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Articles

Complexes of terrestrial molluscs of various biotopes in the Gissar Range, Uzbekistan

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The article presents the results of studying the complexes of terrestrial molluscs of various biotopes in the Gissar Range, Uzbekistan. Taxonomic identification of terrestrial molluscs collected from 13 biotopes in 4 altitude regions, determination of individual species' density, and assessment of the similarity of species content among biotopes was carried out. Forty-six species of molluscs are found in the studied biotopes. Biotopes no. 5 (along ditches among thickets of grass, under stones), no. 10 (near springs among grasses), and no. 11 (on the banks of small streams among thickets of grasses) were found to maintain the highest species richness. The most common species in the studied biotopes are *Cochlicopa lubrica*, *Vallonia costata*, and *Pupilla muscorum*.

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Keywords

Biotopes, density, Gissar Range, species composition, terrestrial molluscs

Introduction

Mollusca is the second most diverse animal phylum occurring in all major environments except the aerospace (Pazilov et al. 2022). They have significant functions in food webs and ecosystem equilibrium, such as nutrient cycling, biofiltration, and storage (Fatemeh et al. 2019; Kudratov et al. 2023). Molluscs are animals that have the potential to be able to monitor species stability and the environment; they can also be bioindicators of ecosystem changes (Isroni et al., 2023). The most species-rich class of Mollusca is Gastropoda, comprising 80% of this phylum (Bouchet, Rocroi, 2005; Bouchet et al., 2017; Islamy et al., 2020; Abdurasulova and Pazilov, 2021). It is known that the biological diversity of plants and animals in mountain regions uniquely differs from other biotopes, and the number and variety of species are different (Schilkeyko et al. 2017; Akramov et al.2023; Khalimov 2023). One of the areas with a high probability of changes due to anthropogenic influence is the mountain ranges and their adjacent areas (Khalimov 2020).

Complexes of terrestrial molluscs of various biotopes of the southern slope of the Gissar ridge (Uzbekistan) were analyzed in detail by Z. Izzatullaev (Izzatullaev 1970; Izzatullaev 1975). However, over the past 30 years, the vegetation cover has changed dramatically under the influence of human activity: development for agriculture, logging, and grazing. The exploitation of woody vegetation has led to a reduction in its area and noticeably disrupted the structure of plantings. The herbaceous vegetation of the ridge has changed significantly as a result of grazing and, probably, the excessive overload of many pastures for a long time. Similar changes, although to a lesser extent, occurred in high-mountain heath meadows and groups of alpine short-grass and other heaths located even in the most remote, inaccessible areas.

It should be noted that these changes directly affect the ecology and distribution of terrestrial molluscs. Geobotanically, the slopes of the ridge are heterogeneous. According to the characteristics of Zakirov, high-altitude zones are divided into Desert, Hill, Mountain, and Pasture (Zakirov 1955).

The climate of the mountain region is dry continental, which caused the formation of unique flora and fauna in this region. It has been proven in several studies that the biological diversity of animals (Schilkeyko et al., 2021; Pazilov and Umarov, 2021; Baymuradov et al., 2021; Zokirova and Khalimov, 2022; Khalimov et al. 2023;) and plants (Bazarov et al. 2023; Ruziev et al. 2023; Alikulov et al. 2022) in the mountainous regions of Uzbekistan is high. However, information on the current species content and distribution of the malacofauna of the Gissar mountain range in different biotopes is practically absent from scientific literature and other sources, which indicates that no in-depth research has been conducted in this regard.

Therefore, our research aimed to determine the species composition of terrestrial malacofauna in different biotopes of the Gissar mountain range.

Materials and methods

The research area comprised 13 biotopes: 1 – in gardens and vegetable gardens, in grass, in fallen leaves and rotting plant debris; 2 – on the banks of rivers and ditches among thickets of grass; 3 – on undeveloped lands in semi-shrubs and the stems of grass thickets; 4 – at the foot of the slopes,

among semi-shrubs; 5 – along ditches among thickets of grass, under stones; 6 – close to streams. Among bushes and under rocks; 7 – in tree and shrub vegetation on gravelly slopes; 8 – in bushes with screes; 9 – on rocks and screes with plants; 10 – near springs among grasses; 11 – on the banks of small streams among thickets of grasses; 12 – on rocks and screes; 13 – in subalpine meadows in the Gissar Range of Uzbekistan. A complete description of the sampling station is shown in Fig. 1.

