The fauna of collembola in soil layers of natural ecosystems of Kashkadarya region (Republic of Uzbekistan)

Z U Elmuratova[1*], *O M* Mamarakhimov[1], *M M* Makhmudova[1], *M J* Kamalova[1], and N.Kh. Karshibayeva[2]

[1]National University of Uzbekistan, Tashkent, 61010333, Uzbekistan
[2]Jizzakh State Pedagogical University, Jizzakh, 130100, Uzbekistan

Abstract. The paper presents data concerning the species composition, biological traits, and faunal indicators of Collembola discovered in the soil fauna of Shahrisabz and Yakkabogh districts within the Kashkadarya region (Republic of Uzbekistan). The study involved the analysis of soil layers at depths of 0-10 cm, 10-20 cm, and 20-30 cm in both districts. The results were used to determine the species composition of the fauna, calculate faunal diversity indices, and elucidate the factors driving changes in diversity. *Xenylla maritima, Agrenia bidenticulata,* and *Heteromurus nitidus* were identified as dominant species

1 Introduction

Currently, the number of Collembola species exceeds 8,600, with ongoing growth due to the discovery of new species. Collembola possess specialized morphological features, including a sacrificial fork, a hook that secures the sacrificial fork, and a ventral tube. Collembola primarily feeds on fungal spores, although certain species may consume other soil organisms, process plant debris, and extract plant cell sap [1]. For instance, Micranurida species, equipped with a mouth-sucking apparatus, specialize in feeding on plant cell sap, while Frisea species are carnivorous, preying on nematodes [2]. The dietary habits of Collembola are determined through the examination of their oral apparatus and digestive system. Moreover, the abundance of Collembola often correlates with biomass and plant diversity [3].

Collembola plays crucial roles in organic matter decomposition, chemical element cycling as reductants, and the exchange of organic substances in the environment, thus contributing to soil stability and fertility. They are considered one of the most promising model groups for comparative ecological analyses of soils due to their widespread distribution and sensitivity to environmental changes, making them extensively studied pedobiont taxa. In temperate climates, certain spring Collembola species aid in controlling bio- and geohelminths by consuming roundworm eggs. Additionally, Collembola serve as effective indicator organisms for assessing anthropogenic impacts on soils and analyzing

* Corresponding author: eyangiboyev348@gmail.com

the restoration processes of contaminated soils. In summary, Collembola play vital roles in organic matter decomposition, chemical element circulation, and environmental stability, particularly in ensuring soil fertility [4, 28, 46]. Soil Collembola have been observed to actively participate in soil mineralization processes and influence the degradation of pesticides and herbicides within soil.genera [4].

2 Materials and methods

Our investigation was carried out in the Shahrisabz district of the Kashkadarya region at coordinates 39.045972, 67.002160, and in the Yakkabog district at coordinates 38.910505, 66.818428 during the period of 2022-2023. The Sampling was conducted at depths of 0-10 cm, 10-20 cm, and 20-30 cm in natural ecosystems, resulting in a total of 1440 samples of 1 dm3 each being collected. Soil samples were gathered from specified points in the field, placed into labeled bags, and recorded with details such as sampling date, location, ecosystem type, soil layer, and additional relevant information. Stationary methods were employed to study the species composition and ecological dynamics of Collembola within these areas and throughout various seasons [5].

The widely accepted "Berleze-Thulgren apparatus" was utilized to extract Collembola from soil samples. This apparatus comprises a tripod, a large funnel, a sieve, and a glass container. Initially, the funnel is positioned on the tripod, followed by placing the sieve atop the funnel, and adding the soil sample onto the sieve. A glass container, containing a fixing liquid (such as alcohol), is positioned below the funnel. The operation of this apparatus involves the downward drying of the soil samples placed on the sieve, causing small soil-dwelling organisms to move downwards. The fixative then collects in the container, typically filled with 70-80% ethyl alcohol. Small arthropods collected in the dish are transferred into a Petri dish for observation under a binocular microscope and further examination.In order to determine the species composition, permanent preparations were prepared. Permanent preparations were made by the method of fixation [6].

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Fixation: 70-80% ethyl alcohol is traditionally used to fix Oribatid mites. It is recommended to add 1-2% glycerine to alcohol. In this case, glycerin prevents the alcohol from drying out during the storage of the material in the test tube [6].

Dominance: To express the relative abundance of species, percentages of the total were utilized [3, 6]. In our investigation, employing an index ranging from 0% to 20%, the Engelman scale was employed as follows:

- 0-3.99%: characterized as subresident.
- 4-7.99%: characterized as resident.
- 8-11.99%: characterized as subdominant.
- 12-14.99%: characterized as dominant.
- ≥15%: collectively considered eudominant.
- Statistical analyzes were performed in the PAST program [7-8].

