotopes	Agroce-noses	Shareofspecies, %
Cicindelinae	Megacephalini	*Megacephala euphratica*	+	-	3.97
	Cicindelini	*Cicindela turkestanica*	+	+	0.17
		Cylindela sublacerata	+	-	0.35
Omophroninae	Omophronini	*Omophron limbatum*	+	-	0.17
		Omophron rotundatum	+	+	0.17
Carabinae	Carabini	*Calosoma auropunctatum*	-	+	0.35
Brachininae	Brachinini	*Brachinus explodens*	+	-	0.17
Scaritinae	Scaritini	*Scarites terricola*	+	+	4.32
		Scarites bucida	+	-	7.60
		Scarites subcylindricus	-	+	1.04
		Scarites procerus	+	-	0.17
	Dyschiriini	*Dyschiriuscylindricus*	+	-	1.55
Melaeninae	Cymbionotini	*Cymbionotumsemelederi*	+	-	0.17
Broscinae	Broscini	*Broscus asiaticus*	-	+	0.86
Trechinae	Bembidiini	*Bembidion almum*	-	+	0.52
		Bembidion luridicorne	-	+	0.17
		Bembidion quadrimaculatum	-	+	1.04
		Elaphropus sp.	-	+	0.17
	Tachyini	*Tachyscentriustatus*	+	-	0.17
		Tachussp.		+	0.17
	Trechini	*Trechus quadristriatus*	+	-	0.17
	Pogonini	*Sirdenusgrayii*	-	-	0.17
Harpalinae	Chlaeniini	*Chlaenius festivus*	+	+	0.52
		Chlaenius inderiensis	-	+	0.17
	Harpalini	*Acupalpu sflaviceps*	+	-	1.90
		Harpalus affinis	-	+	1.04
		Harpalus distinguendus	-	+	16.23
		Harpalus griseus	-	+	0.69
		Harpulus rubripes	-	+	2.07
		Harpalus rufipes	-	+	1.55
		Loxoncusprocerus	+	-	0.17
		Liochiruscycloderus	+	-	0.52
		Machozetus lehmanni	+	-	17.44
		Machozetus concinnus	+	-	5.35
	Lebiini	*Cymindis andreae*	+	-	0.86
		Syntomusobscuroguttatus	+	-	0.35
		Singilis flavipes	+	-	0.35
		Lebia festiva	+	-	0.17
	Pterostichini	*Poecilus cupreus*	-	+	0.86
	Sphodrini	*Calathus ambiguus*	-	+	20.21
	Zabrini	*Amara aenea*	-	+	2.94
		Amara ovata	-	+	2.25
		Amara similata	-	+	0.69
9	19	43	23	23	100.0

The number of species is clearly dominated by the subfamily Harpalinae, which includes 21 species and 49% of the total species diversity (Fig. 1).