The sampling and processing of the malacological material were carried out using the methods of Izzatullayev (2019) and Pazilov and Umarov (2021). The collected snails were fixed with 70-75% alcohol. If it was impossible to fix them with alcohol, they were fixed in 2% formalin, and soda (NaHCO3) was added to the mixture to prevent the shells from dissolving. All shells are kept dry in the malacological collection of Samarkand State University.

Likharev's (1952) and Schileyko (1978) keys were used to identify molluscs. After being photographed and identified, the animals were stored in the collection bottle. The method used to identify mollusc species consisted of morphological and anatomical analysis. Molluscs were identified based on the morphology of their shells and the structure of genital organs. At least five specimens from each species was dissected to determine differences in genitalia, including the penis.

The similarity of the species composition of the investigated biotopes was analyzed by the Neighbor-joining method (Yan et al. 2021) and described using the cluster prepared in the PAST 4.0 program (Hammer 2001).

Result

During the study, 46 terrestrial molluscs were collected (Table 1).

Desert. Located at altitudes of 650–900 m above sea level. The malacofauna of this belt has been studied in the following biotopes: gardens and orchards, banks of rivers, and ditches.

In gardens and orchards, on grass, in fallen leaves, and in rotting plant remains were found the following species: *Deroceras laeve* (5 individuals per m^2), *D agreste* (6), *Candacharica levanderi* (3).

Along the banks of rivers and ditches, among thickets of grasses, we identified *Cochlicopa nitens* (10 individuals per m^2), *C. lubrica* (6), *Vallonia costata* (11), *Pupilla muscorum* (14), *Angomphalia regeliana* (4), *Candacharica levanderi* (3), *Zonitoides nitidus* (9).

On undeveloped lands in subshrubs and the stems of grass thickets, *Xeropicta candaharica* forms dense populations (25 individuals per m^2).

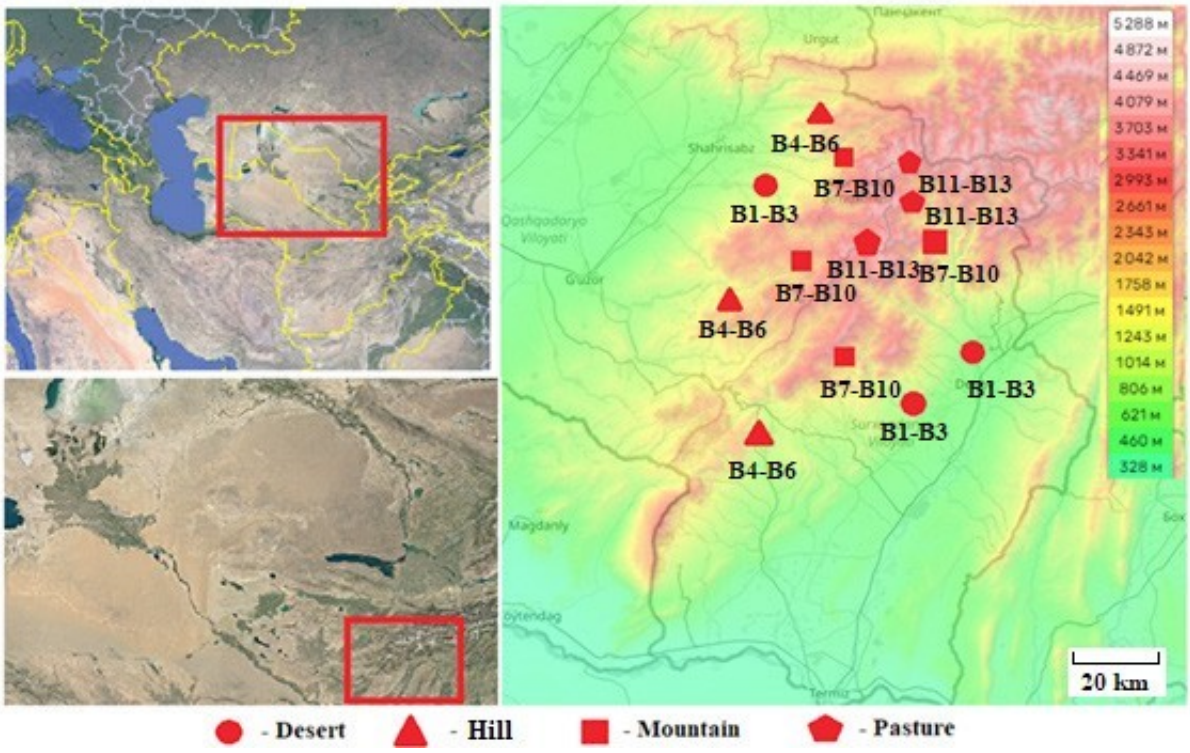

Figure 1. *A map of the studied area.*

Thus, in the desert belt we found 10 species of terrestrial mollusks. In terms of population density, *Xeropicta candaharica* dominates. But *Candacharica levanderi* became more widespread since this species was recorded in two biotopes of the desert belt.