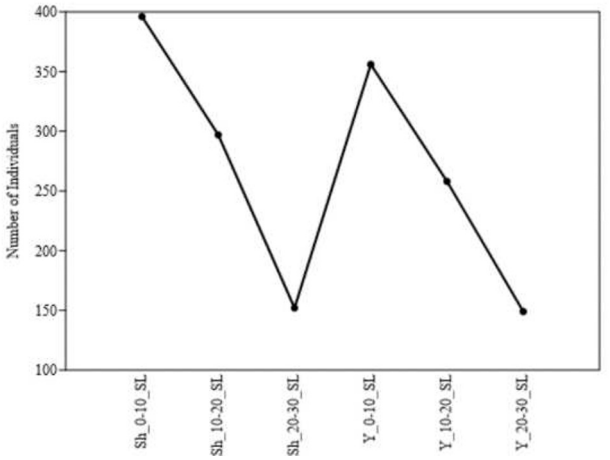
3 Results

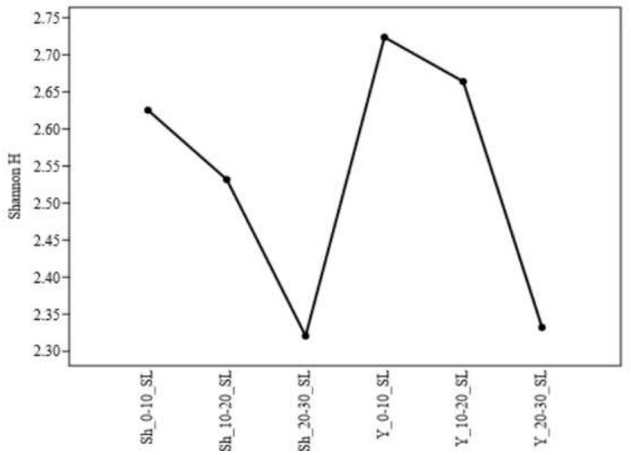
From During our investigation, we identified 25 species of Collembola distributed across soil layers within natural ecosystems located in the Yakkabog and Shahrisabz districts of the Kashkadarya region (Table 1). The distribution of these species varies according to soil composition and depth, particularly notable in the 0-10 cm and 20-30 cm layers of the Shahrisabz region. In this area, *Agrenia bidenticulata* and *Heteromurus nitidus* emerge as

dominant species, whereas *Agrenia bidenticulata* dominates the 10-20 cm layer but not in the 0-10 cm or 20-30 cm layers. Conversely, *Xenylla maritima* is the dominant species in the 10-20 cm layer of natural ecosystems in the Shahrisabz district, with an abundance of 95.7 ± 0.6 individuals per 1dm3 of soil. In the Yakkabog district, *Heteromurus nitidus* and *Xenylla maritima* species dominate across all soil layers. The varying distribution of species contributes to the diverse soil fauna. Throughout our study, soil fauna diversity was assessed across layers using diversity indices (Figure 1).

Table 1. Distribution of Collembola in soil layers.