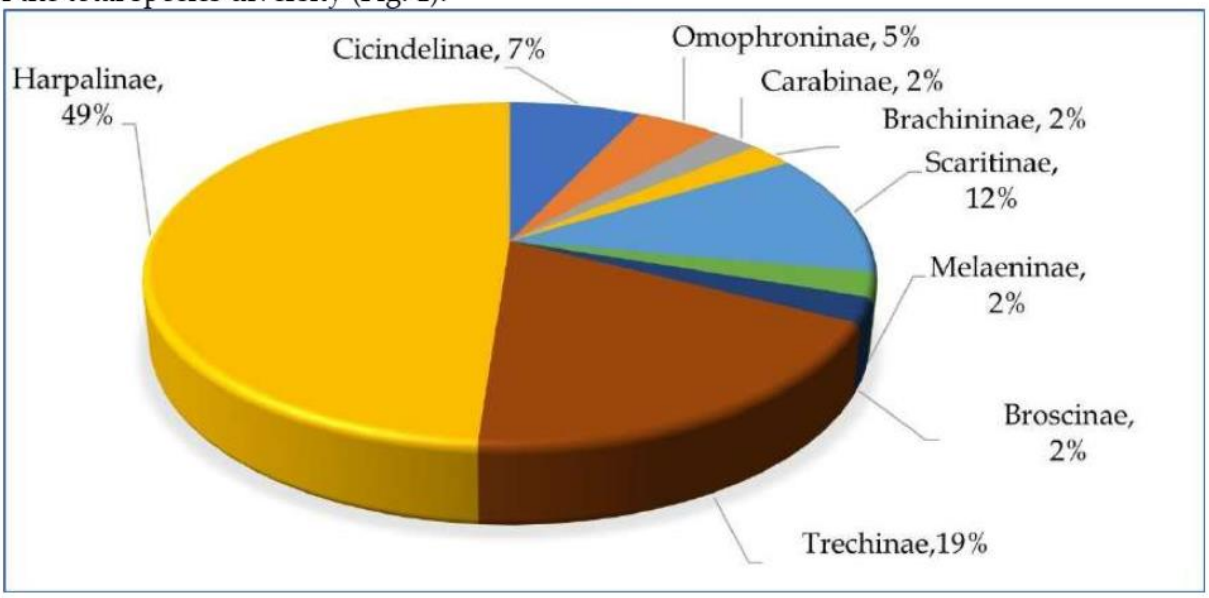

Figure 1: Share of subfamilies by number of species

The subfamily Trechinae accounts for 19% of the species (8 species). Among the dominant subfamilies are also Scaritinae and Cicindelinae, constituting 12% and 8% of the carabid fauna, respectively. The subfamilies Brachininae, Broscinae, Carabinae, and Melaeninae are the only species in the beetle fauna of the region.

However, if you look at the abundance of individuals, the picture changes slightly. Thus, in terms of the abundance of individuals, the share of the subfamily Harpalinae is still increasing and amounts to 82% of all collected beetles (Fig. 2). On the contrary, the share of the subfamilies Trechinae, Cicindelinae and Omophroninae is significantly reduced. Only Scaritinae retains its position, although some changes are also observed. In general, according to the abundance of individuals, the share of 5 out of 9 subfamilies is less than 1%.

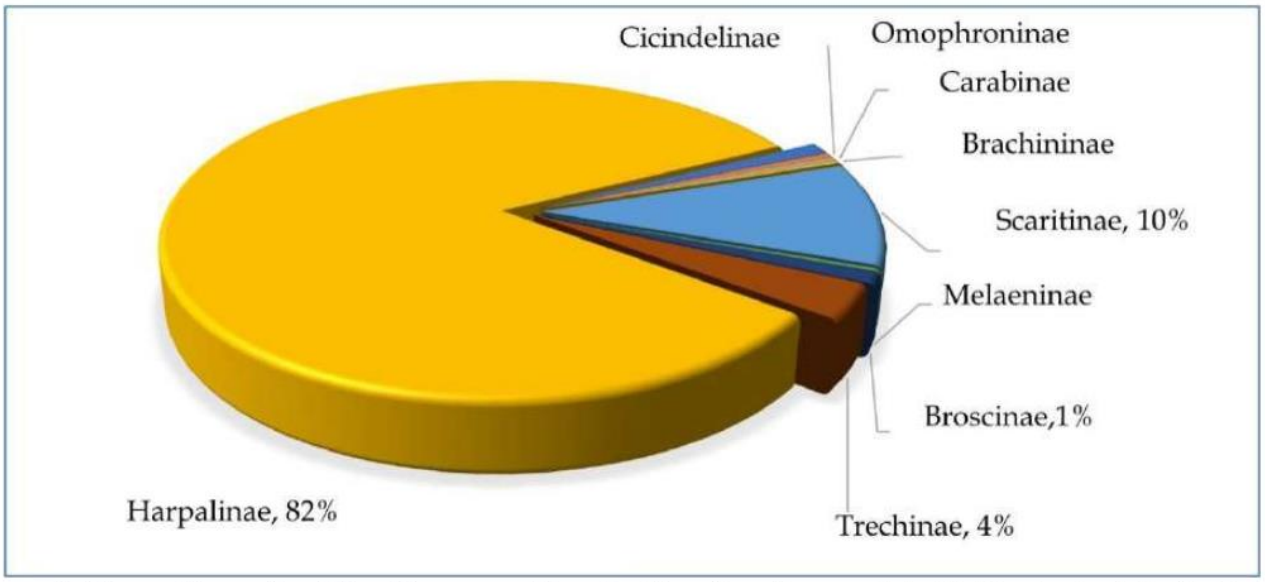

Figure 2: Proportion of subfamilies according to the abundance of individuals (not indicated by proportion figures if they are less than 1%).