Hill covers the entire hilly-undulating foothill space with a loess cover and occupies most of the territory of the northwestern part of the Gissar ridge. Hill, according to the scheme of Zakirov (1955), is divided into two subzones: 1) lower Hill, where the relief is relatively flat, 500–900–1200 m; 2) upper, where the relief is relatively sharp with frequent exposures of subsoil rocks; its height is 1000–1500 m. The vegetation of the lower Hill consists of the following ranks: *Philomis thapsoides*, *Prosalea drupacea*, etc. The vegetation of the upper Hill is represented by almond trees, which survived only in places more or less remote from populated areas.

In the Hill belt we studied the following biotopes: at the foot of the slopes, among subshrubs: *Pseudonapaeus Sogdiana* (17 individuals per m^2), *Sphyradium doliolum* (13), *Chondrulopsina intumescens* (9), *Xeropicta candaharica* (15), *Gibbulnopsis signata* (21).

Along the ditches among thickets of grasses, under stones, the following were found: *Cochlicopa nitens* (11 individuals per m^2), *C. lubrica* (9), *Pupilla muscorum* (18), *Vertigo pygmaea* (5), *Phenacolimax annularis* (13), *Angiomphalia regeliana* (4), *D. laeve* (3), *D. agreste* (5), *Zonitoides nitidus* (5), *Vallonia costata* (15).

Not far from streams, among bushes, under stones, *C. levanderi* (5), *C. roseni* (7) , and *C. kaznakovi* (3) are living.

In total, 17 species have been recorded in the Hill belt.

No	Species name	Desert			Adyr			Mountain				Pasture		
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	*Cochlic*	-	+	-	-	+	-	-	-	-	+	+	-	-

	opa nitens													
2	*C. lubrica*	-	+	-	-	+	-	-	-	-	+	+	-	+
3	*C. lubricella*	-	-	-	-	-	-	-	-	-	-	+	-	-
4	*Sphyradium doliolum*	-	-	-	-	-	-	+	-	-	-	-	-	-
5	*Valloni a costata*	-	+	-	-	+	-	-	-	-	+	+	-	+
6	*V. pulchella*	-	-	-	-	-	-	-	-	-	+	+	-	-
7	*V. lada censis*	-	-	-	-	-	-	-	-	+	-	-	-	-
8	*Gibbulinopsis signata*	-	-	-	+	-	-	+	-	-	-	-	-	-
9	*Pupilla triplicata*	-	-	-	-	-	-	+	-	-	-	-	-	-
10	*P. muscorum*	-	+	-	-	+	-	-	-	-	+	+	-	+
11	*P. sterrii*	-	-	-	-	-	-	-	-	-	-	-	+	-
12	*P. anzobica*	-	-	-	-	-	-	-	-	+	-	-	+	-
13	*Vertigo antivertigo*	-	-	-	-	-	-	+	-	-	+	-	-	-
14	*V. pygmaea*	-	-	-	-	+	-	-	-	-	-	-	-	-
15	*Columella columella*	-	-	-	-	-	-	-	-	-	+	-	-	-
16	*Pyramidula rupestris*	-	-	-	-	-	-	+	-	-	-	-	-	-
17	*Pseudonapaeus albiplicata*	-	-	-	-	-	-	+	-	-	-	-	-	-
18	*Ps. sogdiana*	-	-	-	+	-	-	-	-	-	-	-	-	-
19	*Ps. miser*	-	-	-	-	-	-	-	-	-	-	-	+	-
20	*Ps. kasnakovi*	-	-	-	-	-	-	-	+	-	-	-	-	-
21	*Ps. ostostomus*	-	-	-	-	-	-	-	+	-	-	-	-	-
22		-	-	-	-	-	-	-	-	-	-	-	+	-