No.	Species	Kashkadarya region					
		Shahrisabz district			Yakkabog district		
		Soil layers					
		0-10 *(M±m)*	**10-20 *(M±m)***	**20-30 *(M±m)***	**0-10 *(M±m)***	**10-20 *lin (M±m)***	**20-30 *(M±m)***
1	*Typhlogastrura mendizabali* (F.Bonet, 1930)	13.1 ±0.3	-	7.4 ±0.6	13.2 ±0.3	-	4.2±0.6
2	*Hypogastrura assimilis* (Krausbauer, 1898)	10.2 ±0.4	9.1 ±0.3	-	11.9 ±0.7	7.2 ±0.3	-
3	*Paraxenylla affiniformis* (J.Stach, 1930)	12.1 ±0.6	9.4 ±0.3	-	12.2 ±0.6	7.4 ±0.3	-
4	*Xenylla maritima* (Tullberg, 1869)	45.2 ±0.3	95.7 ±0.6	22.2 ±0.3	47.6 ±0.4	71.1±0.6	16.2 ±0.3
5	*Hypogastrura viatica* (Tullberg, 1872)	8.1 ±0.3	-	9.4 ±0.4	7.1 ±0.3	-	16.2 ±0.3
6	*Metaphorura affinis* (Börner, 1903)	-	7.2 ±0.2	13.2 ±0.3	-	8.1 ±0.3	13.1 ±0.5
7	*Ongulonychiurus colpus* (Thibaud & Z.Massoud, 1986)	5.4 ±0.3	13.4 ±0.6	-	5.1 ±0.6	12.2 ±0.3	-
8	*Lophognathella choreutes* (Börner, 1908)	-	11.2 ±0.3	4.1 ±0.4	-	13.4 ±0.3	4.2 ±0.3
9	*Supraphorura furcifera* (Börner, 1908)	13.1 ±0.1	5.4 ±0.3	-	13.7 ±0.3	2.2 ±0.6	-
10	*Protaphorura taimyrica* (Martynova, 1976)	10.6 ±0.6	-	3.2 ±0.3	12.1 ±0.6	-	5.3±0.3
11	*Axenyllodes bayeri* (Kseneman, 1935)	-	10.1 ±0.4	5.2 ±0.3	-	10.8 ±0.4	5.4±0.6
12	*Xenyllodes armatus* (W.M.Axelson, 1903)	-	9.8 ±0.3	4.2 ±0.4	-	11.1 ±0.3	5.2±0.3
13	*Adbiloba sokolowi* (Philiptschenko, 1926)	12.1 ±0.3	2.8 ±0.6	-	9.2 ±0.3	6.2 ±0.3	-
14	*Pseudachorutes subcrassus* (Tullberg, 1871)	9.4±0.3	-	5.4 ±0.5	13.1 ±0.3	-	5.4±0.6
15	*Archisotoma besselsi* (A.S.Packard, 1877)	7.1±0.5	-	14.1±0.3	6.1±0.3	-	12.4±0.6
16	*Vertagopus cinereus* (H.Nicolet, 1842)	-	13.2 ±0.3	5.2 ±0.4	-	11.6 ±0.4	3.8±0.1
17	*Agrenia bidenticulata* (T.Tullberg, 1877)	93.1 ±0.6	17.1 ±0.3	29.1 ±0.4	63.1 ±0.4	17.1 ±0.2	31.1 ±0.1
18	*Pseudofolsomia acanthella* (Martynova, 1967)	13.1 ±0.1	4.7 ±0.3	-	13.2 ±0.3	5.6 ±0.2	-
19	*Folsomides parvulus* (Stach, 1922)	8.4 ±0.3	13.1 ±0.2	-	9.1 ±0.6	11.2 ±0.3	-
20	*Pseudisotoma sensibilis* (T.Tullberg, 1877)	12.7 ±0.3	9.1 ±0.4	-	12.6 ±0.6	9.1 ±0.3	-
21	*Isotomodes productus* (W.M.Axelson, 1906)	7.4 ±0.6	4.1 ±0.4	-	8.1 ±0.6	3.5 ±0.3	-
22	*Isotomiella minor* (Schäffer, 1896)	5.3 ±0.3	9.1 ±0.5	-	5.4 ±0.5	9.9 ±0.6	-
23	*Metisotoma grandiceps* (Reuter, 1891)	13.1 ±0.3	5.2 ±0.4	-	12.4 ±0.3	4.1 ±0.1	-
24	*Heteromurus nitidus* (R.Templeton, 1836)	72.7 ±0.7	46.2 ±0.3	32.1 ±0.6	63.1 ±0.4	34.8 ±0.6	30.2 ±0.3
25	*Tomocerus sibiricus* (Reuter, 1891)	14.1±0.3	4.1±0.2	-	10.2±0.6	3.1±0.3	-


Number of Individuals
400
350
300
250
200
150
100
Sh_0-10_SL
Sh_10-20_SL
Sh_20-30_SL
Y_0-10_SL
Y_10-20_SL
Y_20-30_SL


Shannon H
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
Sh_0-10_SL
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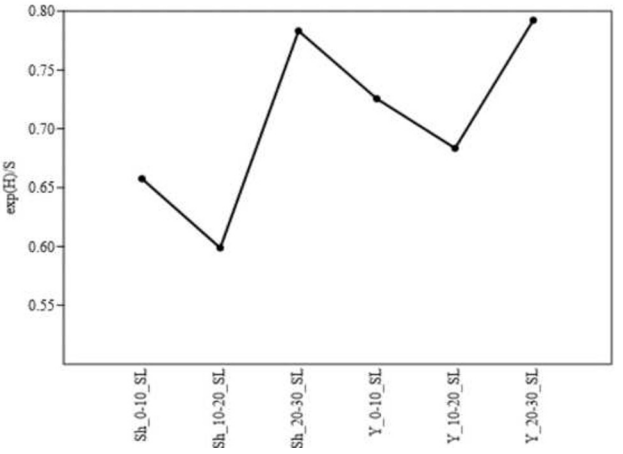
Y_0-10_SL
Y_10-20_SL
Y_20-30_SL


exp(H)/S
0.80
0.75
0.70
0.65
0.60
0.55
Sh_0-10_SL
Sh_10-20_SL
Sh_20-30_SL
Y_0-10_SL
Y_10-20_SL
Y_20-30_SL