If we analyze the fauna of ground beetles by tribes, then the tribe Harpalini has the largest number of representatives - 23.26% (10 species). The following places are occupied by Scaritini, Bembidiini and Lebiini (each 9.3% (4 species) (Fig. 3).

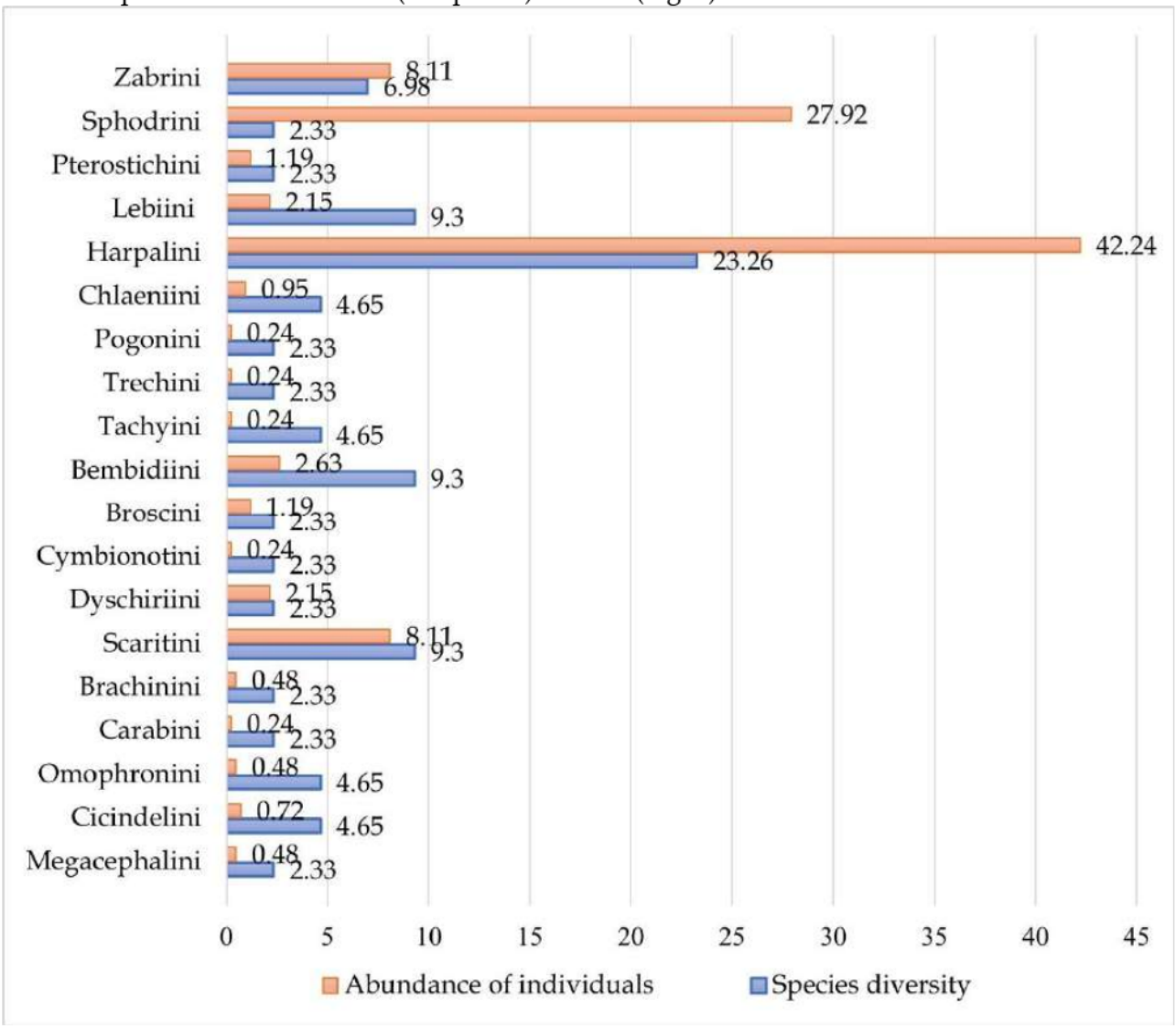

Figure 3: Proportion of tribes in the fauna of ground beetles by the number of species and by the abundance of individuals

And here the proportion of different tribes in terms of the number of species and the abundance of individuals do not coincide. Thus, in terms of the abundance of individuals, the proportion of the tribe Harpalini increases sharply and amounts to 42.24% of all collected beetles. This is due to the abundance of specimens of the dominant species of this tribe – *Harpalus distinguendus* and *Machozetus lehmanni*.

The tribe Sphodrini has a single representative (*Calathus ambiguus*) and makes up 2.33% of the species diversity of the ground beetle fauna. However, due to the high abundance of this species, the tribe Sphodrini accounts for 27.92% of all collected beetles. *Calathus ambiguus* is the most numerous species in agrocenoses and biotopes adjacent to agrocenoses.

In the biocenoses of the lower Zarafshan, the dominant species of ground beetles are *Calathus*

ambiguus (the degree of dominance is 20.21%), *Machozetus lehmanni* (17.44%), *Harpalus distinguendus* (16.23%), *Scarites bucida* (7.6%) and *Machozetus concinnus* (5.35%), and subdominant –*Scarites terricola* (4.32%) *Megacephala euphratica* (3.97%), *Amara aenea* (2.94%), *Amara ovata* (2.25%) and *Harpulus rubripes* (2.07%).

The territory of the Lower Zarafshan geographical district includes a variety of landscapes, however, the biotopes of this region can be conditionally divided into two biotopes that differ sharply in hydrothermal characteristics: desert and artificial (agrocenoses) associated with the economic activity of the population. Of course, desert biocenoses are also used to some extent by the population for grazing sheep and cattle. But the ecological conditions of these biotopes differ significantly from the conditions of agricultural lands. Based on this, we conducted a comparative analysis of the beetle fauna of these biotopes contrasting in terms of conditions.