	Turanena martensiana													
23	*T. conicula*	-	-	-	-	-	-	-	-	-	-	-	+	-
24	*Phenacolimax annularis*	-	-	-	-	+	-	-	-	-	-	-	-	-
25	*Chondrulopsina intumescens*	-	-	-	+	-	-	-	-	-	-	-	-	-
26	*Ch. fedtschenkoi*	-	-	-	-	-	-	+	-	-	-	-	-	-
27	*Leucozonella rubens*	-	-	-	-	-	-	+	-	-	-	-	-	-
28	*L. mesoleuca*	-	-	-	-	-	-	-	+	-	-	-	-	-
29	*L. rufispira*	-	-	-	-	-	-	-	-	+	-	-	-	-
30	*L. retteri*	-	-	-	-	-	-	-	-	+	-	-	-	-
31	*L. caria*	-	-	-	-	-	-	-	-	+	-	-	-	-
32	*Xeropicta candaharica*	-	-	+	+	-	-	-	-	-	-	-	-	-
33	*Angiomphalia regeliana*	-	+	-	-	+	-	-	-	-	-	-	-	-
34	*Deroceras laeve*	+	-	-	-	+	-	-	-	-	+	-	-	-
35	*D. agreste*	+	-	-	-	+	-	-	-	-	-	-	-	-
36	*Lytopelte maculata*	-	-	-	-	-	-	+	-	-	-	-	-	-
37	*Candaharia rutellum*	-	-	-	-	-	-	-	-	-	+	-	-	-
38	*C. levanderi*	+	+	-	-	-	+	-	-	-	-	-	-	-
39	*C. roseni*	-	-	-	-	-	+	-	-	-	-	-	-	-
40	*C. kasnakovi*	-	-	-	-	-	+	-	-	-	-	-	-	-

41	*Macrochlamys turanica*	-	-	-	-	-	-	-	-	+	-	-	-	-
42	*M. sogdiana*	-	-	-	-	-	-	-	+	-	-	-	-	-
43	*Zonitoides nitidus*	-	+	-	-	+	-	-	-	-	+	-	-	-
44	*Novisuccinea evoluta*	-	-	-	-	-	-	-	-	-	-	+	-	-
45	*Pamirsuccinea eximia*	-	-	-	-	-	-	-	-	-	-	+	-	-
46	*Oxyloma elegans*	-	-	-	-	-	-	-	-	-	-	+	-	-

Table 1. *Distribution of terrestrial molluscs across vertical belts and biotopes of the Gissar Range*

Mountain. According to natural-historical conditions, this belt can be divided into two subzones.

1. The lower Mountain subzone – a transitional strip from the underlying adyr zone – is characterized by ephemeral plants with more or less xerophilic long-growing steppe-type dominants. Tree and shrub forms are displaced for various reasons, mainly due to human activity. The height of the strip is 1400–1800–2100 m above sea level.

In this subzone, the same complexes of terrestrial molluscs were found as in the Adyr belt.

2. There are almost no ephemeral plants in the upper subzone. Trees and shrubs are better developed here. Under similar conditions, the number of species of more or less mesophilic plants gradually increases.

In this subzone, molluscs live in various biotopes: on tree and shrub vegetation, on rocks and screes, and on the banks of streams and springs.

We found eight species in tree and shrub vegetation on gravelly slopes: *S. doliolum* (10 individuals per m^2), *G. signata* (15), *Pupilla triplicata* (12), *Vertigo antivertigo* (12), *Pyramidula rupestris* (7), *Pseudonapaeus albiplicata* (4), *Chondrulopsina intumescens* (8), *L. maculata* (5).

In the biotope of shrubs with screes, six species are found: *Ps. kasnakovi* (5 individuals per m^2), *Ps. otostomus* (4), *Ch. fedtschenkoi* (10), *Leucozonella rubens* (6), *L. mesoleuca* (7), *Macrochlamys sogdiana* (2).

Rocks and screes are poorer in mollusks than other biotopes. Here, among the stones and plant remains, six species are observed: *Leucozonella rufispira* (4 individuals per m^2), *L. retteri* (3), *L. caria* (1), *Vallonia ladacensis* (10), *Macrochlamus turanica* (5), *P. anzobica* (10).

Along ditches and springs, as well as near streams among thickets of plants, 11 species live: *Cochlicopa nitens* (5 individuals per m^2), *C. lubrica* (10), *C. lubricella* (9), *Vallonia costata* (11), *V. pulchella* (8), *Pupilla muscorum* (10), *Vertigo antivertigo*(7), *Columella columella* (6), *Deroceras*

laeve (3), *Candaharia rutellum* (2), *Zonitoides nitidus* (10).

In total, 32 species of terrestrial molluscs were found in the upper subzone of the Mountain belt.