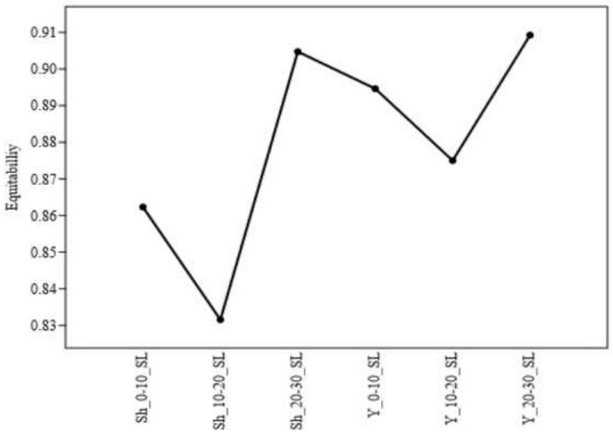


Fig. 1. Diversity indicing of Collembola by Soil layers (Sh_0-10_SL – 0-10 cm soil layer of Shahrisabz district, Y_0-10 cm_SL – 0-10 cm soil layer of Yakkabog district).

4 Discussion

Based on the research, *Xenylla maritima, Agrenia bidenticulata,* and *Heteromurus nitidus* emerge as dominant species in the soils of Shahrisabz and Yakkabog districts within the Kashkadarya region. These species are notably abundant in the 0-10 cm soil layer and are recognized as indicators of soil sensitivity to chemical and mechanical influences in both districts.

A comparison of soil fauna between the two districts reveals that the 0-10 cm soil layer in Shahrisabz, despite having the highest individual count, exhibits a lower-than-expected Shannon diversity index. This is attributed to the infrequent presence of *Ongulonychiurus colpus* and *Folsomides parvulus* species in this layer compared to the 10-20 cm layer. Additionally, the significant discrepancy in the density of these species leads to a reduction in evenness and equitability indices for the Shahrisabz 0-10 cm layer fauna. The limited number of species in the Shahrisabz 10-20 cm layer fauna, coupled with the pronounced difference in individual counts between *Xenylla maritima* and *Heteromurus nitidus* versus other species, results in an inverse relationship between evenness and equitability and the Shannon diversity index in terms of numbers. Although the number of species in the Shahrisabz and Yakkabog 20-30 cm soil layers is small, the species' density approximates the expected indicators, thereby elevating the values of evenness and equity. In the remaining soil layers, the interplay between species count, individual density, and the ratio of differences between them leads to proportional changes in all indicators.

5 Conclusion

In conclusion, our study identified 25 species of Collembola within the soil fauna of the Shahrisabz and Yakkabog districts in the Kashkadarya region. Analysis of soil layers revealed *Xenylla maritima, Agrenia bidenticulata,* and *Heteromurus nitidus* as the dominant species. The 0-10 cm soil layer in Shahrisabz exhibited the highest species diversity and individual density. Additionally, the soil fauna of the Shahrisabz 20-30 cm layer, Yakkabog 10-20 cm layer, and Yakkabog 20-30 cm layer showed moderate indicators in terms of species and individual density.

References

1. E.G. Bjarni, Brynhildur B. Springtail (Collembola) populations in hayfields and pastures in northern Iceland. Icelandic agricultural sciences, **2**, 49-59 (2008)
2. Negri I. Spatial distribution of Collembola in presence and absence of a predator, Pedobiologia, **48**, 585–588 (2004)
3. A. Fjellberg, The Collembola of Fennoscandia and Denmark. Part II: Entomobryomorpha and Symphypleona, Brill, Leiden Boston, 264 (2007)
4. S.P. Hopkin, Biology of springtails: (Insecta: Collembola), Oxford Science Publications, Oxford, 330 (1997)
5. M.B. Potapov, N.A. Kuznetsova, Methods for studying communities of microarthropods, Partnership of scientific publications KMK, Moscow, 84 (2011)
6. S. Barjadze, New records for the Georgian springtail fauna (Collembola), Zoology in the Middle East, **56**, **1**, 143-146 (2012)
7. F.O. Shodiyeva, E.Ch. Yahgiboyev, F.R. Kholboev, M.Sh. Raximov, Significance and Conservation of Birds of the Genus of Bee-eater (MEROPS) in Uzbekistan. Baghdad Science Journal Published Online First: July, 2023, 252-260 (2023) https://dx.doi.org/10.21123/bsj.2023.7109
8. E.Ch. Yangiboyev, O.M. Mamarakhimov, M.M. Makhmudova, U.A. Nabiev, G. Karamatova, The diversity of reptiles in different ecological environments of mountainous parts of Kashkadarya region, ESDCA E3S Web of Conferences, 510 (2024) https://doi.org/10.1051/e3sconf/202451003012