In desert biotopes, where sands, sandy soils and salt marshes predominate, a peculiar fauna of ground beetles is formed. It is dominated by species adapted to desert conditions of the genera Megacephala, Scarites, Machozetus and Dyschirius. *Megacephala euphratica*, the only representative of the genus Megacephala in the Palearctic, is widespread on solonchaks. And in the sand dunes, the most numerous species of the genus Scarites. Although many species of this genus are distributed in the tropical zone, more than 10 species are found in Uzbekistan (Kryzhanovsky, 1953). On the desert biotopes of the study area, 4 species of this genus were identified, where the most numerous is the endemic of Central Asia –*Scarites bucida*. If *Scarites terricola* was found both in desert biocenoses and in agrocenoses, then *Scarites subcylindricus* was found only in agrocenoses. Over the years of research, only one specimen of *Scarites procerus eurytus* was caught. However, this species is widespread in the mountainous and foothill regions of Uzbekistan (Khalimov, 2020).

The genus Machozetus is an endemic genus of Central Asia, which includes only two species – *Machozetus lehmanni* and *Machozetus concinnus*. In addition to Uzbekistan, *Machozetus lehmanni* is also recorded in Afghanistan, Iran, Tajikistan and Turkmenistan, and *Machozetus concinnus* in Tajikistan and Turkmenistan. In our studies, both species are dominant species in desert biocenoses.

In general, 23 species of ground beetles from 18 genera were found in the desert biocenoses of the Lower Zarafshan (Table 1).

The dominant species in desert biocenoses are *Machozetus lehmanni* (37.41%), *Scarites bucida* (16.3%), *Machozetus concinnus* (11.48%), *Scarites terricola* (9.26%), *Megacephala euphratica* (8.52 %). These five species make up 82.97% of all identified beetles. *Acupalpus flaviceps* (4.07%) and *Dyschiriuscylindricus* (3.33%) are noted as subdominant species.