Pasture. This belt consists of two sub-belts: the lower, usually called subalpine, and the upper, known in the literature as “alpine”. There are no conditions for the development of trees and shrubs in the zone.

The lower pasture belt is characterized by the development and distribution of mesophilic formations of mixed-grass meadows, while the upper belt is characterized by short-grass carpet lawns.

In the lower pasture belt, in contrast to the upper one, some woody plants are common, such as *Juniperus turkestanica*, *Sorbus tianschanica*, *Rosa betula*, etc. The malacological complexes on both subbelts of the Pasture are very similar. Therefore, the distribution of terrestrial molluscs in the two sub-belts is considered jointly. Terrestrial molluscs of the Mountain-Pasture belt inhabit the following biotopes: the banks of small streams, rocks, and screes, subalpine meadows:

In the biotope – banks of small streams among thickets of grasses the following were found: *Cochlicopa nitens* (10 individuals per m^2), *C. lubrica* (7), *C. lubricella* (13), *Vallonia costata* (11), *V. pulchella* (15), *Pupilla muscorum* (10), *Novisuccinea evoluta* (3), *Pamirsuccinea eximia* (6), *Oxyloma elegans* (5).

On rocks and screes there are: *Pupilla sterrii* (8 individuals per m^2), *P. anzobica* (2), *Pseudonapaeus miser* (5), *Turanena martensiana* (3), *T. conicula* (1).

The subalpine meadows contain mainly mesophilic interzonal species: *Cochlicopa lubrica* (5 individuals per m^2), *Pupilla muscorum* (10), *Vallonia costata* (11).

In total, 14 species of terrestrial molluscs were found in the Pasture belt.

The density of terrestrial molluscs in biotopes varies. Data on the total density of terrestrial mollusks of the Gissar Range are shown in the figure 2. For example, in biotopes 4, 5, 7, 10, 11, the density of terrestrial molluscs varies from 75 to 81 specimens per m^2. The lowest density of molluscs is observed in biotopes 1, 6, 12 from 15 to 19 specimens per m^2.

As for species diversity, this indicator reaches its maximum value in biotopes 5, 10, 11 (from 9 to 11 species). The lowest species diversity is observed in biotopes 1, 3, 6, 13 (from 1 to 3 species).

When comparing the malacocomplexes using the coefficients of species similarity of the Gissar Range, it turned out that in more than half of the cases, the similarity coefficient is equal to 0 (Table 2 and Figure 3). In only two biotopes: on the banks of rivers and ditches among thickets of grass (2), along ditches among thickets of grasses, under stones (5), and also near springs among grasses (10), species similarity is only 54%. Also similar in the studied biotopes 5- and 13- (50%), 2- and 13- (42.8%), 10- and 11- (35.7%), 5- and 10- (33.3%) types are distributed.

We explain the large number of non-repeatable cases in the composition of species of the biotopes studied by the small area of the biotopes being compared and the fact that their structural components are different.