The small number of the species *Cicindela turkestanica*, as well as the distribution of *Chlaenius festivus* in desert biocenoses, is somewhat unexpected. The first species is widespread throughout the territory of Uzbekistan, and *Chlaenius festivus*, like all species of the genus Chlaenius, is adapted in hygrophilous habitats near water bodies. Apparently, individuals of this species flew into the world from neighboring agrocenoses.

Zoophages predominate in the trophic structure of the beetle fauna of desert biocenoses (17 species, 77.3%). Mixophytophages include 3 species (13.6%), and phytophages are represented by 2 species (9.1%).

In agrocenoses, 23 species of ground beetles from 13 genera were identified. The most representative are the genera Harpalus (five species, 21.8%), Bembidion and Amara (three species, 13.0% each).

The species composition of ground beetles in agrocenoses differs significantly from that in desert biocenoses. The genus Harpalus, both in terms of the number of species and the number of individuals, dominates in agrocenoses, while no species of this genus have been recorded in desert biocenoses. The same situation is observed for the genera Bembidion and Amara.

In general, in agrocenoses, the dominant species are *Calathus ambiguus* (39.8%), *Harpalus distinguendus* (21.77%) and *Amara aenea* (5.78%), and the subdominant species are *Scarites terricola* (4.76%), *Amara ovata* (4.42%), *Harpulus rubripes* (4.08%), *Harpalus rufipes* (3.06%), *Harpalus affinis* (2.04%), *Bembidion quadrimaculatum* (2.04%), *Scarites subcylindricus* (2, 04%).

In agrocenoses, the proportion of subdominant and small numberspecies is somewhat higher compared to desert biocenoses. The trophic structure of ground beetles in agrocenoses consists of zoophages (65.2%) and mixophytophages (34.8%).

A comparative analysis of the ecological diversity of the ground beetle fauna of these biotopes is shown in Table 4.

Comparative analysis of the ecological diversity of the fauna of ground beetles of these biotopes is shown in Table 2.

Table 2: Comparative analysis of the fauna of ground beetles of agrocenoses and desert biocenoses of the Lower Zarafshan

Indicesofecologicaldiversity	**Agrocenoses**	**Desert biocenoses**
Number of species	23	22
The number of species common to both biocenoses	4	
Speciesrichnessindices**:**		
Margalef Index	3,87	3,75
Shannon Index	2,09	2,06
Menhinick Index:	1,43	1,34
Evennessindex:		
Shannonalignment	0,67	0,86
Measuresofdominance**:**		
Simpson Index	0,216	0,196
Berger Parker Index	0,4	0,37
Similarityfactors**:**		
Jaccardcoefficient	0,098	
Chekanovsky-Sørensencoefficient	0,078	

As the data obtained show, the indicators of species richness, evenness, and dominance measures for the two types of biocenoses are quite close. The existing slight difference in evenness indices and dominance measures is explained by a smaller number of dominant species in agrocenoses, as well as their high degree of dominance.

However, it should be noted that the similarity coefficients of these biocenoses have a very low value (Jaccard coefficient-0.098, Chekanovsky-Sorensen coefficient-0.078). This shows that the beetle fauna of the compared biotopes is completely different, since the values of the coefficients are close to zero. Only 4 species of ground beetles (*Cicindela turkestanica, Omophron rotundatum, Scarites terricola* and *Chlaenius festivus*) were recorded in both biotopes.

CONCLUSION

Thus, the fauna of the ground beetles of the Lower Zarafshan includes 43 species belonging to 28 genera, 19 tribes, and 9 subfamilies. The composition of the carabid fauna consists of two ecologically sharply different species complexes: xerophiles (inhabiting desert biotopes) and mesohygrophiles (inhabiting agrcenoses). Of the identified species, *Syntomusobscuroguttatus,*

Harpalus affinis and *Scarites subcylindricus* were first noted for the fauna of Uzbekistan.

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