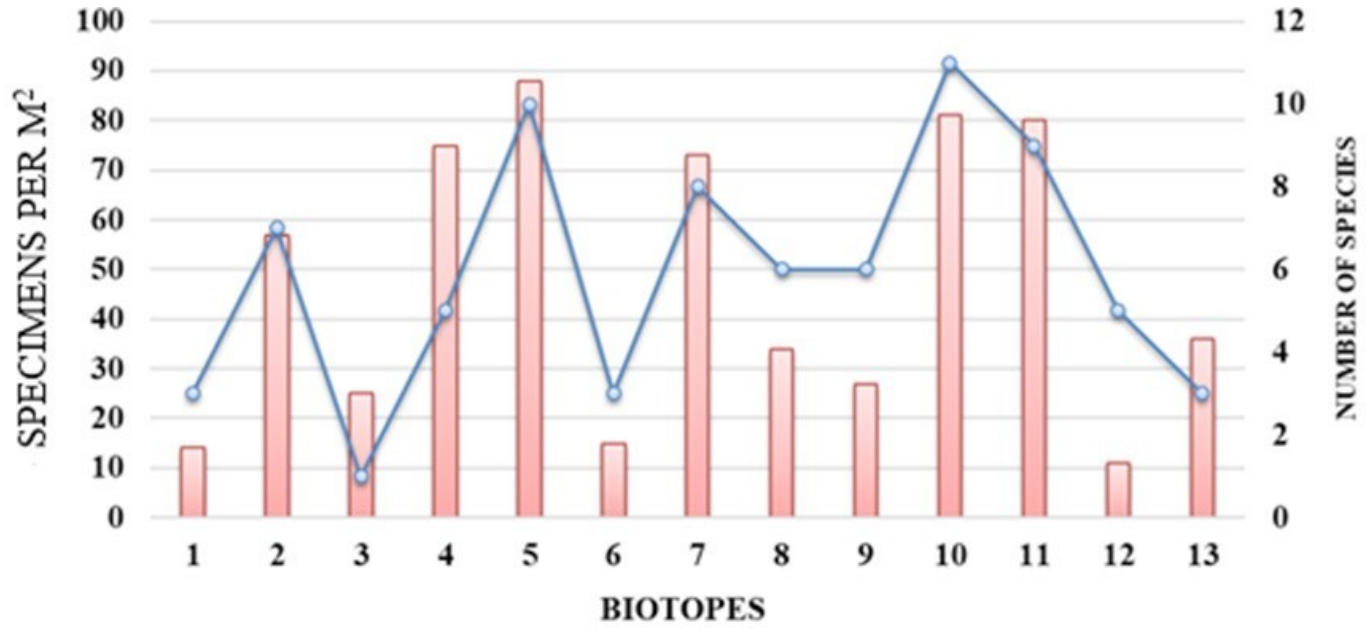

Figure 2. *Density (histogram) and number of species (line) of terrestrial molluscs in various biotopes of the Gissar Range.*

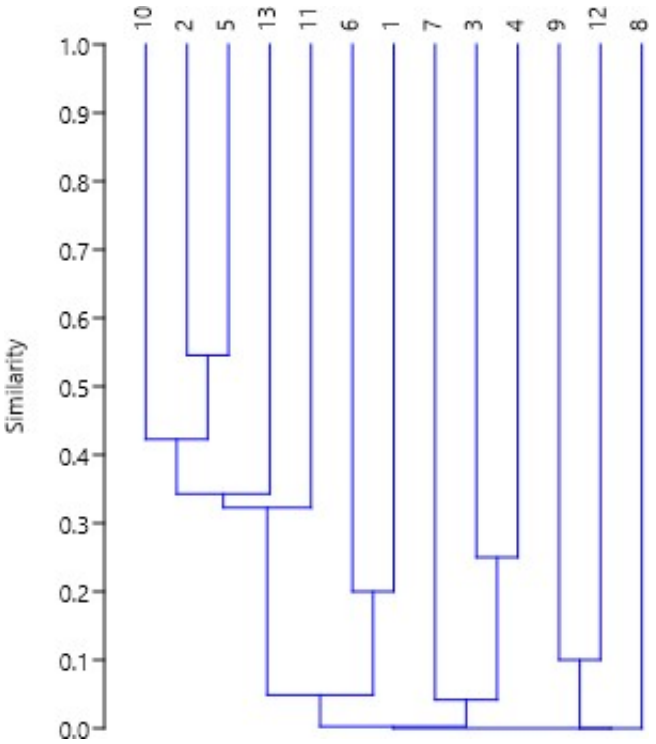

Figure 3. *Dendrogram of faunistic similarity of terrestrial molluscs of various biotopes of the Gissar Range, Uzbekistan (based on Jaccard coefficient).*

K	2	3	4	5	6	7	8	9	10	11	12	13
1	11	0	0	18	0	0	0	0	8.3	0	0	0
2		0	0	54	11.1	0	0	0	54	23.7	0	42.8
3			25	0	0	0	0	0	0	0	0	0
4				0	0	0	0	0	0	0	0	0
5					0	0	0	0	33.3	18.7	0	50
6						0	0	0	0	0	0	0
7							0	0	0	0	0	0

8								0	0	0	0	0
9									0	0	0	0
10										35.7	0	0
11											0	33.3
12												0

Table 2. *Coefficient of species similarity of malacomplexes of different biotopes of the Gissar Range (Jaccard index)*

Conclusion

For the first time, land molluscs of the Gissar mountain range were studied in 13 biotope sections in different altitudinal regions. A list of land mollusks including 46 species was compiled. Species-rich biotopes were identified, and species with high distribution potential (*Cochlicopa lubrica*, *Vallonia costata*, and *Pupilla muscorum*) were revealed. A comparative analysis of the biotopes of terrestrial molluscs is provided. The data obtained by the study of land mollusks in the section of biotopes differing in their altitude position, besides providing important facts about the distribution of these animals, explain the biological diversity of the region's fauna.

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